Sub-			Exp	posure					
ictivity Гуре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
letties									
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project- specific environmental conditions; may range from: Rupture of egg membrane. Fatal injury or permanent auditory tissue damage limiting to survival. Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may affect survival at all life- history stages, depending on project- specific noise intensity and receptor exposure. Likelihood of egg and alevin exposure is limited, as the majority of Chinook spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Likelihood of egg and alevin exposure is limited, as the majority of Chinook spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is highly likely. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Likelihood of egg and alevin exposure is limited, as the majority of Chinook spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is highly likely. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.

Sub-			Ex	posure			_		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Submechanism
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	Likelihood of egg and alevin exposure is limited, as the majority of Chinook spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is highly likely. See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	Likelihood of egg and alevin exposure is limited, as the majority of Chinook spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is highly likely. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

Sub-			Ex	posure	1	1			Resulting Effects of the
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Water Quality Modification	-					-	-	
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation.	Avoid sediment pulses.	Likelihood of egg and alevin exposure is limited, as the majority of Chinook spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, stressor may affect survival. May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and productivity of juveniles and adults.

HPA HCP Shoreline Modification Exposure and Response Matrix for Chinook Salmon.

## HPA HCP Shoreline Modification Exposure and Response Matrix for Chinook Salmon.

)-			Exj	posure		,			
у	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in	Likelihood of egg and alevin expose is limited, as the majority of Chinoo spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, stressor may affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
	Riparian Vegetation Modification								
	Marine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and survival.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.

Table A-1	(continued).
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HPA HCP Shoreline Modification Exposure and Response Matrix for Chinook Salmon.

		Exj	posure					
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Chinook dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, Chinook are known to utilize terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness
Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high quality habitat features.	May affect juvenile survival.
Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Chinook dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown.
Lacustrine							•	
Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by waterlevel variability may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Chinook are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.

## HPA HCP Shoreline Modification Exposure and Response Matrix for Chinook Salmon.

			Ex	posure					
ity	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Chinook dependence on groundwater inflow to nearshore lacustrine habitats is currently a data gap.	Avoid disturbance of vegetation along the shoreline.	Effects of the action resulting from th impact mechanism are unknown.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize	May affect juvenile growth and fitnes
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash,	See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.	grounding, and anchoring, and reduced solar light penetration due to propeller- induced fine bubbles.	May affect juvenile survival. May affect adult growth and spawning productivity.

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Table A-1	(continued).
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Sub-			Ex	xposure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.	disturbance of aquatic vegetation during project construction.Operation:Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash,	See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	grounding, and anchoring.	May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.

ub-			Exj	posure				Resulting Effects of the	
ctivity ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Hydraulic and Geomorphic Modification							-	-
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect survival and productivity juvenile life-history stage. Decrease fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile Chinook salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction	patterns, and wave energy and current patterns.	
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity,		
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		decreased fitness for marine migration, and direct mortality.		
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				

HPA HCP Shoreline Modification Exposure and Response Matrix for Chinook Salmon.

HPA HCP Shoreline Modification Exposure and Response Matrix for Chinook Salmon.

			Exj	posure		1			Resulting Effects of the			
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism			
	Lacustrine											
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivit			
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory habitat for adult Chinook salmon. This may occur through a number of specific stressors, including increased exertion and stress due to	patterns, and wave energy and current patterns.				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging					
	Altered sediment supply		Year-round	Permanent	Continuous		opportunity, and increased competition for suitable habitats. The combined effect of					
	Altered substrate composition		Year-round	Permanent	Continuous		these stressors can result in decreased growth and productivity, decreased fitness for marine					
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous		migration, and direct mortality. Adult Chinook will generally be less sensitive to these stressors. However, increased stress and delayed migration in the migratory corridor may reduce fitness and ultimately reduce spawning success.					
	Cosystem Fragmentation     spawning success.											
ľ	Marine											
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u> : Jetties can fragment nearshore marine rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivi juvenile life-history stage. Decreas fitness may affect survival and productivity during ocean migratio life-history phase.			
	Loss of LWD recruitment	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.			

Table A-1	(continued).
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ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : Jetties can fragment nearshore lacustrine rearing habitats, forcing migrating and foraging salmonids to navigate offshore into deeper water environments. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivity
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.
eakv	waters								
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages:Stressor response dependent on noise magnitude and project- specific environmental conditions; may range from:Rupture of egg membrane.Fatal injury or permanent auditory tissue damage limiting to survival.Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and preyIncreased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may affect survival at all life history stages, depending on project- specific noise intensity and receptor exposure. Likelihood of egg and alevi exposure is limited, as the majority of Chinook spawning habitat is located i areas unsuitable for breakwater development. Should exposure occur however, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Likelihood of egg and alevin exposure is limited, as the majority of Chinook spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is highly likely. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Likelihood of egg and alevin exposure is limited, as the majority of Chinook spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is highly likely. May cause direct mortality or injury at juvenile life- history stage. Injury and stress may affect survival, growth, and fitness.
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	J <mark>uveniles;</mark> Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
		Bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.

HPA HCP Shoreline Modification Exposure and Response Matrix for Chinook Salmon.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	Likelihood of egg and alevin exposure is limited, as the majority of Chinook spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is highly likely. See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	Likelihood of egg and alevin exposure is limited, as the majority of Chinook spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is highly likely. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

HPA HCP Shoreline Modification Exposure and Response Matrix for Chinook Salmon.

HPA HCP Shoreline Modification Exposure and Response Matrix for Chinook Salmon.

Sub-			Exp	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation.	Avoid sediment pulses.	Likelihood of egg and alevin exposure is limited, as the majority of Chinook spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, stressor may affect survival. May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and productivity of juveniles and adults.
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in	Likelihood of egg and alevin exposure is limited, as the majority of Chinook spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, stressor may affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	

Table A-1	(continued).
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Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification			-	-	-			
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	disturbance of aquatic vegetation during project construction.	See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.	_	May affect juvenile survival. May affect adult growth and spawning productivity.

Table A-1	(continued).
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			Exj	posure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Submechanism
	<b>Riverine and Lacustrine</b>	·	-	·	-			·	•
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. Construction: Avoid/minimize	May affect juvenile growth and fitn
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.	disturbance of aquatic vegetation during project construction.	See effects for related stressors und Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness		May affect juvenile survival, growt and fitness, as well as adult spawni productivity.
							and spawning success due to decreased nucleos availability of suitable migratory and spawning habitat.		
	Hydraulic and Geomorphic Modification Riverine								
-	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and	Year-round	Permanent	Continuous	<ul> <li>Eggs and alevins;</li> <li>Juveniles;</li> <li>Adults</li> </ul>	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, an juvenile life-history stages. May affe spawning productivity.
	Altered flow velocity	rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Permanent	Seasonal	Aduits	and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest	
	Altered substrate composition (including placement of non-erodable substrate)		Year round	Permanent	Continuous		changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	extent practicable.	
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel		
	Addition of impervious surface		Year-round	Permanent	Continuous		geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation		

Table A-1	(continued).
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Sub-			Ex	posure	. <u></u>				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered wave energy Altered current velocities	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile Chinook salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction			
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		in available cover or exposure due to reduction habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity,		
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		decreased fitness for marine migration, and direct mortality.		
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

			Ex	posure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect survival at juvenile life- history stage. Decreased fitness ma lead to reduced spawning productive
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common	Common fundamentally alter lacustrine littoral habitats, patterns, and wave e potentially decreasing the suitability of rearing habitat for juvenile and migratory habitat for adult Chinook salmon. This may occur through a number of specific stressors, including increased exertion and stress due to	patterns.	ability of rearing patterns. ory habitat for hay occur stressors, nd stress due to lergy patterns, due to reduced er habitat, food foraging	ent
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging		
	Altered sediment supply		Year-round	Permanent	Continuous		opportunity, and increased competition for suitable habitats. The combined effect of		
	Altered substrate composition		Year-round	Permanent	Continuous		these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adult Chinook will generally be less sensitive to these stressors. However, increased stress and delayed migration in the migratory corridor may reduce fitness and ultimately reduce		
							spawning success.		
_	Ecosystem Fragmentation								
	<b>Riverine</b> Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile survival.
	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No specific recommendations.	May affect juvenile growth and survival, as well as spawning succe and overall population productivity
	Marine								
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile survival.

Sub-			Ex	posure	1		_	
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Loss of LWD recruitment	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Reco accu adja othe whe
	Lacustrine							
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Requ footj obje in ar effec
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Reco accu adja othe when

## HPA HCP Shoreline Modification Exposure and Response Matrix for Chinook Salmon.

Minimization Measures	<b>Resulting Effects of the Submechanism</b>
ecommend moving LWD cumulations on the structures to jacent beaches where they would herwise be naturally deposited, here appropriate during maintenance.	May affect juvenile survival.
equire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative fects are already prevalent.	May affect juvenile survival.
ecommend moving LWD cumulations on the structures to jacent beaches where they would herwise be naturally deposited, here appropriate during maintenance.	May affect juvenile survival.

Sub-			Exp	posure						
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
Groins	s and Bank Barbs									
	Construction and Maintenance Activities									
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project- specific environmental conditions; may range from: Rupture of egg membrane. Fatal injury or permanent auditory tissue damage limiting to survival. Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may affect survival at all life- history stages, depending on project- specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.	
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.	
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Should exposure occur, direct mortality or injury is highly likely. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.	
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Should exposure occur, direct mortality or injury is highly likely. May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.	

HPA HCP Shoreline Modification Exposure and Response Matrix for Chinook Salmon.

HPA HCP Shoreline Modification Exposure and Response Matrix for Chinook Salmon.

Sub-		Exposu		posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential redd scour and/orsedimentation, resulting in decreasedincubation success.Juveniles:Altered habitat suitability,increased stress, increased competition,decreased growth and fitness.Adults:Delayed migration, increased stress,decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	Should exposure occur, decreased survival is likely. May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Altered current and circulation conditions (marine and lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	Should exposure occur, direct mortality or injury is highly likely. See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:       Mortality or injury from entrainment.         Juveniles:       Decreased foraging opportunity due to short-term reduction in prey abundance.         Decreased growth and fitness.         All life-history stages:         See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	Should exposure occur, direct mortality or injury is highly likely. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation.	Avoid sediment pulses.	Should exposure occur, stressor may affect survival. May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.
		Altered pH levels (freshwater only)	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and productivity of juveniles and adults.

## HPA HCP Shoreline Modification Exposure and Response Matrix for Chinook Salmon.

Sub-			Ex	oosure						
activity Fype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in	Should exposure occur, stressor may affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.	
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.		
	Riparian Vegetation Modification									
	Riverine									
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. <u>Adults and juveniles</u> : Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. <u>Adults</u> : Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.	

## HPA HCP Shoreline Modification Exposure and Response Matrix for Chinook Salmon.

		Exj	posure					
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Should exposure occur, stressor may affect survival. May affect survival growth, and fitness during juvenile rearing. May affect adult survival a spawning productivity.
						Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile rearing.
Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, as well as spawning succe and overall population productivity
Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.
Marine								
Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and survival.

HPA HCP Shoreline Modification Exposure and Response Matrix for Chinook Salmon.

Sub-			Ex	posure		Υ.		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoi ripar appr the g
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Chinook dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, Chinook are known to utilize terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoi ripar appro the g
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Enco perm habit
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Chinook dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoi shore
	Lacustrine	L	1					
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoi ripar appro the g
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoi ripar appro the g

Minimization Measures	Resulting Effects of the Submechanism
woid/minimize disturbance of parian vegetation. Maintain system- propriate riparian buffer widths to e greatest extent possible.	May affect juvenile survival.
woid/minimize disturbance of parian vegetation. Maintain system- propriate riparian buffer widths to e greatest extent possible.	May affect juvenile growth and fitness.
acourage project designs that limit rmanent alteration of high quality bitat features.	May affect juvenile survival.
void disturbance of vegetation along oreline.	Effects of the action resulting from this impact mechanism are unknown.
woid/minimize disturbance of parian vegetation. Maintain system- propriate riparian buffer widths to e greatest extent possible.	May affect juvenile survival.
void/minimize disturbance of parian vegetation. Maintain system- propriate riparian buffer widths to e greatest extent possible.	May affect juvenile survival.

HPA HCP Shoreline Modification Exposure and Response Matrix for Chinook Salmon.

			Ex	posure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Chinook are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	Juveniles: Chinook dependence on groundwater inflow to nearshore lacustrine habitats is currently a data gap.	Avoid disturbance of vegetation along the shoreline.	Effects of the action resulting from this impact mechanism are unknown.
_	Aquatic Vegetation Modification Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize	May affect juvenile growth and fitness
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	disturbance of aquatic vegetation during project construction.	See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.		May affect juvenile survival. May affect adult growth and spawning productivity.

Table A-1	(continued).
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		Ex						
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Submechanism
Riverine and Lacustrine	·		·	·		·	·	·
Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. Construction: Avoid/minimize	May affect juvenile growth and fitn
	Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.	disturbance of aquatic vegetation during project construction.	See effects for related stressors und Water Quality Modification.
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growt and fitness, as well as adult spawni productivity.
Geomorphic Modification         Riverine         Altered channel geometry	Change in habitat structure and habitat	Year-round	Permanent	Continuous	Eggs and alevins;	Eggs and alevins: Changes in channel	Carefully evaluate project siting and design and consider the magnitude of	May affect survival at egg, alevin
	suitability, reduced food web complexity, and reduced spawning and				Juveniles;			
	complexity, and reduced spawning and				,	morphology, flow velocity, and substrate composition can alter substrate composition	impact mechanisms produced by the	juvenile life-history stages. May a spawning productivity.
Altered flow velocity	complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Permanent	Seasonal	Adults	composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and	impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest	
Altered flow velocity Altered substrate composition (including placement of non-erodable substrate)	rearing habitat availability and	stressor exposure occurring during high- flow events, fall	Permanent Permanent	Seasonal Continuous	,	composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and	juvenile life-history stages. May a spawning productivity.
Altered substrate composition (including placement of non-erodable	rearing habitat availability and	stressor exposure occurring during high- flow events, fall through spring)			,	composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to	impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest	

Table A-1	(continued).
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Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered wave energy	suitability; reduced food web complexity, habitat availability, and suitability suitability suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile Chinook salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns,	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity a juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The		
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.		
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				

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Table A-1	(continued).
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			Exj	posure					
r	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivit
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory habitat for adult Chinook salmon. This may occur through a number of specific stressors, including incomercial exerction and stress due to	patterns, and wave energy and current patterns.	
_	Altered sediment supply		Year-round	Permanent	Continuous		including increased exertion and stress due to change in current and wave energy patterns,		
	Altered substrate composition		Year-round	Permanent	Continuous		increased predation exposure due to reduced cover or exposure to deep water habitat, food		
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous		web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adult Chinook will generally be less sensitive to these stressors. However, increased stress and delayed migration in the migratory corridor may reduce fitness and ultimately reduce spawning success.		
	<b>Ecosystem Fragmentation</b>							ł	I
Γ	Riverine								
	Habitat loss and fragmentation	Fragmentation of side channel and floodplain habitat; change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Bank barbs and groins can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, an juvenile life-history stages. May affe spawning productivity.
	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No specific recommendations.	May affect juvenile growth and survival, as well as spawning succes and overall population productivity.

Table A-1	(continued).
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b-			Ex	posure					
tivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u> : Bank barbs and groins in the marine environment can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity a juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Loss of LWD recruitment	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.
	Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : Bank barbs and groins in lacustrine environments can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivity
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.

ty	Mechanism of Impact		Ext	oosure		<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Submechanism	
	<b>F</b>	Stressor	When	Duration	Frequency	Life-history Form	F		
S									
	Construction and Maintenance Activities								
F	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<ul> <li><u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may affect survival and productivity at all life-history st depending on project-specific ne intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavio decreased foraging success, and increased predation risk.
	Channel/work area lewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Likelihood of egg and alevin ex is limited, as the majority of col spawning habitat is located in an unsuitable for jetty developmen Should exposure occur, howeve direct mortality or injury is prob May cause direct injury or mort juveniles and adults. Stress may survival, growth, and fitness and spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	<u>Eggs, alevins, and juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Likelihood of egg and alevin exp is limited as the majority of cohe spawning habitat is located in ar unsuitable for jetty development Should exposure occur, however direct mortality or injury is prob May cause direct mortality or in juvenile life-history stage. Stress affect survival, growth, and fitne adult spawning productivity.
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and potentially limiting survival dur ocean migration; may affect adu spawning productivity.

Sub- activity	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Туре	_	Stressor	When	Duration	Frequency	Life-history Form	1	]	]
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses,potential migration delay leading to reducedspawning productivity, reduced foragingopportunities, and increased predation risk.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at egg and alevin life-history stages; may affect adult fitness and spawning productivity. Likelihood of egg and alevin exposure is limited, as the majority of coho spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and productivity at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	See effects for related stressors under Water Quality Modification.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	Likelihood of egg and alevin exposure is limited as the majority of coho spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable. See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modification.	Limit dredging related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Altered migratory behavior.Decreased foraging opportunity due to short- term reduction in prey abundance.Decreased growth and fitness.All life-history stages:See responses described for related stressors under Water Quality Modification.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Likelihood of egg and alevin exposure is limited as the majority of coho spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable. May affect survival during egg and alevin life-history stages. May affect juvenile growth and fitness. See effects for related stressors on all life- history stages under Water Quality Modification.

## HPA HCP Shoreline Modification Exposure and Response Matrix for Coho Salmon.

y	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
0		Stressor	When	Duration	Frequency	Life-history Form	<u> </u>		
	Water Quality Modification				-	· · · · · · · · · · · · · · · · · · ·			- 
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins through reduction in substrate dissolved oxygen. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating e and alevins. May affect juvenile growth and fitness, as well as adult productivity and spawning success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	reduced spawning success. <u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high-water temperature and current velocity)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	Likelihood of egg and alevin expos is limited as the majority of coho spawning habitat is located in areas unsuitable for jetty development. Should exposure occur stressor may affect survival, growth, and fitness. May affect survival, growth and fit of juveniles and adults.

## Table A-2 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Coho Salmon.

Sub- activity	Mechanism of Impact		Exp	osure			<b>Response to Stressor</b>	
Туре	ľ	Stressor	When	Duration	Frequency	Life-history Form		
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	
	Riparian Vegetation Modification					·		
	Marine							
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness. This effect may be limited in magnitude, however, as juvenile coho use of littoral habitats is relatively limited.	Avoid ripari appro the gr
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. This effect may be limited in magnitude, however, as juvenile coho use of littoral habitats is relatively limited. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid ripari appro the gr
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Coho dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, coho are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid ripari appro the gr
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encou perma habita

HPA HCP Shoreline Modification Exposure and Response Matrix for Coho Salmon.

Minimization Measures	Resulting Effects of the Submechanism
Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and growth.
A 11/11/11/11/10	
Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and fitness.
Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.

## Table A-2 (continued).HPA HCP Shoreline Modification Exposure and Response Matrix for Coho Salmon.

	Mechanism of Impact Altered groundwater- surface water exchange	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form		1	
		Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Coho dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from the impact mechanism are unknown.
	Lacustrine			•	·	·			
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of lake stratification, reservoir current patterns, wind conditions, and other factors. However, shallow littoral habitats may experience increased temperatures due to lack of shade, leading to decreased availability of refuge and forage habitat, increased competition, and increased predation exposure.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth and fitness.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival growth and fitness.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduction of organic matter inputs.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Coho dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, coho are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth, fitness, and survival.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and fitm
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Coho dependence on groundwater inflow to littoral lacustrine habitats is currently a data gap. However, loss of groundwater may lead to reduction in shallow water thermal refuge, increased competition, and decreased foraging opportunity.	Avoid disturbance of vegetation along shoreline.	May affect juvenile survival, growth and fitness.

ity	Mechanism of Impact			osure			Response to Stressor	
•		Stressor	When	Duration	Frequency	Life-history Form	<u>m</u>	
	Aquatic Vegetation Modification							
	Marine							
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness.	Desi foot aqua exteCon distu durinOpe rules yege grou redu prof
	,	Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Alteration.	
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover,	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	
	Lacustrine						L	1
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Desi foot aqua exteCon distu duriOpe rules yege grou
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.	
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	

## Table A-2 (continued).HPA HCP Shoreline Modification Exposure and Response Matrix for Coho Salmon.

Minimization Measures	Resulting Effects of the Submechanism
esign: Limit project structural otprint to minimize shading of uatic vegetation to the greatest tent practicable. <u>onstruction</u> : Avoid/minimize sturbance of aquatic vegetation ring project construction. <u>peration</u> : Enforce vessel operation les to limit submerged aquatic getation damage from prop wash, ounding, and anchoring, as well as duced ambient light from fine bubble ofusion.	May affect juvenile survival, growth and fitness.
	See effects for related stressors under Water Quality Modification.
	May affect juvenile survival, growth, and fitness. May affect adult growth and spawning productivity.
esign: Limit project structural otprint to minimize shading of uatic vegetation to the greatest tent practicable. <u>onstruction</u> : Avoid/minimize sturbance of aquatic vegetation ring project construction. <u>peration</u> : Enforce vessel operation les to limit submerged aquatic getation damage from prop wash, ounding, and anchoring.	May affect juvenile growth and fitness.
	See effects for related stressors under Water Quality Modification.
	May affect juvenile survival, growth, and fitness.

Sub- activity	Mechanism of Impact		Response to Stressor							
Туре		Stressor	When	Duration	Frequency	Life-history Form	1			
	Hydraulic and Geomorphic Modification									
	Marine									
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occuring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile coho. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Caref desig impa proje desig sedin patter		
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent					
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal					
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous					
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous					
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous					
	Addition of impervious surface		Year-round	Permanent	Continuous					

## Table A-2 (continued).HPA HCP Shoreline Modification Exposure and Response Matrix for Coho Salmon.

Minimization Measures	Resulting Effects of the Submechanism
Carefully evaluate project siting and lesign and consider the magnitude of mpact mechanisms produced by the roject. Encourage selection of project lesigns that minimize effects on ediment supply, longshore drift atterns, and wave energy and current atterns.	May affect juvenile survival, growth, and fitness.

ty	Mechanism of Impact		Expo	sure			<b>Response to Stressor</b>	
	-	Stressor	When	Duration	Frequency	Life-history Form		
	Lacustrine							
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability.	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory coho salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carei desig impa proje desig sedin patter patter
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common			
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal			
	Altered sediment supply		Year-round	Permanent	Continuous			
	Altered substrate composition		Year-round	Permanent	Continuous			
	Altered groundwater– surface water exchange		Year-round	Permanent	Continuous			
	Addition of impervious surface		Year-round	Permanent	Continuous			
	Ecosystem Fragmentation							
	Marine							_
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u> : Jetties can fragment nearshore marine rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Requ footp objec in are effec

Minimization Measures	Resulting Effects of the Submechanism
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on diment supply, longshore drift tterns, and wave energy and current tterns.	May affect juvenile survival, growth, and fitness.
equire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative fects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.

Sub- activity	Mechanism of Impact		Exp	osure			Response to Stressor	
Туре		Stressor	When	Duration	Frequency	Life-history Form		
	Loss of LWD recruitment	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs Reduced recruitment of large	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recu accu adja othe whe
		woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover						
	Lacustrine							
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Jetties can fragment nearshore lacustrine rearing habitats, forcing migrating and foraging salmonids to navigate offshore into deeper water environments. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Req foot obje in a effe
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Reco accu adja othe whe
Break	waters Construction and							
	Maintenance Activities							
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<ul> <li><u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avo impa NOA habi drivi Use redu conf Encc and

Minimization Measures	Resulting Effects of the Submechanism
ecommend moving LWD cumulations on the structures to jacent beaches where they would nerwise be naturally deposited, nere appropriate during maintenance.	May affect juvenile survival.
equire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative fects are already prevalent.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivity.
ecommend moving LWD cumulations on the structures to jacent beaches where they would nerwise be naturally deposited, nere appropriate during maintenance.	May affect juvenile survival.
void pile-driving noise in excess of pact thresholds established by DAA Fisheries and USFWS in bitats used by species. Limit pile iving to in-water work windows. se double-confined bubble curtain to duce sound pressure, or work within nfined or dewatered work areas. ucourage use of vibratory hammers d wooden pilings where practicable.	Activity may affect survival and productivity at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.

b- tivity	Mechanism of Impact		Exp	osure		Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
pe		Stressor	When	Duration	Frequency	Life-history Form			
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. <u>Juveniles</u> : Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Likelihood of egg and alevin exposu is limited, as the majority of coho spawning habitat is located in areas unsuitable for breakwater development. Should exposure occu however, direct mortality or injury i probable. May cause direct injury o mortality of juveniles and adults. Stress may affect survival, growth, a fitness and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs, alevins, and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Likelihood of egg and alevin exposu is limited as the majority of coho spawning habitat is located in areas unsuitable for breakwater development. Should exposure occu however, direct mortality or injury is probable. May cause direct mortalit or injury at juvenile life-history stag Stress may affect survival, growth, a fitness and adult spawning productivity.
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress,	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitn potentially limiting survival during ocean migration; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	decreased spawning fitness.Eggs and alevins: Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles: Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults: Stress and behavioral modificationsby adults exposed to sediment pulses,potential migration delay leading to reducedspawning productivity, reduced foragingopportunities, and increased predation risk.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at egg and alevin life-history stages; may affect adult fitness and spawning productivity. Likelihood of egg and alevin exposure is limited, as the majority of coho spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is probable.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and productivit juvenile life-history stage.

Sub- activity	Mechanism of Impact		Exp	osure		Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
Туре		Stressor	When	Duration	Frequency	Life-history Form			
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	See effects for related stressors under Water Quality Modification.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	Likelihood of egg and alevin exposure is limited as the majority of coho spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is probable. See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modification.	Limit dredging related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Altered migratory behavior. Decreased foraging opportunity due to short- term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Likelihood of egg and alevin exposure is limited as the majority of coho spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is probable. May affect survival during egg and alevin life-history stages. May affect juvenile growth and fitness See effects for related stressors on all life-history stages under Water Quality Modification.
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins through reduction in substrate dissolved oxygen.Juveniles and adults:Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior.Adults:Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness, as well as adult productivity and spawning success.

#### Working Draft–Do Not Cite Shoreline Modification

Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Stressor When Duration Freq			Frequency	Life-history Form	]		
	Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation.	Avoid sediment pulses.	Likelihood of egg and alevin exposur is limited as the majority of coho spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur stressor may affect survival. May affect juvenile survival, growth, and fitness and adult survival, productivit and spawning success.
	Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high-water temperature and current velocity)	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	Likelihood of egg and alevin exposur is limited as the majority of coho spawning habitat is located in areas unsuitable for breakwater development. Should exposure occu stressor may affect survival, growth, and fitness. May affect survival, growth and fitness of juveniles and adults.
Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.		

Sub- activity	Mechanism of Impact		Expo	osure			Response to Stressor	
Туре		Stressor	When	Duration	Frequency	Life-history Form		
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness.	Des foor aqu exte dist dur rule veg gro redu pro
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Alteration.	
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover,	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	

Minimization Measures	Resulting Effects of the Submechanism
esign: Limit project structural otprint to minimize shading of uatic vegetation to the greatest tent practicable.	May affect juvenile survival, growth and fitness.
onstruction: Avoid/minimize sturbance of aquatic vegetation tring project construction.	
peration: Enforce vessel operation les to limit submerged aquatic getation damage from prop wash, ounding, and anchoring, as well as duced ambient light from fine bubble ofusion.	
	See effects for related stressors under Water Quality Modification.
	May affect juvenile survival, growth, and fitness. May affect adult growth and spawning productivity.

y	Mechanism of Impact		Exp	osure			<b>Response to Stressor</b>			
-5	Ĩ	Stressor	When	Duration	Frequency	Life-history Form				
	Riverine and Lacustrine									
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.			
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : See related stressor responses under Water Quality Modification.			
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness			
							and spawning success due to decreased availability of suitable migratory and spawning habitat.			

Minimization Measures	Resulting Effects of the Submechanism
esign: Site majority of facility fshore to limit grounding and prop ash effects. Limit project structural outprint to minimize shading of quatic vegetation to the greatest attent practicable. Design overwater ructures and mooring buoys in ecordance with USACE guidance to mit shading and anchor scour effects.	May affect juvenile growth and fitness.
onstruction: Avoid/minimize sturbance of aquatic vegetation rring project construction.	
<u>peration</u> : Enforce vessel operation les to limit submerged aquatic egetation damage from prop wash, ounding, and anchoring.	
	See effects for related stressors under Water Quality Modification.
	May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.

у	Mechanism of Impact		Exn	osure		<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Submechanism	
y	internation of impact	Stressor	When	Duration	Frequency	Life-history Form			
	Riverine	-						·	
-	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, juvenile life-history stages. May a spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	,			
	Altered substrate composition (including placement of non- erodable substrate)		Year round	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Addition of impervious surface		Year-round	Permanent	Continuous				

vity	Mechanism of Impact		Exp	osure			<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Submechanism
e		Stressor	When	Duration	Frequency	Life-history Form			
	Marine						·	·	·
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile coho. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect juvenile survival, growth and fitness.
	Altered current velocities	_	Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				
	Addition of impervious surface		Year-round	Permanent	Continuous				

Mechanism of Impact		Expo	osure			<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Submechanism
	Stressor	When	Duration	Frequency	Life-history Form			
Lacustrine								
Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability.	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory coho salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect juvenile survival, grow and fitness.
Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common				
Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
Altered sediment supply		Year-round	Permanent	Continuous	1			
Altered substrate composition		Year-round	Permanent	Continuous				
Altered groundwater– surface water exchange		Year-round	Permanent	Continuous				
Addition of impervious surface		Year-round	Permanent	Continuous				
Ecosystem Fragmentation								
Riverine								
Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile survival.
Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No specific recommendations.	May affect juvenile growth and survival, as well as spawning succ and overall population productivit

#### Working Draft–Do Not Cite Shoreline Modification

)- vity	Mechanism of Impact			Exposure			<b>Response to Stressor</b>	
vity be	meenumsm or impuct	Stressor	When	Duration	Frequency	Life-history Form		
·	Marine	•					·	<u> </u>
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Req foot obje in a effe
	Loss of LWD recruitment	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Rec accu adja othe whe
		Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover						
Ĩ	Lacustrine							
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Req foot obje in a effe
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Reco accu adja othe whe

Minimization Measures	Resulting Effects of the Submechanism
equire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative fects are already prevalent.	May affect juvenile survival.
ecommend moving LWD cumulations on the structures to jacent beaches where they would herwise be naturally deposited, here appropriate during maintenance.	May affect juvenile survival.
equire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative fects are already prevalent.	May affect juvenile survival.
ecommend moving LWD cumulations on the structures to jacent beaches where they would herwise be naturally deposited, here appropriate during maintenance.	May affect juvenile survival.

	Mechanism of Impact		1	oosure			Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
ns	and Bank Barbs								
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<ul> <li><u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may affect survival and productivity at all life-history stag depending on project-specific nois intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Channel/work area lewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality.Adults and juveniles:Mortality, injury, or stress from capture, handling, and relocation.Juveniles:Increased competition once relocated, reduced growth and fitness, and increased predation exposure.Adults:Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Should exposure occur, direct mortality or injury is probable. M cause direct injury or mortality of juveniles and adults. Stress may a survival, growth, and fitness and a spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs, alevins, and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Should exposure occur, direct mortality or injury is probable. M cause direct mortality or injury at juvenile life-history stage. Stress affect survival, growth, and fitness adult spawning productivity.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. <u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress,	Limit alteration of flow conditions to minimal area.	Should exposure occur, decreased survival is likely. May affect surv during egg and alevin life-history stage, may affect adult spawning productivity.

Sub- activity	Mechanism of Impact		Exp	oosure			Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Туре		Stressor	When	Duration	Frequency	Life-history Form			
		Altered current and circulation conditions (marine and lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness, potentially limiting survival during ocean migration; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses,potential migration delay leading to reducedspawning productivity, reduced foragingopportunities, and increased predation risk.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at egg and alevin life-history stages; may affect adult fitness and spawning productivity. Should exposure occur, direct mortality or injury is probable.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and productivity at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	See effects for related stressors under Water Quality Modification.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	Should exposure occur, direct mortality or injury is probable. See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Altered migratory behavior.Decreased foraging opportunity due to short- term reduction in prey abundance.Decreased growth and fitness.All life-history stages:See responses described for related stressors under Water Quality Modification.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Should exposure occur, direct mortality or injury is probable. May affect survival during egg and alevin life-history stages. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

N	Mechanism of Impact		Exp	osure			Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	ater Quality odification				-			·	
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins through reduction in substrate dissolved oxygen. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating and alevins. May affect juvenile growth and fitness, as well as adu productivity and spawning success
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	se of creosote-treated ood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high-water temperature and current velocity)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	Should exposure occur stressor ma affect survival, growth, and fitness May affect survival, growth and fi of juveniles and adults.

v	Mechanism of Impact		Expo	osure			Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
,	-	Stressor	When	Duration	Frequency	Life-history Form			
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.		
	Riparian Vegetation Modification	·				·			
	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns. <u>Adults and juveniles</u> : Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. <u>Adults</u> : Decreased spawning fitness due to	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	migration delays caused by thermal barriers. <u>Eggs/alevins:</u> Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival an
		complexity (e.g., filling of pools)					<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	ule greatest extent possible.	spawning productivity.
							<u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential, migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile rearing.

Sub- activity	Mechanism of Impact		Exp	osure			Response to Stressor	
Туре		Stressor	When	Duration	Frequency	Life-history Form		
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition, and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality, decreased fitness, and spawning success due to decreased availability of suitable migratory and spawning habitat.	Enco perm habit
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Decreased incubation success. Juveniles: Decreased availability of thermal refuge habitat, resulting in increased thermal stress, increased competition for suitable habitats. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoi with signi Limi to gro
	Marine	-						
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness. This effect may be limited in magnitude, however, as juvenile coho use of littoral habitats is relatively limited.	Avoi ripari appro the g
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. This effect may be limited in magnitude, however, as juvenile coho use of littoral habitats is relatively limited. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoi ripari appro the g
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Coho dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, coho are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoi ripar appro the g

Minimization Measures	Resulting Effects of the Submechanism
Encourage project designs that limit ermanent alteration of high-quality abitat features.	May affect juvenile growth and survival, spawning success, and overall population productivity.
Avoid permitting of projects in areas with springs, seeps, or other sources of ignificant groundwater recharge. imit alteration of riparian vegetation o greatest extent practicable.	May affect survival of eggs and alevins. May affect juvenile survival and growth. May affect adult spawning productivity.
Avoid/minimize disturbance of iparian vegetation. Maintain system- ppropriate riparian buffer widths to he greatest extent possible.	May affect juvenile survival and growth.
Avoid/minimize disturbance of iparian vegetation. Maintain system- ppropriate riparian buffer widths to he greatest extent possible.	May affect juvenile survival and fitness.
Avoid/minimize disturbance of iparian vegetation. Maintain system- ppropriate riparian buffer widths to he greatest extent possible.	May affect juvenile growth and fitness.

Table A-2	(continued).
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7	Mechanism of Impact		Expo	osure			Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form	1		
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Coho dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from impact mechanism are unknown.
	Lacustrine	•		•					
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of lake stratification, reservoir current patterns, wind conditions, and other factors. However, shallow littoral habitats may experience increased temperatures due to lack of shade, leading to decreased availability of refuge and forage habitat, increased competition, and increased predation exposure.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growt and fitness.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival growt and fitness.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduction of organic matter inputs.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Coho dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, coho are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth, fitness, and survival.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and fith
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Coho dependence on groundwater inflow to littoral lacustrine habitats is currently a data gap. However, loss of groundwater may lead to reduction in shallow water thermal refuge, increased competition, and decreased foraging opportunity.	Avoid disturbance of vegetation along shoreline.	May affect juvenile survival, grow and fitness.

ıb- tivity	Mechanism of Impact		Expo	osure			Response to Stressor	
pe		Stressor	When	Duration	Frequency	Life-history Form		
	Aquatic Vegetation codification						·	
	Marine							
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness.	Des offs was foot aqu exte stru acco limi dist duri
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Alteration.	
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover,	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles:Decreased refuge habitatavailability and foraging opportunities,leading to increased competition and predationexposure resulting in decreased survival,growth, and fitness.Adults:Decreased foraging opportunity dueto decreased food web productivity.Decreased growth and reproductive fitness.	
	Riverine and Lacustrine					I		
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Des offs was foot aqu exte stru acco limi dist duri
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : See related stressor responses under Water Quality Modification.	
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	

Minimization Measures	Resulting Effects of the Submechanism
esign: Site majority of facility fshore to limit grounding and prop ash effects. Limit project structural otprint to minimize shading of uatic vegetation to the greatest tent practicable. Design overwater uctures and mooring buoys in cordance with USACE guidance to nit shading and anchor scour effects. <u>onstruction</u> : Avoid/minimize sturbance of aquatic vegetation ring project construction.	May affect juvenile survival, growth and fitness.
	See effects for related stressors under Water Quality Modification.
	May affect juvenile survival, growth, and fitness. May affect adult growth and spawning productivity.
esign: Site majority of facility fshore to limit grounding and prop ash effects. Limit project structural otprint to minimize shading of uatic vegetation to the greatest tent practicable. Design overwater uctures and mooring buoys in cordance with USACE guidance to nit shading and anchor scour effects. onstruction: Avoid/minimize sturbance of aquatic vegetation ring project construction.	May affect juvenile growth and fitness.
	See effects for related stressors under Water Quality Modification.
	May affect juvenile survival, growth, and fitness.

Mechanism of Impact		Exp	osure			<b>Response to Stressor</b>	
L L	Stressor	When	Duration	Frequency	Life-history Form		
Hydraulic and Geomorphic Modification		<u> </u>	÷		·	÷	
Riverine							
Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	
tered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal			
Altered substrate composition (including placement of nonerodable ubstrate)		Year round	Permanent	Continuous			
Altered groundwater– surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous			
Addition of impervious surface		Year-round	Permanent	Continuous			

Minimization Measures	Resulting Effects of the Submechanism
	<u> </u>
arefully evaluate project siting and esign and consider the magnitude of apact mechanisms produced by the oject. Encourage selections of oject designs that minimize effects a channel geometry, flow velocity, bstrate composition, and oundwater exchange to the greatest tent practicable.	May affect survival, growth, and fitness at egg and alevin and juvenile life-history stages. May affect spawning productivity. Effects on spawning habitat are unlikely, however, as the cold water streams preferred by these species are unsuitable sites for groin and bank barb development.
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7	Mechanism of Impact		Exp	osure		<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Submechanism		
	r · · · · ·	Stressor	When	Duration	Frequency	Life-history Form				
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile coho. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect juvenile survival, grow and fitness.	
4	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent					
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous					
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous					
	Altered groundwater– surface water exchange		Year-round	Permanent	Continuous					
	Addition of impervious surface		Year-round	Permanent	Continuous					

	Mechanism of Impact		Expo	sure			Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	-	Stressor	When	Duration	Frequency	Life-history Form			
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability.	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory coho salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns. profile characteristics where impacts are unavoidable.	May affect juvenile survival, grow and fitness.
A	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common				
A	Altered sediment supply		Year-round	Permanent	Continuous		-		
	Altered substrate composition		Year-round	Permanent	Continuous				
	Altered groundwater– surface water exchange		Year-round	Permanent	Continuous				
	Addition of impervious surface		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
ŀ	Riverine								
	Habitat loss and fragmentation	Fragmentation of side channel and floodplain habitat; change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Bank barbs and groins can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, juvenile life-history stages. May a spawning productivity.
Ι	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No specific recommendations.	May affect juvenile growth and survival, as well as spawning succ and overall population productivi

Sub- activity	Mechanism of Impact		Exp	osure			Response to Stressor	
Туре		Stressor	When	Duration	Frequency	Life-history Form	]	
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u> : Bank barbs and groins in the marine environment can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Requ footp objec in are effec
	Loss of LWD recruitment	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Reco accun adjac other wher
	Lacustrine							
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : Bank barbs and groins in lacustrine environments can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Requ footp objec in are effec
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Reco accur adjac other wher

Minimization Measures	Resulting Effects of the Submechanism
equire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative fects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
ecommend moving LWD cumulations on the structures to jacent beaches where they would herwise be naturally deposited, here appropriate during maintenance.	May affect juvenile survival.
equire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative fects are already prevalent.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivity.
ecommend moving LWD cumulations on the structures to jacent beaches where they would herwise be naturally deposited, here appropriate during maintenance.	May affect juvenile survival.

bub- tivity			Ex	posure				Resulting Effects of the		
ity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism	
ties										
	Construction and Maintenance Activities									
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<ul> <li><u>All life-history stages</u>: Stressor response dependent on noise magnitude; project specific environmental conditions may range from:</li> <li>Rupture of egg membrane.</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work-areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may affect survival and productivity at all life-history stage depending on project-specific noise intensity and receptor exposure. Likelihood of egg and alevin expos is limited, as the majority of chum spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probabl	
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.	
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality.Adults and juveniles:Mortality, injury, or stress from capture, handling, and relocation.Juveniles:Increased competition once relocated, and reduced growth and fitness, increased predation exposure.Adults:Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Likelihood of egg and alevin expos is limited, as the majority of chum spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probabl May cause direct injury or mortality juveniles and adults. Stress may af survival, growth, and fitness and ad spawning productivity.	
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs, alevins, and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Likelihood of egg and alevin expos is limited as the majority of chum spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probabl May cause direct mortality or injury juvenile life-history stage. Stress m affect survival, growth, and fitness.	

Sub-			Ex	xposure					Resulting Effects of the
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	To greatest extent practicable, limit alteration of current and circulation patterns to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses, potential migration delay leading to reduced spawning productivity, reduced foraging opportunities, and increased predation risk.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at egg and alevin life-history stages; may affect adult fitness and spawning productivity. Likelihood of egg and alevin exposure is limited, as the majority of chum spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Effects on chum salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile chum salmon.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	See effects for related stressors under Water Quality Modification.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	Likelihood of egg and alevin exposure is limited as the majority of chum spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable. See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults;	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Alteration of migratory behavior.Decreased foraging opportunity due to short- term reduction in prey abundance.Decreased growth and fitness.All life-history stages:See responses described for related stressors under Water Quality Modification.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Likelihood of egg and alevin exposure is limited as the majority of chum spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable. May affect survival during egg and alevin life-history stages. May affect juvenile growth and fitness. See effects for related stressors on all life- history stages under Water Quality Modification.

Sub-Exposure Activity **Mechanism of Impact Response to Stressor** Туре Stressor When Duration Frequency Life-history Form Water Quality Modification Eggs and alevins; Increased suspended solids Dependent on contributing Temporary to short-Intermittent to Eggs and alevins: Turbidity sufficient to term (dependent on interannual-decadal Juveniles; cause fine sediment embeddedness may lead mechanism of impact contributing mechanism (dependent on Adults to direct mortality and decreased survival of of impact) contributing eggs and alevins through reduction in mechanism of substrate dissolved oxygen. impact) Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success. Eggs and alevins; All life-history stages: Mortality in acute low Altered dissolved oxygen Dependent on contributing Temporary to short-Intermittent to levels mechanism of impact term (e.g., contaminant permanent Juveniles; dissolved oxygen events due to asphyxiation. spill or discharge) to (dependent on Adults contributing seasonal (e.g., reduced submerged aquatic mechanism of vegetation productivity impact) due to changes in ambient light patterns) dependent on contributing mechanism of impact All life-history stages: Physiological responses Use of creosote-treated Leaching of polycyclic Leaching begins upon installation Long-term (with Continuous with Eggs and alevins; wood aromatic hydrocarbons with highest levels after initial decreasing seasonal pulses Juveniles; to exposure at toxic levels, causing mortality (PAHs) immersion, followed by peaks (associated with high or injury leading to reduced fitness. concentration intensity Adults during periods of increased Bioaccumulation of contaminants at subacute over time) water temperature temperatures and higher flows. and current velocity) levels, resulting in chronic physiological Leaching more pronounced when effects leading to reduced fitness and/or used in fresh water. Spikes in mortality. concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area. Use of ACZA- and CCA Leaching of metals (Cu, As, Leaching begins upon installation. Intermediate-term Continuous with Eggs and alevins; All life-history stages: Physiological with highest levels occurring type C-treated Cr, Zn) seasonal pulses Juveniles; responses to exposure at toxic levels, causing within 7 months of initial (dependent on current Adults mortality or injury leading to reduced fitness. wood immersion. Spikes in Bioaccumulation of contaminants at subacute velocity) concentration occur during levels, resulting in chronic physiological removal due to leaching from effects leading to reduced fitness and/or freshly cut surfaces and dispersal mortality. of sawdust fragments with high surface area

 Table A-3 (continued).

HPA HCP Shoreline Modification Exposure and Response Matrix for Chum Salmon.

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Minimization Measures	Resulting Effects of the Submechanism
Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness, as well as adult productivity and spawning success.
Avoid sediment pulses.	Likelihood of egg and alevin exposure is limited as the majority of chum spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, stressor may affect survival. May affect juvenile survival, growth, and fitness, as well as adult survival, productivity, and spawning success.
Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	Likelihood of egg and alevin exposure is limited as the majority of chum spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, stressor may affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.

v			Ex	posure				<b>Resulting Effects of the</b>	
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Riparian Vegetation Modification		-				-		·
	Marine	1			1				
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and growth.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and fitness.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduced organic matter inputs.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Chum dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, chum are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitnes
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition, and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Chum dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from thi impact mechanism are unknown.

HPA HCP Shoreline Modification Exposure and Response Matrix for Chum Salmon.

y			Ех	posure			4		Resulting Effects of the			
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism			
	Aquatic Vegetation Modification											
L	Marine								1			
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect juvenile growth and f potentially limiting subadult surv during ocean migration.			
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, and reduced ambient light from fine bubble profusion.	See effects for related stressors u Water Quality Modification.			
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.		May affect juvenile survival. Ma affect adult growth and spawning productivity.			
							<u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.					
	Hydraulic and Geomorphic Modification     Decreased growth and reproductive fitness.											
	Marine	-	1				1	T				
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on	May affect survival, growth, and fitness at juvenile life-history sta Decreased fitness may affect sur and productivity during ocean migration life-history phase.			
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent		more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile chum salmon. This may occur	sediment supply, longshore drift patterns, and wave energy and current patterns.				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site- specific geography and bathymetry, and project configuration)	Permanent	Seasonal		through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased					
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in					
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	ed				
			Year-round	Permanent	Continuous							
	Altered groundwater- surface water exchange											

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HPA HCP Shoreline Modification Exposure and Response Matrix for Chum Salmon.

Sub-			Ex	kposure				
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Ecosystem Fragmentation	<u> </u>	<u>-</u>	<u>+</u>	<u>+</u>	<u>_</u>		<u></u>
	Marine							
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u> : Jetties can fragment nearshore marine rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Re foo ob in eff
Break	Loss of LWD recruitment waters Construction and	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Re acc ad oth wh
	Maintenance Activities Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<ul> <li><u>All life-history stages</u>: Stressor response dependent on noise magnitude; project specific environmental conditions may range from:</li> <li>Rupture of egg membrane.</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Av im NO hai dri Us rec co En an

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Resulting Effects of the Submechanism
May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
May affect juvenile survival.
Activity may affect survival and productivity at all life-history stages, depending on project-specific noise intensity and receptor exposure. Likelihood of egg and alevin exposure is limited, as the majority of chum spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is probable.

Sub-			Ez	kposure					Resulting Effects of the
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short -term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality.Adults and juveniles:Mortality, injury, or stress from capture, handling, and relocation.Juveniles:Increased competition once relocated, and reduced growth and fitness, increased predation exposure.Adults:Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Likelihood of egg and alevin exposure is limited, as the majority of chum spawning habitat is located in areas unsuitable for breakwater development Should exposure occur, however, direcc mortality or injury is probable. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs, alevins, and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Likelihood of egg and alevin exposure is limited as the majority of chum spawning habitat is located in areas unsuitable for breakwater development Should exposure occur, however, direc mortality or injury is probable. May cause direct mortality or injury at juvenile life-history stage. Stress may affect survival, growth, and fitness.
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress,	To greatest extent practicable, limit alteration of current and circulation patterns to minimal area.	May affect juvenile growth and fitness may affect adult spawning productivity.
							decreased spawning fitness.		
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity	Eggs and alevins; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at egg and alevin life-history stages; may affect adult fitness and spawning
					frequency)		<u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses, potential migration delay leading to reduced spawning productivity, reduced foraging opportunities, and increased predation risk.		productivity. Likelihood of egg and alevin exposure is limited, as the majority of chum spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is probable.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Effects on chum salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile chum salmon.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	See effects for related stressors under Water Quality Modification.

Sub-			E	xposure					
ctivity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	Likelihood of egg and alevin exposure is limited as the majority of chum spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is probable. See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults;	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Alteration of migratory behavior. Decreased foraging opportunity due to short- term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Likelihood of egg and alevin exposure is limited as the majority of chum spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is probable. May affect survival during egg and alevin life-history stages. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins through reduction in substrate dissolved oxygen. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness, as well as adult productivity and spawning success.

			Ex	posure					<b>Resulting Effects of the</b>
Me	echanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation.	Avoid sediment pulses.	Likelihood of egg and alevin exposure is limited as the majority of chum spawning habitat is located in areas unsuitable for breakwater developmer Should exposure occur, stressor may affect survival. May affect juvenile survival, growth, and fitness, as well a adult survival, productivity, and spawning success.
Use o wood	of creosote-treated d	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	itywood and prevent new uses in accordance with pertinent regulations.cuteAvoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.ing ess.Removal: Completely remove treated	Likelihood of egg and alevin exposure is limited as the majority of chum spawning habitat is located in areas unsuitable for breakwater developmen Should exposure occur, stressor may affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
	of ACZA- and CCA C-treated d	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.		
Aqua Modi	atic Vegetation lification								
Mari	ine								
	red autochthonous uction	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect juvenile growth and fitness potentially limiting subadult survival during ocean migration.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation	See effects for related stressors under Water Quality Modification.
Altere	red habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, and reduced ambient light from fine bubble profusion.	May affect juvenile survival. May affect adult growth and spawning productivity.
							<u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		

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Table A-3	(continued).
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HPA HCP Shoreline Modification Exposure and Response Matrix for Chum Salmon.

			E	posure					<b>Resulting Effects of the</b>
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
]	Riverine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Design</u> : Site majority of facility offshore to limit grounding and prop wash effects. Limit project structural footprint to minimize shading of	May affect juvenile growth and fit
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	responses under Water Quality Modification.	aquatic vegetation to the greatest extent practicable. Design overwater structures and mooring buoys in accordance with USACE guidance to limit shading and anchor scour effects.	See effects for related stressors un Water Quality Modification.
1	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival, grow and fitness, as well as adult spawn productivity.
							<u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	<u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring.	
•	Hydraulic and Geomorphic Modification								
_	Riverine		1	1_	[				
1	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity,	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, juvenile life-history stages. May a spawning productivity.
Altered flow velocity	and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor	Permanent	Seasonal	Adults	and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition and		
1			exposure occurring during high- flow events, fall through spring)				Juveniles: Altered channel geometry, flow	channel geometry, flow velocity,	
	Altered substrate composition (including placement of non-erodable substrate)		exposure occurring during high-	Permanent	Continuous		<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to		
	composition (including placement of non-erodable		exposure occurring during high- flow events, fall through spring)	Permanent Permanent	Continuous Continuous		<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase	channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest	

HPA HCP Shoreline Modification Exposure and Response Matrix for Chum Salmon.

7			Ех	posure	- <b>F</b>		_		<b>Resulting Effects of the</b>
,	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project	May affect survival, growth, and fitness at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities	suitability	Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent		nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juyenile chum salmon. This may occur	designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site- specific geography and bathymetry, and project configuration)	Permanent	Seasonal		through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.		
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Altered groundwater– surface water exchange		Year-round	Permanent	Continuous				
	Addition of impervious surface		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile survival.
	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No specific recommendations.	May affect juvenile growth and survival, as well as spawning suc and overall population productivi
	Marine	•	•	•	-	•	•	•	•
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile survival.

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Sub-			Ε	xposure					Resulting Effects of the Submechanism
tivity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	
	Loss of LWD recruitment	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.
		Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover							
roin	s and Bank Barbs								
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Júveniles; Adults	<ul> <li><u>All life-history stages</u>: Stressor response dependent on noise magnitude; project specific environmental conditions may range from:</li> <li>Rupture of egg membrane.</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work-areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may affect survival and productivity at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortal or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold	Interannual to decadal (during project construction	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and

HPA HCP Shoreline Modification Exposure and Response Matrix for Chum Salmon.

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 Table A-3 (continued).

Sub-			Ex	xposure				Doculting Effects of the	
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. <u>Juveniles</u> : Increased competition once relocated, and reduced growth and fitness, increased predation exposure. <u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Should exposure occur, direct mortality or injury is probable. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs, alevins, and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Should exposure occur, direct mortality or injury is probable. May cause direct mortality or injury at juvenile life- history stage. Stress may affect survival, growth, and fitness.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	Should exposure occur, decreased survival is likely. May affect survival during egg and alevin life-history stage, may affect adult spawning productivity.
		Altered current and circulation conditions (marine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	To greatest extent practicable, limit alteration of current and circulation patterns to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses, potential migration delay leading to reduced spawning productivity, reduced foraging opportunities, and increased predation risk.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at egg and alevin life-history stages; may affect adult fitness and spawning productivity. Should exposure occur, direct mortality or injury is probable.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Effects on chum salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile chum salmon.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	See effects for related stressors under Water Quality Modification.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	Should exposure occur, direct mortality or injury is probable. See effects for related stressors under Hydraulic and Geomorphic Modification.

Sub- Activity Type	Mechanism of Impact	Exposure							Dogulting Effects of the	
		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.	
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Eggs and alevins; Juveniles; Adults;	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Alteration of migratory behavior. Decreased foraging opportunity due to short- term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Should exposure occur, direct mortalit or injury is probable. May affect survival during egg and alevin life- history stages. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.	
	Water Quality Modification									
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins through reduction in substrate dissolved oxygen. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness, as well as adult productivity and spawning success.	
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation.	Avoid sediment pulses.	Should exposure occur, stressor may affect survival. May affect juvenile survival, growth, and fitness, as well a adult survival, productivity, and spawning success.	
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults	

b-			Exposure						Resulting Effects of the
vity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of	Should exposure occur, stressor may affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
	Riparian Vegetation Modification								
	Riverine								-
	Altered shading, solar input and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Potential delays in migration or alterations in migration behavior. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
							<u>Adults</u> : Decreased spawning fitness due to migration delays caused by thermal barriers.		
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity	Year-round (with specific stressors prominent during high- flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Potential delays in migration or	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
		(e.g., filling of pools)					Adults:Decreased spawning success due to decreased availability of suitable spawning habitat.Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.		

-		Exposure							
ity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduction in organic matter inputs.	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Limited effects from food web alteration due to minimal dependence on freshwater forage resources.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Unlikely to affect juvenile rearing.
-	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat, increased predation exposure. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, spawning success, and ove population productivity.
-	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen; reduced thermal refuge	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Decreased incubation success. Juveniles: Decreased availability of thermal refuge habitat, resulting in increased thermal stress and increased competition for suitable habitats. <u>Adults</u> : Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid permitting of projects in areas with springs, seeps, or other sources of significant groundwater recharge. Limit alteration of riparian vegetation to greatest extent practicable.	May affect survival of eggs and alevins. May affect juvenile surviv and growth. May affect adult spawning productivity.
-	Marine	1	I	1				1	1
	Altered shading, solar input and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and growth.
-	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and fitness.

Table A-3	(continued).
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Sub-			Ex	kposure				
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduced organic matter inputs.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Chum dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, chum are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Av rip app the
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition, and resulting effects on growth and fitness.	End per hat
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Chum dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Ave sho
	Aquatic Vegetation Modification							
	Marine							
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Des foot aqu exte
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	<u>Cor</u> dist dur
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	
							<u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	

Minimization Measures	Resulting Effects of the Submechanism
void/minimize disturbance of iparian vegetation. Maintain system- ppropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
Encourage project designs that limit ermanent alteration of high-quality abitat features.	May affect juvenile survival.
void disturbance of vegetation along horeline.	Effects of the action resulting from this impact mechanism are unknown.

Design: Limit project structural ootprint to minimize shading of quatic vegetation to the greatest xtent practicable.	May affect juvenile growth and fitness, potentially limiting subadult survival during ocean migration.
Construction: Avoid/minimize isturbance of aquatic vegetation uring project construction.	See effects for related stressors under Water Quality Modification.
	May affect juvenile survival. May affect adult growth and spawning productivity.

b-			E	xposure				Des foot aqua exte <u>Con</u> distu duri
vity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Riverine	·	·				·	
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Chum dependence on autochthonous inputs from aquatic vegetation is limited, as this species does not forage in riverine and lacustrine environments. Therefore, effects on juvenile chum growth and fitness will be limited.	foot aqu exte Cor
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.	duri
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability, potentially leading to altered migratory behavior and increased predation exposure.	
	Hydraulic and Geomorphic Modification							
	Riverine		1					
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, reduced spawning and rearing	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation	desi imp
	Altered flow velocity	habitat availability and suitability	Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Permanent	Seasonal		success and alevin survival. Juveniles: Altered channel geometry, flow	desi chai
	Altered substrate composition (including placement of non-erodable substrate)		Year round	Permanent	Continuous		velocity, substrate composition, and groundwater inputs can result in decreased refuge habitat suitability, potentially leading to changes in migratory behavior, increased stress, and increased predation exposure.	grou exte
	Altered groundwater– surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading	
	Addition of impervious surface		Year-round	Permanent	Continuous		to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations	n foot aqua exte <u>Con</u> distr duri

Minimization Measures	Resulting Effects of the Submechanism
	·
Design: Limit project structural ootprint to minimize shading of quatic vegetation to the greatest xtent practicable. Construction: Avoid/minimize	Impact mechanism is unlikely to affect chum salmon.
isturbance of aquatic vegetation uring project construction.	See effects for related stressors under Water Quality Modification.
	May affect juvenile survival.
Carefully evaluate project siting and esign and consider the magnitude of mpact mechanisms produced by the roject. Encourage selection of project esigns that minimize effects on hannel geometry, flow velocity, ubstrate composition, and roundwater exchange to the greatest xtent practicable.	May affect survival at egg and alevin, and juvenile life-history stages. May affect spawning productivity.

Sub-			Ex	posure				
ctivity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Marine							
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the	Car des imp pro
	Altered current velocities	suitability	Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent		nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile chum salmon. This may occur	I des imp he pro- des v sed patt for patt to on t in ed I Rec effe avo disc ent
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction	
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	
	Altered groundwater– surface water exchange		Year-round	Permanent	Continuous			
	Addition of impervious surface		Year-round	Permanent	Continuous			
	Ecosystem Fragmentation							
	Riverine							
	Habitat loss and fragmentation	Fragmentation of side channel and floodplain habitat; change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Bank barbs and groins can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	effe avo
	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No

Minimization Measures	Resulting Effects of the Submechanism
Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
No specific recommendations.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.

Sub-		Exposure		Resulting Effects of the					
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Marine								
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u> : Bank barbs and groins in the marine environment can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Loss of LWD recruitment	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.

### HPA HCP Shoreline Modification Exposure and Response Matrix for Chum Salmon.

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ub- ctivity			Exp	osure	-	-			Resulting Effects of the
ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
etties									
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<ul> <li><u>All life-history stages</u>: Stressor response dependent on noise magnitude and project specific environmental conditions; may range from:</li> <li>Rupture of egg membrane.</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may affect survival and productivity at all life-history stages, depending on project-specific noise intensity and receptor exposure. Likelihood of egg and alevin exposure is limited, as the majority of pink spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	J <mark>uveniles;</mark> Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, or stressfrom capture, handling, and relocation.Juveniles:Increased competition once relocated,and reduced growth and fitness, increasedpredation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Likelihood of egg and alevin exposure is limited, as the majority of pink spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	<u>Eggs, alevins, and juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Likelihood of egg and alevin exposure is limited as the majority of pink spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable. May cause direct mortality or injury at juvenile life-history stage. Stress may affect survival, growth, and fitness.
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	To greatest extent practicable, limit alteration of current and circulation patterns to minimal area.	May affect juvenile growth and fitness may affect adult spawning productivity.

Sub-			Exp	osure					Resulting Effects of the
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses, potential migration delay leading to reduced spawning productivity, reduced foraging opportunities, and increased predation risk.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage; may affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Effects on pink salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile pink salmon.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system- specific in-water work windows.	See effects for related stressors under Water Quality Modifications.
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	Likelihood of egg and alevin exposure is limited as the majority of pink spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable. See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual-decadal	Eggs and alevins; Juveniles; Adults;	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Alteration of migratory behavior. Decreased foraging opportunity due to short- term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Likelihood of egg and alevin exposure is limited as the majority of pink spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable. May affect egg and alevin survival and productivity. May affect juvenile productivity and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

Sub- activity			Exp	osure					Resulting Effects of the
аснуну Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins through reduction in substrate dissolved oxygen. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation.	Avoid sediment pulses.	Likelihood of egg and alevin exposure is limited as the majority of pink spawning habitat is located in areas unsuitable for marine or terminal development. Should exposure occur, stressor may affect survival. May affect juvenile survival, growth, and fitness, as well as adult survival and spawning productivity.

Table A-4	(continued).
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			Ехро	osure	r	T			Resulting Effects of the	
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism	
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid	Likelihood of egg and alevin exposu is limited as the majority of pink spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, stressor may affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles, and adults.	
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.		
Riparian Vegetation Modification										
	Marine									
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures).	Year-round (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and survival.	
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.	
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduced organic matter inputs.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Pink salmon dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, pink are known to utilize terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity	Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitr	

Table A-4 (continued).	HPA HCP Shoreline Modification Exposure and Response Matrix for Pink Salmon.
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Sub-			Expo	osure					<b>Resulting Effects of the</b>
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	<b>Minimization Measures</b>	Submechanism
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition, and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high quality habitat features.	May affect juvenile survival.
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Pink dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown.

			Expo	osure	1				<b>Resulting Effects of the</b>
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Aquatic Vegetation Modification						-	•	
]	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect juvenile growth and fitm potentially limiting subadult surviva during ocean migration.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction. Operation: Enforce vessel operation	See effects for related stressors und Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.	rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced solar light penetration due to propeller-induced fine bubbles.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Hydraulic and Geomorphic Modification			·	· · · · · · · · · · · · · · · · · · ·				
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occuring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects	May affect survival and productivit juvenile life-history stage. Decreas fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site specific current dynamics and project configuration)	Permanent	Intermittent		parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile pink salmon. This may occur through a number of specific stressors, including increased exertion	on sediment supply, longshore drift patterns, and wave energy and current patterns.	
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased		
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.		
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Altered groundwater– surface water exchange		Year-round	Permanent	Continuous				
	Addition of impervious surface		Year-round	Permanent	Continuous				

Sub-			Expo	osure					Resulting Effects of the
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	<b>Minimization Measures</b>	Submechanism
	Ecosystem Fragmentation			-		-			
	Marine								
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u> : Jetties can fragment nearshore marine rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Loss of LWD recruitment	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.
		Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover							

HPA HCP Shoreline Modification Exposure and Response Matrix for Pink Salmon.

# Breakwaters

Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Stressor response dependent on noise magnitude and project specific environmental conditions; may range from:	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile	Activity may affect survival a productivity at all life-history depending on project-specific intensity and receptor exposu
						<ul> <li>Rupture of egg membrane.</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and</li> </ul>	driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Likelihood of egg and alevin is limited, as the majority of J spawning habitat is located ir unsuitable for breakwater development. Should exposu however, direct mortality or i probable.
Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles:       Auditory masking or         temporary hearing threshold effects may increase         risk of predation and/or decrease foraging         efficiency due to decreased ability to sense	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology	May affect survival, growth, a fitness due to avoidance behav decreased foraging success, an increased predation risk.

Sub-			Exp	osure					Resulting Effects of the
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, or stressfrom capture, handling, and relocation.Juveniles:Increased competition once relocated,and reduced growth and fitness, increasedpredation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Likelihood of egg and alevin exposure is limited, as the majority of pink spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is probable. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs, alevins, and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Likelihood of egg and alevin exposure is limited as the majority of pink spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is probable. May cause direct mortality or injury at juvenile life-history stage. Stress may affect survival, growth, and fitness.
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	To greatest extent practicable, limit alteration of current and circulation patterns to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses, potential migration delay leading to reduced spawning productivity, reduced foraging opportunities, and increased predation risk.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage; may affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Effects on pink salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile pink salmon.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system- specific in-water work windows.	See effects for related stressors under Water Quality Modifications.
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	Likelihood of egg and alevin exposure is limited as the majority of pink spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is probable. See effects for related stressors under Hydraulic and Geomorphic Modification.

Sub- activity			Exp	oosure					Resulting Effects of the
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults;	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Alteration of migratory behavior.Decreased foraging opportunity due to short- term reduction in prey abundance.Decreased growth and fitness.All life-history stages:See responses described for related stressors under Water Quality Modification.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Likelihood of egg and alevin exposure is limited as the majority of pink spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is probable. May affect egg and alevin survival and productivity. May affect juvenile productivity and fitness. See effects for related stressors on all life- history stages under Water Quality Modification.
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins through reduction in substrate dissolved oxygen. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation.	Avoid sediment pulses.	Likelihood of egg and alevin exposure is limited as the majority of pink spawning habitat is located in areas unsuitable for marine or terminal development. Should exposure occur, stressor may affect survival. May affect juvenile survival, growth, and fitness, as well as adult survival and spawning productivity.

Table A-4	(continued).
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		Expo	sure	Τ	1			Resulting Effects of the
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	Likelihood of egg and alevin exposu is limited as the majority of pink spawning habitat is located in areas unsuitable for marine or terminal development. Should exposure occu stressor may affect survival, growth and fitness. May affect survival, growth, and fitness of juveniles, and adults.
Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.		
Aquatic Vegetation Modification								
Marine		1	1					
Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect juvenile growth and fit potentially limiting subadult surviv during ocean migration.
	Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	See effects for related stressors und Water Quality Modification.
		vegetation growth is most extensive)						
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover		Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.	during project construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced solar light penetration due to propeller-induced fine bubbles.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Reduced food web productivity, reduced foraging opportunity,	extensive)	permanent (dependent on nature	Continuous	,	and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to	<u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced solar light penetration due	May affect juvenile survival. Ma affect adult growth and spawning
complexity	Reduced food web productivity, reduced foraging opportunity,	extensive)	permanent (dependent on nature	Continuous	,	and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to	<u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced solar light penetration due	May affect juvenile survival. Ma affect adult growth and spawning

y			Expe	osure		- 1			<b>Resulting Effects of the</b>
Ŷ	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	guidance to limit shading and anchor scour effects. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring.	May affect juvenile survival, growth and fitness, as well as adult spawnin productivity.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success	project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes		
	Altered substrate composition (including placement of non- erodable substrate)		Year round	Permanent	Continuous		in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success.		
	Addition of impervious surface		Year-round	Permanent	Continuous		Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		
	Marine	I				1	•	I	
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivit juvenile life-history stage. Decreas fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site specific current dynamics and project configuration)	Permanent	Intermittent		parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile pink salmon. This may occur through a number of specific stressors, including increased exertion		
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased		

Sub-			Exp	osure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous			
	Altered groundwater– surface water exchange		Year-round	Permanent	Continuous			
	Addition of impervious surface		Year-round	Permanent	Continuous			
	Ecosystem Fragmentation							
	Riverine							
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie- in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Ref for pro- cu pro- cu
	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No
	Marine							
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie- in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Re for pr cu pr
	Loss of LWD recruitment	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Re acu ad otl wh ma

Minimization Measures	Resulting Effects of the Submechanism
Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile survival.
No specific recommendations.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile survival.
Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.

y			Ехро	osure					Resulting Effects of the
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
ins	s and Bank Barbs								
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<ul> <li><u>All life-history stages</u>: Stressor response dependent on noise magnitude and project specific environmental conditions; may range from:</li> <li>Rupture of egg membrane.</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may affect survival and productivity at all life-history stag depending on project-specific nois intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	J <mark>uvenile</mark> s; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior decreased foraging success, and increased predation risk.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, or stressfrom capture, handling, and relocation.Juveniles:Increased competition once relocated,and reduced growth and fitness, increasedpredation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Should exposure occur, direct mortality or injury is probable. M cause direct injury or mortality of juveniles and adults. Stress may survival, growth, and fitness and spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	<u>Eggs, alevins, and juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Should exposure occur, direct mortality or injury is probable. M cause direct mortality or injury at juvenile life-history stage. Stress affect survival, growth, and fitnes
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	Should exposure occur, decrease survival is likely. May affect sur- during egg and alevin life-history stage; may affect adult spawning productivity.

Sub-			Exp	osure					Resulting Effects of the
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Altered current and circulation conditions (marine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress,	To greatest extent practicable, limit alteration of current and circulation patterns to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
							decreased spawning fitness.		
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity	Eggs and alevins; Adults	<u>Eggs and alevins</u> : Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage; may affect adult fitness and spawning
					frequency)		<u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses, potential migration delay leading to reduced spawning productivity, reduced foraging opportunities, and increased predation risk.		productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Effects on pink salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile pink salmon.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system- specific in-water work windows.	See effects for related stressors under Water Quality Modifications.
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	Should exposure occur, direct mortality or injury is probable. See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults;	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Alteration of migratory behavior. Decreased foraging opportunity due to short- term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Should exposure occur, direct mortality or injury is probable. May affect egg and alevin survival and productivity. May affect juvenile productivity and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

Sub- activity			Exp	osure					Resulting Effects of the
аспуну Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Water Quality Modification			-					-
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins through reduction in substrate dissolved oxygen. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation.	Avoid sediment pulses.	Should exposure occur, stressor may affect survival. May affect juvenile survival, growth, and fitness, as well as adult survival and spawning productivity.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.

Table A-4	(continued).
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ıb-			Expo	osure					Resulting Effects of the
tivity ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid	Should exposure occur, stressor may affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles, and adults.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
	Riparian Vegetation Modification			·					
	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: ice formation and scour.Juveniles: Potential delays in migration or alterations in migration behavior.Adults and juveniles: exposure to temperatures in excess of tolerance thresholds.Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline stability	Increased suspended solids, decreased redd dissolved oxygen, decreased area of suitable spawning habitat, reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high-flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins:Decreased incubation success due to decreased redd dissolved oxygen, as described for related stressor responses under Water Quality Modification.Juveniles:Potential delays in migration or alteration in migration behavior; increased predation exposure.Adults:Decreased spawning success due to decreased availability of suitable spawning habitat.Potential, migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival and productivity during egg and alevin, juvenile, and adult spawning life-history stages.

		Exp	osure	<u> </u>	_		<b>Resulting Effects of the</b>			
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism		
Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Limited effects from food web alteration due to minimal dependence on freshwater forage resources.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Unlikely to affect juvenile rearing.		
Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat; increased predation exposure. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, spawning success, and overa population productivity.		
Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen; reduced thermal refuge	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Decreased incubation success. Juveniles: Decreased availability of thermal refuge habitat, resulting in increased thermal stress and increased competition for suitable habitats. <u>Adults</u> : Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid permitting of projects in areas with springs, seeps, or other sources of significant groundwater recharge. Limit alteration of riparian vegetation to greatest extent practicable.	May affect survival of eggs and alevins. May affect juvenile survival and productivity. May affect adult spawning productivity.		
Marine										
Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures).	Year-round (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and survival.		
Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.		
Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduced organic matter inputs.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Pink salmon dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, pink are known to utilize terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity	Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitnes		
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition, and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high quality habitat features.	May affect juvenile survival.		

			Ехро	osure		_		Resulting Effects of the	
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Pink dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from t impact mechanism are unknown.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect juvenile growth and fitn potentially limiting subadult surviva during ocean migration.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	See effects for related stressors und Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to		May affect juvenile survival. May affect adult growth and spawning productivity.
_	Riverine						decreased food web productivity.		
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Pink salmon dependence on autochthonous inputs from aquatic vegetation is limited, as this species does not forage in riverine and lacustrine environments. Therefore, effects on juvenile pink growth and fitness will be limited.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation	Impact mechanism is unlikely to aft pink salmon.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : See related stressor responses under Water Quality Modification.	during project construction.	See effects for related stressors und Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability, potentially leading to altered migratory behavior and increased predation exposure.		May affect juvenile survival.

1b-			Ехро	osure	-			
ctivity ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	
	Hydraulic and Geomorphic Modification	-		-			•	
	Riverine							
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, reduced spawning	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles Adults	<u>Eggs and alevins</u> : Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and	Ca de of
	Altered flow velocity	and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Aduits	stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, substrate composition, and groundwater	the pro on su
	Altered substrate composition (including placement of non- erodable substrate)		Year round	Permanent	Continuous		inputs can result in decreased refuge habitat suitability, potentially leading to changes in migratory behavior, increased stress, and increased predation exposure.	gre
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability	
	Addition of impervious surface		Year-round	Permanent	Continuous		resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	
	Marine		L					_
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these	Ca de of the pro
	Altered current velocities		Year-round (with variable effects depending on site specific current dynamics and project configuration)	Permanent	Intermittent		parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile pink salmon. This may occur through a number of specific stressors, including increased exertion	on pa cu
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and	
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	
	Altered groundwater– surface water exchange Addition of impervious		Year-round Year-round	Permanent	Continuous	_		
	Addition of impositions			Permanent	Continuous			

Minimization Measures	Resulting Effects of the Submechanism
Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg and alevin, and juvenile life-history stages. May affect spawning productivity.
Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.

Sub-			Expe	osure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Ecosystem Fragmentation	-		•	•	-		
	Riverine							
	Habitat loss and fragmentation	Fragmentation of side channel and floodplain habitat; change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Bank barbs and groins can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	R ef pe th fle
	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	N
	Marine		·					
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u> : Bank barbs and groins in the marine environment can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Ro fo pr pr cu pr
	Loss of LWD recruitment	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Ra ac ad ot m

Minimization Measures	Resulting Effects of the Submechanism
Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
No specific recommendations.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.

Sub- activity			Ex	posure					Resulting Effects of the
аспуну Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Jetties									
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<ul> <li><u>All life-history stages</u>: Stressor response dependent on noise magnitude and project specific environmental conditions; may range from:</li> <li>Rupture of egg membrane.</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may affect survival and productivity at all life-history stages, depending on project-specific noise intensity and receptor exposure. Likelihood of egg and alevin exposure is limited, as the majority of sockeye spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	J <mark>uveniles;</mark> Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short -term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality.Adults and juveniles:Mortality, injury, or stress from capture, handling, and relocation.Juveniles:Increased competition once relocated, reduced growth and fitness, increased predation exposure.Adults:Delayed migration, resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Likelihood of egg and alevin exposure is limited, as the majority of sockeye spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness as well as adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs, alevins, and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Likelihood of egg and alevin exposure is limited as the majority of sockeye spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable. May cause direct mortality or injury at juvenile life-history stage. Stress may affect survival, growth, and fitness as well as adult spawning productivity.
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness may affect adult spawning productivity.

Sub-	Mechanism of Impact		Ex	posure				Resulting Effects of the	
ctivity Type		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modifications	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect egg and alevin incubation success and survival; may affect growth and fitness at juvenile life- history stage; may affect adult spawning productivity.
							by adults exposed to sediment pulses, potential migration delay leading to reduced spawning productivity, reduced foraging opportunities, and increased predation risk.		
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and productivity at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	Likelihood of egg and alevin exposure is limited, as the majority of sockeye spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable. See effects for related stressors under Water Quality Modification.
-	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Altered migratory behavior. Decreased foraging opportunity due to short- term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Likelihood of egg and alevin exposure is limited as the majority of sockeye spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable. May affect survival during egg and alevin life-history stage. May affect juvenile growth and fitness. See effects for related stressors on all life- history stages under Water Quality Modification.

Sub- activity			Ex	posure				<b>Resulting Effects of the</b>	
Sype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Water Quality Modification					-	-	-	-
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins through reduction in substrate dissolved oxygen. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating egg and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation.	Avoid sediment pulses.	Likelihood of egg and alevin exposur is limited as the majority of sockeye spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, stressor may affect survival. May affect juvenile survival, growth, and fitness, as well adult survival, productivity, and spawning success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.

		Exj	posure	1	T	Resulting Effects of			
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism	
Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.	Likelihood of egg and alevin expos is limited as the majority of sockey spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, stressor ma affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.	
Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.		
Riparian Vegetation Modification									
Marine			-						
Altered shading, solar input, ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. Juvenile sockeye dependence on the nearshore marine environment is relatively limited. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and growth.	
Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and fitness.	
Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Sockeye dependence on allochthonous inputs from marine riparian vegetation is a data gap but is likely limited due to the lesser dependence of this species on the nearshore marine environment.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from th impact mechanism are unknown.	

b- ivity			Ex	oosure			_		Resulting Effects of the
pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Sockeye dependence on nearshore marine habitats is limited in comparison to other salmonids. Sockeye response to alteration of nearshore habitat complexity is currently a data gap. <u>Adults</u> : Reduction in nearshore habitat complexity may affect availability of forage for returning adult sockeye, affecting growth and productivity during spawning.	Encourage project designs that limit permanent alteration of high-quality habitat features.	Potential effects on juvenile sockeye resulting from this impact mechanism are unknown. May affect adult grow and productivity.
	Altered groundwater surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Sockeye dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from the impact mechanism are unknown.
	Lacustrine		I	•				L	•
	Altered shading, solar input, ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of lake stratification, reservoir current patterns, wind conditions, and other factors. However, shallow littoral habitats may experience increased temperatures due to lack of shade, leading to decreased availability of refuge and forage habitat, increased competition, and increased predation exposure.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth and fitness.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential reduction in egg survival and incubation success (for beach spawning sockeye) due to increased sedimentation and turbidity, as described under Water Quality Modification. <u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification. <u>Adults</u> : May affect spawning habitat suitability, leading to decreased spawning productivity as described under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect egg and alevin survival. May affect juvenile survival and productivity. May affect adult spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Sockeye dependence on allochthonous inputs from lacustrine riparian vegetation is a data gap. Sockeye are primarily planktonic feeders in the photic zone, so direct dependence on allochthonous inputs for prey is likely limited.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from this impact mechanism are unknown.

			Exj	osure				<b>Resulting Effects of the</b>	
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Intermediate-term to permanent (dependent on nature of activity and time required for recovery)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, growth and fitness.
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Decreased egg and alevin survival (beach-spawning sockeyes) due to lower dissolved oxygen levels in spawning substrate. <u>Juveniles</u> : Sockeye dependence on groundwater inflow to nearshore habitats is currently a data gap. <u>Adults</u> : Decreased suitable spawning habitat, leading to decreased spawning productivity.	Avoid disturbance of vegetation along shoreline.	May affect egg and alevin survival. May affect adult spawning productivity. Effects on juveniles ar unknown.
	Aquatic Vegetation Modification								
	Marine						,		
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Sockeye dependence on autochthonous inputs from marine littoral vegetation is a data gap but is likely limited due to the lesser dependence of this species on the nearshore marine environment.	Construction: Avoid/minimize         disturbance of aquatic vegetation         during project construction.         Operation: Enforce vessel operation         rules to limit submerged aquatic         vegetation damage from propeller         wash, grounding, and anchoring, as         well as reduced ambient light from fine         bubble profusion.	Potential effects resulting from this impact mechanism are unknown.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.		See effects for related stressors unde Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Sockeye dependence on nearshore marine habitats is limited in comparison to other salmonids. Sockeye response to alteration of nearshore habitat complexity is currently a data gap. <u>Adults</u> : Reduction in nearshore habitat complexity may affect availability of forage for returning adult sockeye, affecting growth		Potential effects on juvenile sockeye resulting from this impact mechanism are unknown. May affect adult grow and productivity.
-	Lacustrine						and productivity during spawning.		
-	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Alteration of aquatic vegetation may indirectly affect food web dynamics, potentially leading to decreased foraging opportunities.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.Operation: Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring.	May affect juvenile productivity.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : See related stressor responses under Water Quality Modification.		See effects for related stressors unde Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles</u> : Alteration of aquatic vegetation may indirectly affect food web dynamics, potentially leading to decreased foraging opportunities.		May affect juvenile survival.

Sub-			Ex	posure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	
	Hydraulic and Geomorphic Modification					-		
	Marine							
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occuring in spring and summer when juveniles transit nearshore habitats)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the	
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Juvenile sockeye have relatively limited dependence on nearshore marine habitats. However,	i he yye yye yye yye yy.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		alteration of habitat productivity in the nearshore may lead to alteration of food web dynamics in offshore environments, potentially affecting foraging opportunities, leading to decreased growth and productivity.	
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		<u>Adults</u> : Alteration of nearshore habitat characteristics can demonstrably affect the productivity of forage species preyed upon by returning adult sockeye. Decreased foraging	
	Altered substrate composition			Permanent	Continuous		opportunity may lead to decreased growth and productivity.	
	Altered groundwater surface water exchange		Year-round	Permanent	Continuous			
	Addition of impervious		Yaer Round	Permanent	Continuous			

HPA HCP Shoreline Modification Exposure and Response Matrix for Sockeye Salmon.

surface

Minimization Measures	Resulting Effects of the Submechanism
Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. May affect adult growth and productivity.

)- 			Exp	osure							
ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor				
	Lacustrine						<u> </u>				
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that	proje			
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats. Alteration of nearshore lacustrine habitats may	proje on se patte patte			
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		lead to direct mortality and decreased survival of eggs and alevins (beach-spawning sockeyes).	putte			
	Altered sediment supply		Year-round	Permanent	Continuous		Juveniles: Alteration of nearshore lacustrine				
	Altered substrate composition		Year-round	Permanent	Continuous		rearing habitat may forcing migrating and foraging salmonids to navigate away from nearshore habitats. Alteration of habitat				
	Altered groundwater– surface water exchange		Year-round	Permanent	Continuous		productivity in the nearshore may also lead to alteration of food web dynamics in offshore				
	Addition of impervious surface		Year-round	Permanent	Continuous		environments. This stressor may increase exposure to predation, increase stress and exertion, and potentially affect foraging opportunities affecting survival, growth, and fitness.				
							<u>Adults</u> : Alteration of nearshore habitat parameters may alter the suitability of shoreline spawning habitats for beach spawning sockeye, leading to decreased spawning productivity.				
	<b>Ecosystem Fragmentation</b>										
	Marine										
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u> : Jetties can fragment nearshore marine rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Requ footp objec in are effec			
	Loss of LWD recruitment	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Reco accur adjac other wher			
		complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover									

Minimization Measures	Resulting Effects of the Submechanism
arefully evaluate project siting and sign and consider the magnitude of apact mechanisms produced by the oject. Encourage selections of oject designs that minimize effects a sediment supply, longshore drift tterns, and wave energy and current tterns.	May affect egg and alevin survival. May affect growth and fitness at juvenile life-history stage. May affect adult spawning productivity.
equire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative fects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
ecommend moving LWD cumulations on the structures to jacent beaches where they would herwise be naturally deposited, here appropriate during maintenance.	May affect juvenile survival.

Table A-5	(continued).
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ity			Ex	posure				<b>Resulting Effects of the</b>	
ıy	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : Jetties can fragment nearshore lacustrine rearing habitats, forcing migrating and foraging salmonids to navigate offshore into deeper water environments. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life- history stage. Decreased fitness ma lead to reduced spawning productiv
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.
kv	waters								
	Construction and Maintenance Activities				_				
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<ul> <li><u>All life-history stages</u>: Stressor response dependent on noise magnitude and project specific environmental conditions; may range from:</li> <li>Rupture of egg membrane.</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may affect survival and productivity at all life-history stag depending on project-specific nois intensity and receptor exposure. Likelihood of egg and alevin expo is limited, as the majority of socket spawning habitat is located in area unsuitable for breakwater development. Should exposure of however, direct mortality or injury probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior decreased foraging success, and increased predation risk.

Sub- activity			Ех	xposure					Resulting Effects of the
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short -term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality.Adults and juveniles:Mortality, injury, or stress from capture, handling, and relocation.Juveniles:Increased competition once relocated, reduced growth and fitness, increased predation exposure.Adults:Delayed migration, resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Likelihood of egg and alevin exposure is limited, as the majority of sockeye spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is probable. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness as well as adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs, alevins, and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Likelihood of egg and alevin exposure is limited as the majority of sockeye spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is probable. May cause direct mortality or injury at juvenile life-history stage. Stress may affect survival, growth, and fitness as well as adult spawning productivity.
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance.Juveniles:Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.Adults:Stress and behavioral modifications by adults exposed to sediment pulses, potential migration delay leading to reduced spawning productivity, reduced foraging opportunities, and increased predation risk.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect egg and alevin incubation success and survival; may affect growth and fitness at juvenile life- history stage; may affect adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and productivity at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	Likelihood of egg and alevin exposure is limited, as the majority of sockeye spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is probable. See effects for related stressors under Water Quality Modification.

Sub- activity			Ex	posure				Resulting Effects of the	
Sype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Altered migratory behavior. Decreased foraging opportunity due to short- term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Likelihood of egg and alevin exposur is limited as the majority of sockeye spawning habitat is located in areas unsuitable for breakwater development. Should exposure occu however, direct mortality or injury is probable. May affect survival during egg and alevin life-history stage. Ma affect juvenile growth and fitness. S effects for related stressors on all life history stages under Water Quality Modification.
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins through reduction in substrate dissolved oxygen. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating egg and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	reduced spawning success. <u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation.	Avoid sediment pulses.	Likelihood of egg and alevin exposu is limited as the majority of sockeye spawning habitat is located in areas unsuitable for breakwater development. Should exposure occu stressor may affect survival. May affect juvenile survival, growth, and fitness, as well as adult survival, productivity, and spawning success.

r			Exj	posure				Resulting Effects of the	
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.	Likelihood of egg and alevin expost is limited as the majority of sockeye spawning habitat is located in areas unsuitable for breakwater development. Should exposure occr stressor may affect survival, growth and fitness. May affect survival, growth, and fitness of juveniles and adults.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Sockeye dependence on autochthonous inputs from marine littoral vegetation is a data gap but is likely limited due to the lesser dependence of this species on the nearshore marine environment.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize	Potential effects resulting from this impact mechanism are unknown.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic	See effects for related stressors und Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Sockeye dependence on nearshore marine habitats is limited in comparison to other salmonids. Sockeye response to alteration of nearshore habitat complexity is currently a data gap.	vegetation damage from propeller wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	Potential effects on juvenile socker resulting from this impact mechan are unknown. May affect adult gro and productivity.
							<u>Adults</u> : Reduction in nearshore habitat complexity may affect availability of forage for returning adult sockeye, affecting growth and productivity during spawning.		

HPA HCP Shoreline Modification Exposure and Response Matrix for Sockeye Salmon.

		Ex	posure					<b>Resulting Effects of the</b>
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Riverine and Lacustrine								
Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Alteration of aquatic vegetation may indirectly affect food web dynamics, potentially leading to decreased foraging opportunities.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect juvenile productivity.
	Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	See effects for related stressors und Water Quality Modification.
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles</u> : Alteration of aquatic vegetation may indirectly affect food web dynamics, potentially leading to decreased foraging opportunities.	<u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring.	May affect juvenile survival.
Hydraulic and Geomorphic Modification								
 Riverine			T	T				
Altered channel geometry Altered flow velocity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round Year-round (with stressor	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest	May affect survival at egg, alevin, juvenile life-history stages. May a spawning productivity.
Anered now velocity	availability and suitability	exposure occurring during high-flow events, fall through spring)	i emanent	Seasonal		success and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and		
Altered substrate composition (including placement of non-erodable substrate)		Year round	Permanent	Continuous		changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	extent practicable.	
Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning	1	
Addition of impervious surface		Year-round	Permanent	Continuous		success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of		

		Exp	oosure	I	T	4		Resulting Effects of the
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Marine								
Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles transit nearshore habitats)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the	patterns. For example:	May affect survival, growth, and fitness at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. May affect adult growth and productivity.
Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Juvenile sockeye have relatively limited dependence on nearshore marine habitats. However,		
Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		alteration of habitat productivity in the nearshore may lead to alteration of food web dynamics in offshore environments, potentially affecting foraging opportunities, leading to decreased growth and productivity.		
Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		<u>Adults</u> : Alteration of nearshore habitat characteristics can demonstrably affect the productivity of forage species preyed upon by returning adult sockeye. Decreased foraging		
Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		opportunity may lead to decreased growth and productivity.		
Altered groundwater surface water exchange		Year-round	Permanent	Continuous				
Addition of impervious surface		Year-Round	Permanent	Continuous				
Lacustrine								
Altered wave energy (short- period waves)	- Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of	May affect egg and alevin survival. May affect growth and fitness at juvenile life-history stage. May aff adult spawning productivity.
Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats. Alteration of nearshore lacustrine habitats may	project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns. For example:	
Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		lead to direct mortality and decreased survival of eggs and alevins (beach-spawning sockeyes).		
Altered sediment supply		Year-round	Permanent	Continuous		Juveniles: Alteration of nearshore lacustrine		
Altered substrate composition		Year-round	Permanent	Continuous		rearing habitat may forcing migrating and foraging salmonids to navigate away from nearshore habitats. Alteration of habitat productivity in the nearshore may also lead to alteration of food web dynamics in offshore		
Altered groundwater– surface water exchange		Year-round	Permanent	Continuous	1			

y			E	xposure				
ý	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	
	Addition of impervious surface		Year-round	Permanent	Continuous		environments. This stressor may increase exposure to predation, increase stress and exertion, and potentially affect foraging opportunities affecting survival, growth, and fitness. <u>Adults</u> : Alteration of nearshore habitat parameters may alter the suitability of	
							shoreline spawning habitats for beach spawning sockeye, leading to decreased spawning productivity.	
	<b>Ecosystem Fragmentation</b>	·		·				•
Ī	Riverine							
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Requ footp object in art effect
	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No s
	Marine						•	
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Requ footj obje in ar effec
	Loss of LWD recruitment	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recc accu adjac othe when
ŀ	Lacustrine		I				1	
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Requ footp object in ar effect

Minimization Measures	Resulting Effects of the Submechanism
equire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative fects are already prevalent.	May affect juvenile survival.
o specific recommendations.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
equire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative fects are already prevalent.	May affect juvenile survival.
ecommend moving LWD cumulations on the structures to jacent beaches where they would herwise be naturally deposited, here appropriate during maintenance.	May affect juvenile survival.
equire structures with the minimal	May affect juvenile survival.
otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative fects are already prevalent.	

Sub-			Ex	posure				Resulting Effects of the	
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.
Groin	s and Bank Barbs								
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<ul> <li><u>All life-history stages</u>: Stressor response dependent on noise magnitude and project specific environmental conditions; may range from:</li> <li>Rupture of egg membrane.</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may affect survival and productivity at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short -term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality.Adults and juveniles:Mortality, injury, or stress from capture, handling, and relocation.Juveniles:Increased competition once relocated, reduced growth and fitness, increased predation exposure.Adults:Delayed migration, resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Should exposure occur, direct mortality or injury is probable. May cause direct injury or mortality of juveniles and adults. Stress may affec survival, growth, and fitness as well a adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs, alevins, and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Should exposure occur, direct mortality or injury is probable. May cause direct mortality or injury at juvenile life-history stage. Stress may affect survival, growth, and fitness as well as adult spawning productivity.

Table A-5	(continued).
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Sub- activity			Ex	posure		•			Resulting Effects of the
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	Limit alteration of flow conditions to minimal area.	Should exposure occur, decreased survival is likely. May affect survival during egg and alevin life-history stage; may affect adult spawning productivity.
							<u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.		
		Altered current and circulation conditions (marine and lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress,	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
							decreased spawning fitness.		
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect egg and alevin incubation success and survival; may affect growth and fitness at juvenile life- history stage; may affect adult spawning productivity.
							<u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses, potential migration delay leading to reduced spawning productivity, reduced foraging opportunities, and increased predation risk.		
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and productivity at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	Should exposure occur, direct mortality or injury is probable. See effects for related stressors under Water Quality Modification.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Altered migratory behavior.Decreased foraging opportunity due to short- term reduction in prey abundance.Decreased growth and fitness.All life-history stages:See responses described for related stressors under Water Quality Modification.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Should exposure occur, direct mortality or injury is probable. May affect survival during egg and alevin life-history stage. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

Sub- activity			Ex	posure	I				<b>Resulting Effects of the</b>
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Water Quality Modification	-		-	-	-	-	-	-
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins through reduction in substrate dissolved oxygen. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation.	Avoid sediment pulses.	Should exposure occur, stressor may affect survival. May affect juvenile survival, growth, and fitness, as well a adult survival, productivity, and spawning success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.

ity			Exj	posure					Resulting Effects of the
ıy	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.	Should exposure occur, stressor may affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
	Riparian Vegetation Modification								
	Riverine								
	Altered riparian shading	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered ambient air temperature regime						Adults and juveniles:       Direct mortality caused         by exposure to temperatures in excess of       tolerance thresholds.         Adults:       Decreased spawning fitness due to         migration delays caused by thermal barriers.		

Table A-5	(continued).
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ub-			Ex	posure					Resulting Effects of the
ctivity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high-flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins:Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.Juveniles:Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.Adults:Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile rearing.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, spawning success, and overall population productivity.
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Decreased incubation success.Juveniles:Decreased availability of thermal refuge habitat, resulting in increased thermal stress and increased competition for suitable habitats.Adults:Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid permitting of projects in areas with springs, seeps, or other sources of significant groundwater recharge. Limit alteration of riparian vegetation to greatest extent practicable.	May affect survival of eggs and alevins. May affect juvenile survival and growth. May affect adult spawning productivity.

Table A-5 (	continued).
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y			Exp	osure				Resulting Effects of the	
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Marine Altered shading, solar	Expansion of thermal regime	Year-round (pronounced in	Long-term to	Seasonal	Juveniles	Juveniles: Riparian shade and ambient	Avoid/minimize disturbance of	May affect juvenile survival and
	nput, and ambient air emperature	(i.e., increased summer temperatures)	summer during solar radiation and ambient temperature extremes)	permanent (dependent on nature of riparian impacts)			temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. Juvenile sockeye dependence on the nearshore marine environment is relatively limited. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	growth.
	Altered shoreline and bluff tability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and fitness.
	Altered allochthonous nputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Sockeye dependence on allochthonous inputs from marine riparian vegetation is a data gap but is likely limited due to the lesser dependence of this species on the nearshore marine environment.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from the impact mechanism are unknown.
A	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Sockeye dependence on nearshore marine habitats is limited in comparison to other salmonids. Sockeye response to alteration of nearshore habitat complexity is currently a data gap.	Encourage project designs that limit permanent alteration of high-quality habitat features.	Potential effects on juvenile socker resulting from this impact mechar are unknown. May affect adult gr and productivity.
		web productivity, reduced foraging opportunity, reduction in available cover.					<u>Adults</u> : Reduction in nearshore habitat complexity may affect availability of forage for returning adult sockeye, affecting growth and productivity during spawning.		
	Altered groundwater urface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Sockeye dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from impact mechanism are unknown.
L	Lacustrine								
Aa	Altered shading, solar input ind ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of lake stratification, reservoir current patterns, wind conditions, and other factors. However, shallow littoral habitats may experience increased temperatures due to lack of shade, leading to decreased availability of refuge and forage habitat, increased competition, and increased predation exposure.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, grov and fitness.

ıb- tivity			Exp	osure				<b>Resulting Effects of the</b>	
pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential reduction in egg survival and incubation success (for beach spawning sockeye) due to increased sedimentation and turbidity, as described under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect egg and alevin survival. May affect juvenile survival and productivity. May affect adult spawning productivity.
		vegetation)					<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification. <u>Adults</u> : May affect spawning habitat suitability, leading to decreased spawning productivity as described under Water Quality Modification.		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Sockeye dependence on allochthonous inputs from lacustrine riparian vegetation is a data gap. Sockeye are primarily planktonic feeders in the photic zone, so direct dependence on allochthonous inputs for prey is likely limited.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from this impact mechanism are unknown.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Intermediate-term to permanent (dependent on nature of activity and time required for recovery)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, growth, and fitness.
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Decreased egg and alevin survival (beach-spawning sockeyes) due to lower dissolved oxygen levels in spawning substrate. <u>Juveniles</u> : Sockeye dependence on groundwater inflow to nearshore habitats is currently a data gap. <u>Adults</u> : Decreased suitable spawning habitat, leading to decreased spawning productivity.	Avoid disturbance of vegetation along shoreline.	May affect egg and alevin survival. May affect adult spawning productivity. Effects on juveniles are unknown.

Table A-5	(continued).
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			Exp	posure				Resulting Effects of the	
Mechanism of l	Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Aquatic Vegetation	on	-		•	-	•		•	
Marine									
Altered autochthor production	nous	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Sockeye dependence on autochthonous inputs from marine littoral vegetation is a data gap but is likely limited due to the lesser dependence of this species on the nearshore marine environment.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. Construction: Avoid/minimize	Potential effects resulting from this impact mechanism are unknown.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	disturbance of aquatic vegetation during project construction.	See effects for related stressors unde Water Quality Modification.
Altered habitat con	mplexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Sockeye dependence on nearshore marine habitats is limited in comparison to other salmonids. Sockeye response to alteration of nearshore habitat complexity is currently a data gap.		Potential effects on juvenile sockeye resulting from this impact mechanism are unknown. May affect adult grow and productivity.
							<u>Adults</u> : Reduction in nearshore habitat complexity may affect availability of forage for returning adult sockeye, affecting growth and productivity during spawning.		
Riverine and Lac	ustrine		1	1					
Altered autochthor production	nous	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Alteration of aquatic vegetation may indirectly affect food web dynamics, potentially leading to decreased foraging opportunities.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile productivity.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : See related stressor responses under Water Quality Modification.		See effects for related stressors unde Water Quality Modification.
Altered habitat con	mplexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles</u> : Alteration of aquatic vegetation may indirectly affect food web dynamics, potentially leading to decreased foraging opportunities.		May affect juvenile survival.

Table A-5	(continued).
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		Exp	posure				<b>Resulting Effects of the</b>				
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism			
Hydraulic and Geomorphic Modification	•	•		-	-	-		-			
Riverine											
Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, reduced	reduced food duced     Juveniles;     morphology, flow velocity, and substrate composition can alter substrate composition     design and consider the magnitude of impact mechanisms produced by the	May affect survival, growth, and fitness at egg, alevin, and juvenile life history stages (river rearing sockeye). May affect spawning productivity								
Altered flow velocity	spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Auuts	and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result	designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	designs that minimize effects on channel geometry, flow velocity, substrate composition, and	May affect spawning productivity.	t May affect spawning productivity.	May affect spawning productivity.
Altered substrate composition (including placement of non-erodable substrate)		Year-round	Permanent	Continuous		in decreased refuge habitat during migration to lacustrine rearing environments, and increased predation exposure. Juvenile river rearing sockeye may also experience decreased foraging opportunity, leading to increased					
Altered groundwater– surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		competition and decreased growth and fitness. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading					
Addition of impervious surface		Year-round	Permanent	Continuous		to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.					
Marine											
Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles transit nearshore habitats)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. May affect adult growth and productivity.			
Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Juvenile sockeye have relatively limited dependence on nearshore marine habitats. However,					
Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		alteration of habitat productivity in the nearshore may lead to alteration of food web dynamics in offshore environments, potentially affecting foraging opportunities,					
Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		leading to decreased growth and productivity. <u>Adults</u> : Alteration of nearshore habitat characteristics can demonstrably affect the productivity of forage species preyed upon by returning adult sockeye. Decreased foraging opportunity may lead to decreased growth and productivity.					
Altered groundwater surface water exchange		Year-round	Permanent	Continuous							
Addition of impervious surface		Year-round	Permanent	Continuous							

			Exp	posure	-	_		<b>Resulting Effects of the</b>	
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
Ι	acustrine								
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats. Alteration of nearshore lacustrine habitats may lead to direct mortality and decreased survival of eggs and alevins (beach-spawning sockeyes). Juveniles: Alteration of nearshore lacustrine rearing habitat may forcing migrating and foraging salmonids to navigate away from nearshore habitats. Alteration of habitat productivity in the nearshore may also lead to alteration of food web dynamics in offshore environments. This stressor may increase exposure to predation, increase stress and exertion, and potentially affect foraging opportunities affecting survival, growth, and fitness. <u>Adults</u> : Alteration of nearshore habitat parameters may alter the suitability of shoreline spawning habitats for beach spawning sockeye, leading to decreased	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect egg and alevin survival. May affect growth and fitness at juvenile life-history stage. May affect adult spawning productivity.
A	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common				
A	Altered sediment supply		Year-round	Permanent	Continuous			puterns.	
	Altered substrate composition		Year-round	Permanent	Continuous				
sur	Altered groundwater– urface water exchange		Year-round	Permanent	Continuous				
	Addition of impervious urface		Year-Round	Permanent	Continuous				
F	Ecosystem Fragmentation					•	spawning productivity.		
	Riverine								
H	Habitat loss and ragmentation	Fragmentation of side channel and floodplain habitat; change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Bank barbs and groins can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, a juvenile life-history stages. May af spawning productivity.
I	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No specific recommendations.	May affect juvenile growth and survival, as well as spawning succe and overall population productivity

Sub-								
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u> : Bank barbs and groins in the marine environment can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Requi footpr objec in are effect
	Loss of LWD recruitment	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recor accun adjace otherv where
	Lacustrine							
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	J <mark>uvenil</mark> es; Adults	<u>All exposed life-history stages</u> : Bank barbs and groins in lacustrine environments can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Requi footpr object in area effect
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recor accun adjace otherv where

Minimization Measures	Resulting Effects of the Submechanism
equire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative fects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
ecommend moving LWD cumulations on the structures to jacent beaches where they would herwise be naturally deposited, here appropriate during maintenance.	May affect juvenile survival.
equire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative fects are already prevalent.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivity.
ecommend moving LWD cumulations on the structures to jacent beaches where they would herwise be naturally deposited, here appropriate during maintenance.	May affect juvenile survival.

Sub-			Exp	osure					Resulting Effects of the
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Jetties									
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<ul> <li><u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Rupture of egg membrane.</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may affect survival and productivity at all life-history stages, depending on project-specific noise intensity and receptor exposure. Likelihood of egg and alevin exposure is limited, as the majority of steelhead spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	J <mark>uvenil</mark> es, Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	may crease d ability tolimit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.fitnes decrease incre incre incre, or stress on. Egg ling toUse protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.Likel is lin spaw unsu Shou direc May juver spaw urvi spaw g in	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness,increased predation exposure.Adults:Delayed migration, resulting indecreased fitness and spawning success.		Likelihood of egg and alevin exposure is limited, as the majority of steelhead spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs, alevins, and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Likelihood of egg and alevin exposure is limited as the majority of steelhead spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable. May cause direct mortality or injury at juvenile life-history stage. Stress may affect survival, growth, and fitness and adult spawning productivity.

# Table A-6. HPA HCP Shoreline Modification Exposure and Response Matrix for Steelhead.

Sub-			Exp	osure				Resulting Effects of the	
Activity Type	y Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
					frequency)		<u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.		
		Stream bed disturbance, increased turbidity (associated with site rewatering).	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<ul> <li><u>Eggs and alevins</u>: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance.</li> <li><u>Juveniles</u>: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.</li> <li><u>Adults</u>: Stress and behavioral modifications by adults exposed to sediment pulses, potential migration delay leading to reduced spawning productivity, reduced foraging opportunities, and increased predation risk.</li> </ul>	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at egg and alevin life-history stages; may affect adult fitness and spawning productivity. Likelihood of egg and alevin exposure is limited, as the majority of steelhead spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and productivity at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	See effects for related stressors under Water Quality Modification.
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	Likelihood of egg and alevin exposure is limited as the majority of steelhead spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable. See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Altered migratory behavior. Decreased foraging opportunity due to short- term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Likelihood of egg and alevin exposure is limited as the majority of steelhead spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, however, direct mortality or injury is probable. May affect survival during egg and alevin life-history stages. May affect juvenile growth and fitness. See effects for related stressors on all life- history stages under Water Quality Modification.

# HPA HCP Shoreline Modification Exposure and Response Matrix for Steelhead.

Sub-			Exp	oosure					Resulting Effects of the
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
	Water Quality Modification	-		·	·	·	<u>.</u>	•	•
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins through reduction in substrate dissolved oxygen. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness as well as adult productivity and spawning success.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation.	Avoid sediment pulses.	Likelihood of egg and alevin exposure is limited as the majority of steelhead spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, stressor may affect survival. May affect juvenile survival, growth, and fitness as well as adult survival, productivity, and spawning success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.

Table A-6	(continued).
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ty			Expo	sure					Resulting Effects of the
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.	Likelihood of egg and alevin exposis is limited as the majority of steelhed spawning habitat is located in areas unsuitable for jetty development. Should exposure occur, stressor ma affect survival, growth, and fitness May affect survival, growth, and fitness of juveniles and adults.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
Riparian Vegetation Modification									
-	Marine		1			1			1
	Altered riparian shading Altered ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. The extent of nearshore habitat use by juvenile steelhead is currently a data gap. However, juveniles trapped by tidal exchange in specific habitats, such as pocket estuaries, may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	The potential effects of this mechanism on juvenile steelhead a generally unknown. However, ma affect juvenile survival and growth
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. This effect may be limited in magnitude, however, as juvenile steelhead use of littoral habitats is relatively limited. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	The potential effects of this mechanism on juvenile steelhead a generally unknown. However, ma affect juvenile survival and fitness

Table A-6	(continued).
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Sub-			Ехро	osure				
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Steelhead dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, steelhead are known to use terrestrial insect resources recruited from the riparian zone in freshwater environments, so exploitation of these resources in marine environments is possible.	Avoi ripari appro the g
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Steelhead dependence on nearshore habitat complexity is currently a data gap. Altered habitat complexity may lead to decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Enco perm habit
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Steelhead dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoi shore
	Lacustrine							
	Altered shading, solar input, ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of lake stratification, reservoir current patterns, wind conditions, and other factors. However, shallow littoral habitats may experience increased temperatures due to lack of shade, leading to decreased availability of refuge and forage habitat, increased competition, and increased predation exposure.	Avoid ripari appro the gr
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid ripari appro the g
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Steelhead dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, steelhead are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid ripari appro the g

Minimization Measures	Resulting Effects of the Submechanism
void/minimize disturbance of arian vegetation. Maintain system- propriate riparian buffer widths to greatest extent possible.	The potential effects of this mechanism on juvenile steelhead are generally unknown. However, may affect juvenile survival, growth, and fitness.
courage project designs that limit rmanent alteration of high-quality bitat features.	The potential effects of this mechanism on juvenile steelhead are generally unknown. However, may affect juvenile survival, growth, and fitness.
void disturbance of vegetation along oreline.	Effects of the action resulting from this impact mechanism are unknown.
void/minimize disturbance of arian vegetation. Maintain system- propriate riparian buffer widths to a greatest extent possible.	May affect juvenile survival, growth, and fitness.
void/minimize disturbance of arian vegetation. Maintain system- propriate riparian buffer widths to a greatest extent possible.	May affect juvenile survival and fitness.
roid/minimize disturbance of arian vegetation. Maintain system- propriate riparian buffer widths to e greatest extent possible.	May affect juvenile growth, fitness, and productivity.

Table A-6	(continued).
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7			Expo			Resulting Effects of the			
r	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival and fitness, spawning success, and over population productivity.
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Steelhead dependence on groundwater inflow to littoral lacustrine habitats is currently a data gap. However, loss of groundwater may lead to reduction in shallow water thermal refuge, increased competition, and decreased foraging opportunity.	Avoid disturbance of vegetation along shoreline.	May affect juvenile survival and fitness.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness.	Design:       Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.         Construction:       Avoid/minimize disturbance of aquatic vegetation during project construction.         Operation:       Enforce vessel operation	May affect juvenile growth and fit
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.		See effects for related stressors une Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.	rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	May affect juvenile survival and productivity. May affect adult gro and spawning productivity.
							Decreased growth and reproductive fitness.		
	Lacustrine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect juvenile productivity.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : See related stressor responses under Water Quality Modification.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation	See effects for related stressors une Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition, and resulting effects on growth and fitness.	rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring.	May affect juvenile survival and productivity.

Sub- ctivity			Ехро	osure	-	-		Resulting Effects of the	
ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Hydraulic and Geomorphic Modification					- -	- 		
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability.	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or	designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at juvenile life-history stag May affect adult growth and productivity.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile steelhead. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct		
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous	mortality. <u>Adults</u> : Subadult and returning adult steelhead forage in nearshore environments Alteration in nearshore ecosystem processe	mortality. <u>Adults</u> : Subadult and returning adult steelhead forage in nearshore environments. Alteration in nearshore ecosystem processes may decrease foraging opportunity, affecting		
	Altered groundwater– surface water exchange		Year-round	Permanent	Continuous				
	Addition of impervious surface		Year-round	Permanent	Continuous				

Sub-			Ехро	osure								
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>					
	Lacustrine											
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that	Caret desig impa proje				
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing	desig sedim patter				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		habitat for juvenile and migratory habitat for adult steelhead. This may occur through a number of specific stressors, including increased exertion and stress due to change in	patter				
	Altered sediment supply		Year-round	Permanent	Continuous		current and wave energy patterns, increased					
	Altered substrate composition		Year-round	Permanent	Continuous		predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adult steelhead will generally be less sensitive to these stressors. However, increased stress and delayed migration may reduce fitness and ultimately reduce spawning success.					
	Altered groundwater– surface water exchange		Year-round	Permanent	Continuous							
	Addition of impervious surface		Year-round	Permanent	Continuous	0						
	Ecosystem Fragmentation											
	Marine											
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u> : Jetties can fragment nearshore marine rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Requ footp object in are effect				
	Loss of LWD recruitment	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Reco accur adjac other where				

Minimization Measures	Resulting Effects of the Submechanism
Carefully evaluate project siting and design and consider the magnitude of mpact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
Require structures with the minimal cootprint necessary to achieve project objectives. Avoid permitting projects n areas where significant cumulative effects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.

b-			Exp	osure				Resulting Effects of the	
vity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : Jetties can fragment nearshore lacustrine rearing habitats, forcing migrating and foraging salmonids to navigate offshore into deeper water environments. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivit
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.
kv	waters								
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<ul> <li><u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Rupture of egg membrane.</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may affect survival and productivity at all life-history stages depending on project-specific noise intensity and receptor exposure. Likelihood of egg and alevin exposu is limited, as the majority of steelhe spawning habitat is located in areas unsuitable for breakwater development. Should exposure occ however, direct mortality or injury i probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles, Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.

 Table A-6 (continued).
 HPA HCP Shoreline Modification Exposure and Response Matrix for Steelhead.

Sub-			Exp	osure					Resulting Effects of the
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stress from capture, handling, and relocation.Egg relocation is impractical, likely leading to mortality.Adults and juveniles:Mortality, injury, or stress from capture, handling, and relocation.Juveniles:Increased competition once relocated, reduced growth and fitness, increased predation exposure.Adults:Delayed migration, resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Likelihood of egg and alevin exposure is limited, as the majority of steelhead spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is probable. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs, alevins, and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Likelihood of egg and alevin exposure is limited as the majority of steelhead spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is probable. May cause direct mortality or injury at juvenile life-history stage. Stress may affect survival, growth, and fitness and adult spawning productivity.
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering).	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses,potential migration delay leading to reducedspawning productivity, reduced foragingopportunities, and increased predation risk.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at egg and alevin life-history stages; may affect adult fitness and spawning productivity. Likelihood of egg and alevin exposure is limited, as the majority of steelhead spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is probable.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and productivity at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	See effects for related stressors under Water Quality Modification.

Sub-			Exp	osure				Dogulting Efforts of the	
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	Likelihood of egg and alevin exposure is limited as the majority of steelhead spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is probable. See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Altered migratory behavior. Decreased foraging opportunity due to short- term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Likelihood of egg and alevin exposure is limited as the majority of steelhead spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, however, direct mortality or injury is probable. May affect survival during egg and alevin life-history stages. May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins through reduction in substrate dissolved oxygen. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness as well as adult productivity and spawning success.

Table A-6	(continued).
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Sub-			Expe	osure					Resulting Effects of the
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation.	Avoid sediment pulses.	Likelihood of egg and alevin exposure is limited as the majority of steelhead spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, stressor may affect survival. May affect juvenile survival, growth, and fitness as well as adult survival, productivity, and spawning success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.	Likelihood of egg and alevin exposure is limited as the majority of steelhead spawning habitat is located in areas unsuitable for breakwater development. Should exposure occur, stressor may affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	

Table A-6	(continued).
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ub-			Expo	osure				
tivity ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Aquatic Vegetation Modification			-	-		-	
	Marine							
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness.	Des foot aqua exte
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	Cons distu durin Oper
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	rules vege grou redu prof
							<u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	
	Lacustrine							
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness.	Desi foot aqua exte
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : See related stressor responses under Water Quality Modification.	Con distu durin Oper
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition, and resulting effects on growth and fitness.	rules vege grou

Minimization Measures	Resulting Effects of the Submechanism

esign: Limit project structural otprint to minimize shading of puatic vegetation to the greatest stent practicable.	May affect juvenile growth and fitness.
onstruction: Avoid/minimize sturbance of aquatic vegetation uring project construction.	See effects for related stressors under Water Quality Modification.
<u>peration</u> : Enforce vessel operation les to limit submerged aquatic egetation damage from prop wash, ounding, and anchoring, as well as duced ambient light from fine bubble ofusion.	May affect juvenile survival and productivity. May affect adult growth and spawning productivity.
esign: Limit project structural otprint to minimize shading of quatic vegetation to the greatest stent practicable.	May affect juvenile productivity.
onstruction: Avoid/minimize sturbance of aquatic vegetation rring project construction.	See effects for related stressors under Water Quality Modification.
<u>peration</u> : Enforce vessel operation les to limit submerged aquatic egetation damage from prop wash, ounding, and anchoring.	May affect juvenile survival and productivity.

Sub-			Expo	osure					Resulting Effects of the		
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism		
	Hydraulic and Geomorphic Modification	- 				- 	- 	- 	- 		
	Riverine										
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, reduced spawning	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival, growth, and fitness at egg, alevin, and juvenile life- history stages. May affect spawning		
	Altered flow velocity	and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		<ul> <li>and stability, leading to decreased incubation success and alevin survival.</li> <li><u>Juveniles</u>: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.</li> <li><u>Adults</u>: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.</li> <li><u>All life-history stages</u>: Because the amount of impervious surface associated with breakwaters is a relatively inconsequential component of the overall drainage area of the larger river systems that would support this type of development, the magnitude of the hydrologic modification stressor is not expected to significantly affect the riverine environment, and there will be no response to the stressor.</li> </ul>	success and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result	on project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and	designs that minimize effects on channel geometry, flow velocity,	productivity.
	Altered substrate composition (including placement of non- erodable substrate)		Year-round	Permanent	Continuous			extent practicable.			
	Altered groundwater– surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous						
	Addition of impervious surface	Alteration in the magnitude, volume, and timing of peak flows	During storm events (predominantly from fall through spring)	Permanent	Common	Eggs and alevins; Juveniles; Adults		Encourage facilities to employ modern low-impact development and stormwater treatment technology.	Impervious surface at anticipated scale would not produce stressors of sufficient magnitude to adversely affect steelhead at any life-history stage.		

Table A-6 (continue)	d).	
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Sub- Activity			Exp	osure				Resulting Effects of the				
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism			
	Marine											
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability.	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	sediment supply, substrate composition, and design and consider the magnitude of fitness at juve	design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on	May affect survival, growth, and fitness at juvenile life-history stage May affect adult growth and productivity.			
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent			alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile steelhead. This may occur through a	alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile steelhead. This may occur through a	alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile steelhead. This may occur through a	ittoral habitats, potentially e suitability of rearing habitat for head. This may occur through a	
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				to change in , increased on in ep water decreased			
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous							
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		Adults:       Subadult and returning adult         steelhead forage in nearshore environments.         Alteration in nearshore ecosystem processes         may decrease foraging opportunity, affecting         growth and fitness.					
	Altered groundwater– surface water exchange		Year-round	Permanent	Continuous							
	Addition of impervious surface		Year-round	Permanent	Continuous							

ıb-			Ехро	osure				
ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Lacustrine							
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that	Care: desig impa proje
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing	desig sedin patter
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		habitat for juvenile and migratory habitat for adult steelhead. This may occur through a number of specific stressors, including increased exertion and stress due to change in	patter
	Altered sediment supply		Year-round	Permanent	Continuous		current and wave energy patterns, increased	
	Altered substrate composition		Year-round	Permanent	Continuous		predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging	
	Altered groundwater– surface water exchange		Year-round	Permanent	Continuous		opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth	
	Addition of impervious surface		Year-round	Permanent	Continuous		and productivity, decreased fitness for marin migration, and direct mortality. Adult steelhead will generally be less sensitive to these stressors. However, increased stress an delayed migration may reduce fitness and ultimately reduce spawning success.	
	Ecosystem Fragmentation				·			
	Riverine					,		
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Required footp object in are effect
	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No sj
	Marine							
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Requ footp objec in are effec

Minimization Measures	Resulting Effects of the Submechanism
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on liment supply, longshore drift terns, and wave energy and current terns.	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
quire structures with the minimal opprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative jects are already prevalent.	May affect juvenile survival.
specific recommendations.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
quire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative jects are already prevalent.	May affect juvenile survival.

Sub-			Ехр	osure				
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Loss of LWD recruitment	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Reco accur adjac other where
		Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover						
	Lacustrine				1			
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	Juveniles: Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Requ footp objec in are effect
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Record accurd adjac other where
	s and Bank Barbs Construction and Maintenance Activities					T		
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<ul> <li><u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Rupture of egg membrane.</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid impact NOA habita drivin Use c reduc confi Enco and v

# HPA HCP Shoreline Modification Exposure and Response Matrix for Steelhead.

Minimization Measures	Resulting Effects of the Submechanism
commend moving LWD cumulations on the structures to facent beaches where they would herwise be naturally deposited, here appropriate during maintenance.	May affect juvenile survival.
	Man affect investige in 1
quire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative ects are already prevalent.	May affect juvenile survival.
commend moving LWD cumulations on the structures to jacent beaches where they would herwise be naturally deposited, here appropriate during maintenance.	May affect juvenile survival.
roid pile-driving noise in excess of pact thresholds established by DAA Fisheries and USFWS in bitats used by species. Limit pile ving to in-water work windows. e double-confined bubble curtain to luce sound pressure, or work within nfined or dewatered work areas. courage use of vibratory hammers d wooden pilings where practicable.	Activity may affect survival and productivity at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.

Sub-			Exp	osure				Resulting Effects of the	
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles, Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stress from capture, handling, and relocation.Egg relocation is impractical, likely leading to mortality.Adults and juveniles:Mortality, injury, or stress from capture, handling, and relocation.Juveniles:Increased competition once relocated, reduced growth and fitness, increased predation exposure.Adults:Delayed migration, resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Should exposure occur, direct mortality or injury is probable. May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs, alevins, and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Should exposure occur, direct mortality or injury is probable. May cause direct mortality or injury at juvenile life-history stage. Stress may affect survival, growth, and fitness and adult spawning productivity.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	<mark>Eggs and</mark> alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	Should exposure occur, decreased survival is likely. May affect survival during egg and alevin life-history stages, may affect adult spawning productivity.
		Altered current and circulation conditions (marine and lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles:       Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> :       Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering).	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses,potential migration delay leading to reducedspawning productivity, reduced foragingopportunities, and increased predation risk.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at egg and alevin life-history stages; may affect adult fitness and spawning productivity. Should exposure occur, direct mortality or injury is probable.

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rity De	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and productivity at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	See effects for related stressors under Water Quality Modification.
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	Should exposure occur, direct mortality or injury is probable. See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Altered migratory behavior.Decreased foraging opportunity due to short- term reduction in prey abundance.Decreased growth and fitness.All life-history stages:See responses described for related stressors under Water	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Should exposure occur, direct mortality or injury is probable. May affect survival during egg and alevin life-history stages. May affect juvenil growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Water Quality						Quality Modification.		
	Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins through reduction in substrate dissolved oxygen.Juveniles and adults: Duvoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior.Adults: Reduction in suitable spawning	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating egg and alevins. May affect juvenile growth and fitness as well as adult productivity and spawning success.
							<u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.		

Sub- Activity Type	Mechanism of Impact	Exposure							
		Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation.	Avoid sediment pulses.	Should exposure occur, stressor may affect survival. May affect juvenile survival, growth, and fitness as well as adult survival, productivity, and spawning success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.	Should exposure occur, stressor may affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	

		Exposure							Resulting Effects of the		
у	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism		
	Riparian Vegetation Modification										
	Riverine										
	Altered shading, solar input, ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due to winter ice formation and scour.Juveniles:Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns.Adults and juveniles:Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.Adults:Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival ar spawning productivity.		
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen, decreased area of suitable spawning habitat, reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high-flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen, as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival an spawning productivity.		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile rearing.		
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival; spawning success; and overall population productivity		

HPA HCP Shoreline Modification Exposure and Response Matrix for Steelhead.

ub-			Expe	osure					Resulting Effects of the
tivity 'ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Altered groundwater- surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Decreased incubation success. Juveniles: Decreased availability of thermal	Avoid permitting of projects in areas with springs, seeps, or other sources of significant groundwater recharge. Limit alteration of riparian vegetation	May affect survival of eggs and alevins. May affect juvenile survival and growth. May affect adult
							refuge habitat, resulting in increased thermal stress, increased competition for suitable habitats.	spawning productivity.	
							<u>Adults</u> : Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.		
	Marine								
	Altered shading, solar input, ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures).	Year-round (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. The extent of nearshore habitat use by juvenile steelhead is currently a data gap. However, juveniles trapped by tidal exchange in specific habitats, such as pocket estuaries, may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	The potential effects of this mechanism on juvenile steelhead are generally unknown. However, may affect juvenile survival and growth.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. This effect may be limited in magnitude, however, as juvenile steelhead use of littoral habitats is relatively limited. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	The potential effects of this mechanism on juvenile steelhead are generally unknown. However, may affect juvenile survival and fitness.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Steelhead dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, steelhead are known to use terrestrial insect resources recruited from the riparian zone in freshwater environments, so exploitation of these resources in marine environments is possible.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	The potential effects of this mechanism on juvenile steelhead are generally unknown. However, may affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover	e occurs during nearshore permanent rearing period in spring and summer) of activity)		Continuous	Juveniles	<u>Juveniles:</u> Steelhead dependence on nearshore habitat complexity is currently a data gap. Altered habitat complexity may lead to decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	The potential effects of this mechanism on juvenile steelhead ard generally unknown. However, may affect juvenile survival, growth, and fitness.
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Steelhead dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from t impact mechanism are unknown.

# HPA HCP Shoreline Modification Exposure and Response Matrix for Steelhead.

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Table A-6	(continued).
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HPA HCP Shoreline Modification Exposure and Response Matrix for Steelhead.

			Expe	osure				Deputting Effects of the	
r	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered shading, solar input, ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of lake stratification, reservoir current patterns, wind conditions, and other factors. However, shallow littoral habitats may experience increased temperatures due to lack of shade, leading to decreased availability of refuge and forage habitat, increased competition, and increased predation exposure.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth and fitness.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and fitness.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Steelhead dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, steelhead are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth, fitness, and productivity.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival and fitness, spawning success, and overa population productivity.
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Steelhead dependence on groundwater inflow to littoral lacustrine habitats is currently a data gap. However, loss of groundwater may lead to reduction in shallow water thermal refuge, increased competition, and decreased foraging opportunity.	Avoid disturbance of vegetation along shoreline.	May affect juvenile survival and fitness.

Table A-6 (	continued).
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HPA HCP Shoreline Modification Exposure and Response Matrix for Steelhead.

Sub-			Exp	osure				
ctivity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Aquatic Vegetation Modification			-	-	-		
	Marine							
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness.	Des foot aqua exte
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	<u>Con</u> distu duri
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	
							<u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	
	Riverine and Lacustrine		·			6/7		
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness.	Desi foot aqua exte
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : See related stressor responses under Water Quality Modification.	<u>Con</u> distu durin
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition, and resulting effects on growth and fitness.	

Minimization Measures	Resulting Effects of the Submechanism
esign: Limit project structural otprint to minimize shading of uatic vegetation to the greatest tent practicable.	May affect juvenile growth and fitness.
onstruction: Avoid/minimize sturbance of aquatic vegetation ring project construction.	See effects for related stressors under Water Quality Modification.
	May affect juvenile survival and productivity. May affect adult growth and spawning productivity.
esign: Limit project structural otprint to minimize shading of uatic vegetation to the greatest tent practicable.	May affect juvenile productivity.
onstruction: Avoid/minimize sturbance of aquatic vegetation ring project construction.	See effects for related stressors under Water Quality Modification.
	May affect juvenile survival and productivity.

Sub- Activity			Expo	osure					Resulting Effects of the
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	<b>Minimization Measures</b>	Submechanism
	Hydraulic and Geomorphic Modification	- 	·			- 	- 	- 	- 
	Riverine								
	geometry habitat suitability, reduced web complexity, reduced s and rearing habitat availab	Change in habitat structure and habitat suitability, reduced food web complexity, reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth, and fitness at egg, alevin, and juvenile life- history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition (including placement of non- erodable substrate)		Year-round	Permanent	Continuous				
	Altered groundwater– surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Addition of impervious surface		Year-round	Permanent	Continuous		geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		

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HPA HCP Shoreline Modification Exposure and Response Matrix for Steelhead.

Sub- ctivity			Expo	osure		T		
си <b>ч</b> ну Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Marine				_		-	-
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability.	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or	Caref design impac projec design
Î	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile steelhead. This may occur through a number of specific stressors, including	sedim patter patter
-	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water	
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. <u>Adults</u> : Subadult and returning adult steelhead forage in nearshore environments.	
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous		Alteration in nearshore ecosystem processes may decrease foraging opportunity, affecting growth and fitness.	
Î	Addition of impervious surface		Year-round	Permanent	Continuous			
ſ	Lacustrine							
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that	Caref design impac projec
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing	design sedim patter patter
[	Altered sediment supply		Year-round	Permanent	Continuous		habitat for juvenile and migratory habitat for adult steelhead. This may occur through a	
	Altered substrate composition		Year-round	Permanent	Continuous		number of specific stressors, including increased exertion and stress due to change in	
	Altered groundwater– surface water exchange	-	Year-round	Permanent	Continuous		current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web	
	Addition of impervious surface		Year-round	Permanent	Continuous		alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adult steelhead will generally be less sensitive to these stressors. However, increased stress and delayed migration may reduce fitness and ultimately reduce spawning success.	

Minimization Measures	Resulting Effects of the Submechanism
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the ject. Encourage selection of project signs that minimize effects on liment supply, longshore drift terns, and wave energy and current terns.	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult growth and productivity.
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on liment supply, longshore drift terns, and wave energy and current terns. For example:	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

Sub-			Exp	osure				
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Ecosystem Fragmentation	•		•	-	-	•	
	Riverine							
	Habitat loss and fragmentation	Fragmentation of side channel and floodplain habitat; change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Bank barbs and groins can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Requ effec avoid disco
	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No sj
	Marine							
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u> : Bank barbs and groins in the marine environment can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Requ footp objec in are effec
	Loss of LWD recruitment	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Reco accu adjac other wher

HPA HCP Shoreline Modification Exposure and Response Matrix for Steelhead.

Minimization Measures	Resulting Effects of the Submechanism
quire assessment of the hydraulic ects of the project before permitting; oid permitting designs that lead to sconnection of floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
specific recommendations.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
quire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative ects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
commend moving LWD cumulations on the structures to jacent beaches where they would herwise be naturally deposited, here appropriate during maintenance.	May affect juvenile survival.

Table A-6	(continu	led)
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# I). HPA HCP Shoreline Modification Exposure and Response Matrix for Steelhead.

Sub-			Ex	xposure					Deculting Effects of the
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : Bank barbs and groins in lacustrine environments can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivity.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.

			Expo	sure					
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanis
ies									
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<ul> <li><u>Adults and juveniles</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work- areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality or injury and/or affect survival, growth, an fitness of exposed life-history stages, depending on project-specific noise intensity and receptor exposure.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect juvenile survival, growth, ar fitness due to avoidance behavior, decreased foraging success, and increas predation risk. May affect adult fitness to decreased foraging success.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. <u>Juveniles</u> : Increased competition once relocated; reduced growth and fitness; increased predation exposure. <u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality or injury to affected life-history stages. May affect survival, growth, and fitness at juvenile adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows. Avoid use when juveniles are present.	May affect survival, growth, and fitness juvenile life-history stage.
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness, potentially limiting survival during ocea migration; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles:       Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.         Adults:       Stress and behavioral modifications by adult spawners exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.	Adhere to system-specific in-water work windows.	May affect juvenile growth and fitness; affect adult spawning productivity.

# Table A-7 (continued).HPA HCP Shoreline Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

y			Expo	sure	•	•			
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system- specific in-water work windows.	See effects for related stressors under Wate Quality Modification.
	Construction/maintenan ce dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	<u>Adults and juveniles</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Adults and juveniles: See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Altered migratory behavior. Decreased foraging opportunity due to short- term reduction in prey availability. Decreased growth and fitness.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.
							Adults and juveniles: See responses described for related stressors under Water Quality Modification.		
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to Interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Adults and juveniles</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival, growth, and fitness. Reduced adult fitness may affect spawning success.
							Adults: Decreased spawning success resulting from reduced fitness.		

			Expo	sure			1		
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechani
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to Interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Adults and juveniles: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect juvenile and adult survival, growth, and fitness. Reduced adult fitn may affect spawning success.
	Use of creosote-treated wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Juveniles; Adults	Adults and juveniles: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary use dense- grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.	May affect juvenile and adult survival, growth, and fitness. Reduced adult fitr may affect spawning success.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	Adults and juveniles: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	fragmentation and release of treated	
	Riparian Vegetation Modification	L	I			-			I
	Marine								
	Altered shading, solar input, ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth, a fitness.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity.

			Expos	sure	1	1	1		
N	Aechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Submechanism
	ltered allochthonous puts	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Cutthroat trout dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, cutthroat trout are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth, fitness, and productivity.
	ltered habitat omplexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival and productivity, spawning success, and overa population productivity.
	ltered freshwater flow	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Cutthroat trout dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along stream.	Effects of the action resulting from this impact mechanism are unknown.
L	acustrine								
in	ltered shading, solar iput, ambient air imperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of lake stratification, reservoir current patterns, wind conditions, and other factors. However, shallow littoral habitats may experience increased temperatures due to lack of shade, leading to decreased availability of refuge and forage habitat, increased competition, and increased predation exposure.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity.
	ltered shoreline ability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity.
	ltered allochthonous aputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Cutthroat trout dependence on allochthonous inputs from riparian vegetation is a data gap. However, cutthroat trout are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth, fitness, and productivity.

Table A-7	(continued).
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			Expos	sure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival and productivity, spawning success, and overa population productivity.
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Cutthroat trout dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along stream.	Effects of the action resulting from this impact mechanism are unknown.
	Aquatic Vegetation Modification								
Ē	Marine								
_	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect juvenile productivity.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Adults and juveniles: See related stressor responses under Water Quality Modification.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	See effects for related stressors under Wa Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure resulting in decreased survival, growth, and fitness.	<u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, and reduced ambient light from fine bubble profusion.	May affect juvenile survival and productivity. May affect adult growth and spawning productivity.
							<u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		
	Lacustrine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect juvenile productivity.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	See effects for related stressors under Wa Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	<u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring.	May affect juvenile survival and productivity.

Sub-			Expo	sure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that comprise the nearshore ecosystem. Alteration in one or	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile coastal cutthroat trout. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased	on sediment supply, longshore drift patterns, and wave energy and current patterns.	
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct		
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		mortality.		
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				
	Addition of impervious surface		Year-round	Permanent	Continuous				

		Expo	sure				
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minim
Lacustrine							
Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that	Carefully eva design and co of impact me the project. I
Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing	project design on sediment a patterns, and current patter
Altered nearshore circulation patterns		Year-round, with variable effects by season (e.g., circulation patterns)	Permanent	Seasonal		habitat for juvenile and migratory habitat for adult coastal cutthroat. This may occur through a number of specific stressors,	
Altered sediment supply		Year-round	Permanent	Continuous		including increased exertion and stress due to	
Altered substrate composition		Year-round	Permanent	Continuous		change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food	
Altered groundwater– surface water exchange		Year-round	Permanent	Continuous		web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of	
Addition of impervious surface		Year-round	Permanent	Continuous		these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	
						<u>Adults</u> : Adult cutthroat trout will generally be less sensitive to these stressors. However, increased stress and delayed migration may reduce fitness and ultimately reduce spawning success.	
Ecosystem					-		
Fragmentation							
Marine	1	1			1	1	
Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u> : Jetties can fragment nearshore marine rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require struct footprint neco project object projects in an cumulative ef prevalent.
Loss of LWD recruitment	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend accumulation adjacent beac otherwise be where approp maintenance.

imization Measures	Resulting Effects of the Submechanism
evaluate project siting and d consider the magnitude mechanisms produced by t. Encourage selection of signs that minimize effects nt supply, longshore drift nd wave energy and tterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
ructures with the minimal lecessary to achieve jectives. Avoid permitting a areas where significant e effects are already	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
nd moving LWD ions on the structures to eaches where they would be naturally deposited, ropriate during ce.	May affect juvenile survival.

# Table A-7 (continued).HPA HCP Shoreline Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

			Expos	sure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanis
1	Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Jetties can fragment nearshore lacustrine rearing habitats, forcing migrating and foraging salmonids to navigate offshore into deeper water environments. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life-histor stage. Decreased fitness may lead to reduced spawning productivity.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.
w	vaters								
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<ul> <li><u>Adults and juveniles</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work- areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality or injury and/or affect survival, growth, and fitness of exposed life-history stages, depending on project-specific noise intensity and receptor exposure.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect juvenile survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk. May affect adult fitness d to decreased foraging success.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles:Mortality, injury, or stress from capture, handling, and relocation.Juveniles:Increased competition once relocated; reduced growth and fitness; increased predation exposure.Adults:Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality or injury to affected life-history stages. May affect survival, growth, and fitness at juvenile a adult life-history stages.

	 Mechanism of Impact		Expos	sure					
<b>y</b> ]		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows. Avoid use when juveniles are present.	May affect survival, growth, and fitness at juvenile life-history stage.
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness, potentially limiting survival during ocean migration; may affect adult spawning productivity.
					frequency)		<u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.		productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.	Adhere to system-specific in-water work windows.	May affect juvenile growth and fitness; ma affect adult spawning productivity.
							<u>Adults</u> : Stress and behavioral modifications by adult spawners exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.		
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system- specific in-water work windows.	See effects for related stressors under Wat Quality Modification.
	Construction/maintenan ce dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	<u>Adults and juveniles</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Adults and juveniles: See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Altered migratory behavior. Decreased foraging opportunity due to short- term reduction in prey availability. Decreased growth and fitness.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	May affect juvenile growth and fitness. S effects for related stressors under Water Quality Modification.
							<u>Adults and juveniles</u> : See responses described for related stressors under Water Quality Modification.		

#### Table A-7 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Table A-7	(continued).
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HPA HCP Shoreline Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-			Expo	osure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification						·		
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to Interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Adults and juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Decreased spawning success resulting from reduced fitness.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival, growth, and fitness. Reduced adult fitness may affect spawning success.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	Adults and juveniles: Mortality in acute low dissolved oxygen events due to asphyxiation. Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Avoid sediment pulses.	May affect juvenile and adult survival, growth, and fitness. Reduced adult fitness may affect spawning success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to Interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Adults and juveniles</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect juvenile and adult survival, growth, and fitness. Reduced adult fitness may affect spawning success.

		Ехро	sure						
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanisn	
Use of creosote-treated wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Juveniles; Adults	Adults and juveniles: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary use dense- grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid	May affect juvenile and adult survival, growth, and fitness. Reduced adult fitnes may affect spawning success.	
Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	Adults and juveniles: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.		
Aquatic Vegetation Modification									
Marine									
Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect juvenile productivity.	
	Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	<u>Adults and juveniles</u> : See related stressor responses under Water Quality Modification.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	See effects for related stressors under W Quality Modification.	
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure resulting in decreased survival, growth, and fitness.	<u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, and reduced ambient light from fine bubble profusion.	May affect juvenile survival and productivity. May affect adult growth as spawning productivity.	
						<u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.			

HPA HCP Shoreline Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

			Expo	sure					
Mechanism of	Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Riverine and Lacustrine									
Altered autocht	Altered autochthonous productionReduced food web productivityYear-round (most pronounced in spring and summer when vegetation growth is most extensive)PermanentContinuousJuvenilesJuveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.Altered dissolved oxygen levels due to reduced photosynthesisYear-round (most pronounced 		<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect juvenile productivity.					
			in spring and summer when vegetation growth is most	Permanent	Seasonal			<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation	See effects for related stressors under Wa Quality Modification.
Altered habitat complexity		Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring.	May affect juvenile survival and productivity.
Hydraulic and Geomorphic Modification								·	
Riverine									
Altered channel geometry		Change in habitat structure and habitat suitability, reduced food web complexity, and reduced	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitnes
Altered flow ve	locity	spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
Altered substrat composition (in placement of no erodable substra	cluding on-		Year-round	Permanent	Continuous		Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition		
Altered groundy surface water ex			Year-round (with stressor exposure occurring during juvenile rearing)	Permanent	Continuous		and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected		
Addition of imp surface	vervious	Alteration in the magnitude, volume, and timing of peak flows	During storm events (predominantly from fall through spring)	Permanent	Common	Juveniles; Adults	Adults and juveniles: Because the amount of impervious surface associated with breakwaters is a relatively inconsequential component of the overall drainage area of the larger river systems that would support this type of development, the magnitude of the hydrologic modification stressor is expected to be negligible. As such, this stressor is not expected to significantly affect the riverine environment, and there will be no response to the stressor.	Encourage facilities to employ modern low-impact development and stormwater treatment technology.	Impervious surface at anticipated scale would not produce stressors of sufficient magnitude to adversely affect cutthroat tre at any life-history stage.

# HPA HCP Shoreline Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-			Expo	sure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that comprise the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile coastal cutthroat trout. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent			on sediment supply, longshore drift patterns, and wave energy and current patterns.	
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Altered groundwater- surface water exchange	]	Year-round	Permanent	Continuous				
	Addition of impervious surface		Year-round	Permanent	Continuous				

			Expo	sure							
ty Me	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimi			
Lac	Lacustrine										
	tered wave energy ort-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that	Carefully eva design and co of impact me the project. H			
	tered current locities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing	project design on sediment s patterns, and current patter			
	tered nearshore culation patterns		Year-round, with variable effects by season (e.g., circulation patterns)	Permanent	Seasonal		habitat for juvenile and migratory habitat for adult coastal cutthroat. This may occur through a number of specific stressors,	current patter			
Alte	tered sediment supply		Year-round	Permanent	Continuous		including increased exertion and stress due to				
	tered substrate		Year-round	Permanent	Continuous		change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food				
	tered groundwater– face water exchange		Year-round	Permanent	Continuous		web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of				
	dition of impervious face		Year-round	Permanent	Continuous		these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. <u>Adults</u> : Adult cutthroat trout will generally be less sensitive to these stressors. However, increased stress and delayed migration may reduce fitness and ultimately reduce spawning success.				
	Ecosystem Fragmentation										
Riv	verine										
	teration of edator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Require struc footprint nece project object projects in are cumulative ef prevalent.			
	ss of LWD ruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No specific re			
Ma	arine				· ·	•	•	·			
	teration of dator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Require struc footprint nece project object projects in are cumulative ef prevalent.			

imization Measures	Resulting Effects of the Submechanism
evaluate project siting and d consider the magnitude mechanisms produced by t. Encourage selection of signs that minimize effects nt supply, longshore drift nd wave energy and tterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
maturas with the minim-1	May offact invarile curring
ructures with the minimal necessary to achieve jectives. Avoid permitting nareas where significant e effects are already	May affect juvenile survival.
c recommendations.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
ructures with the minimal necessary to achieve jectives. Avoid permitting n areas where significant e effects are already	May affect juvenile survival.

Sub-			Ехро	sure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minim
	Loss of LWD recruitment	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend accumulation adjacent beau otherwise be where approp maintenance.
	Lacustrine							
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Require struct footprint nece project object projects in ar cumulative et prevalent.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend accumulation adjacent beau otherwise be where approp maintenance.

# Groins and Bank Barbs

Construction and Maintenance Activities							
Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<ul> <li><u>Adults and juveniles</u>: Stressor response dependent on noise magnitude and project- specific environmental conditions; may range from:</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-d of impact the NOAA Fish- habitats used driving to in Use double- to reduce so within confi areas. Enco hammers an practicable.

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imization Measures	Resulting Effects of the Submechanism
nd moving LWD ions on the structures to eaches where they would be naturally deposited, ropriate during ce.	May affect juvenile survival.
ructures with the minimal necessary to achieve jectives. Avoid permitting nereas where significant e effects are already	May affect juvenile survival.
nd moving LWD ions on the structures to eaches where they would be naturally deposited, ropriate during ce.	May affect juvenile survival.
e-driving noise in excess thresholds established by sheries and USFWS in sed by species. Limit pile in-water work windows. e-confined bubble curtain sound pressure, or work ifined or dewatered work- courage use of vibratory and wooden pilings where e.	Activity may cause direct mortality or injury and/or affect survival, growth, and fitness of exposed life-history stages, depending on project-specific noise intensity and receptor exposure.

			Expos	sure	<del></del>				
Mechanism of I	Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Construction vessel operation	ssel	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect juvenile survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk. May affect adult fitness due to decreased foraging success.
Channel/work are dewatering	ea	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles:Mortality, injury, or stress from capture, handling, and relocation.Juveniles:Increased competition once relocated; reduced growth and fitness; increased predation exposure.Adults:Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality or injury to affected life-history stages. May affect survival, growth, and fitness at juvenile and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows. Avoid use when juveniles are present.	May affect survival, growth, and fitness at juvenile life-history stage.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect juvenile growth and fitness; may affect adult spawning productivity.
		Altered current and circulation conditions (marine and lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness, potentially limiting survival during ocean migration; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adult spawners exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.	Adhere to system-specific in-water work windows.	May affect juvenile growth and fitness; may affect adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system- specific in-water work windows.	See effects for related stressors under Water Quality Modification.
Construction/mai ce dredging	intenan	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	Adults and juveniles: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Adults and juveniles: See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.

# Table A-7 (continued).HPA HCP Shoreline Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-			Expos	sure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Juveniles; Adults	<u>Juveniles</u> : Altered migratory behavior. Decreased foraging opportunity due to short- term reduction in prey availability. Decreased growth and fitness.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.
							<u>Adults and juveniles</u> : See responses described for related stressors under Water Quality Modification.		
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to Interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Adults and juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Decreased spawning success resulting from reduced fitness.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival, growth, and fitness. Reduced adult fitness may affect spawning success.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Adults and juveniles</u> : Mortality in acute low dissolved oxygen events due to asphyxiation. Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Avoid sediment pulses.	May affect juvenile and adult survival, growth, and fitness. Reduced adult fitness may affect spawning success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to Interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Adults and juveniles</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect juvenile and adult survival, growth, and fitness. Reduced adult fitness may affect spawning success.

			Expo	sure					
у	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Use of creosote-treated wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Juveniles; Adults	Adults and juveniles: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary use dense- grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fraematation and relaces of treated	May affect juvenile and adult survival, growth, and fitness. Reduced adult fitness may affect spawning success.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	Adults and juveniles: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
	Riparian Vegetation Modification								
	Riverine			1		1			
:	Altered shading, solar input and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures).	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles; Adults	Adults and juveniles:Direct mortality causedby exposure to temperatures in excess of tolerance thresholds.Juveniles:Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns.Adults:Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness o juveniles and adults. Reduced adult fitnes may lead to decreased spawning success.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high-flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition, and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of juveniles and adults. Reduced adult fitne may lead to decreased spawning success.

			Expo	sure		1			
M	echanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanis
Alt	tered allochthonous outs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of juveniles.
	tered habitat mplexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition, and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality and decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect survival, growth, and fitness of juveniles and adults. Reduced adult fitne may lead to decreased spawning success.
	tered groundwater- face water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : Decreased availability of thermal refuge habitat, resulting in increased thermal stress; increased competition for suitable habitats. <u>Adults</u> : Decrease in suitable habitat, increased competition, decreased spawning fitness and success.	Avoid permitting of projects in areas with springs, seeps, or other sources of significant groundwater recharge. Limit alteration of riparian vegetation to greatest extent practicable.	May affect juvenile survival, growth, and fitness. May affect adult spawning productivity.
Ma	arine							•	
inp	tered shading, solar out, ambient air nperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth, and fitness.
	tered shoreline and iff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity.
Alti	tered allochthonous outs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Cutthroat trout dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, cutthroat trout are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth, fitness, and productivity.

Table A-7	(continued).
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HPA HCP Shoreline Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

			Exposure						
y N	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival and productivity, spawning success, and overall population productivity.
	Altered freshwater inflow	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Cutthroat trout dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along stream.	Effects of the action resulting from this impact mechanism are unknown.
	Lacustrine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of lake stratification, reservoir current patterns, wind conditions, and other factors. However, shallow littoral habitats may experience increased temperatures due to lack of shade, leading to decreased availability of refuge and forage habitat, increased competition, and increased predation exposure.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Cutthroat trout dependence on allochthonous inputs from riparian vegetation is a data gap. However, cutthroat trout are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth, fitness, and productivity.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival and productivity, spawning success, and overall population productivity.
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Cutthroat trout dependence on groundwater inflow to nearshore lacustrine habitats is currently a data gap.	Avoid disturbance of vegetation along stream.	Effects of the action resulting from this impact mechanism are unknown.

HPA HCP Shoreline Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

			Expo	sure					
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification						·		- 
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect juvenile productivity.
		Altered dissolved oxygen levels	Year-round (most pronounced	Permanent	Seasonal	Juveniles;	Adults and juveniles: See related stressor	Construction: Avoid/minimize	See effects for related stressors under Wa
		due to reduced photosynthesis	in spring and summer when vegetation growth is most extensive)			Adults	responses under Water Quality Modification.	disturbance of aquatic vegetation during project construction.	Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure resulting in decreased survival, growth, and fitness.		May affect juvenile survival and productivity. May affect adult growth and spawning productivity.
							<u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		
	Riverine and Lacustrine	_						-	
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect juvenile productivity.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : See related stressor responses under Water Quality Modification.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	See effects for related stressors under Wat Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival and productivity.

			Ехро	sure		-					
у	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimi			
	Hydraulic and Geomorphic Modification										
	Riverine										
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and	Carefully eval design and co of impact mee			
	Altered flow velocity	spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	the project. E project design on channel ge substrate com			
	Altered substrate composition (including placement of non- erodable substrate)		Year-round	Permanent	Continuous	-	<u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition	groundwater e greatest exten			
	Altered groundwater– surface water exchange		Year-round (with stressor exposure occurring during juvenile rearing)	Permanent	Continuous		and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through				
	Addition of impervious surface		Year-round	Permanent	Continuous		reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected				
	Marine										
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that comprise the nearshore ecosystem. Alteration in one or	Carefully eval design and co of impact mee the project. E project design			
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent	more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile coastal cutthroat trout. This may occur through a number of specific stressors,	on sediment s patterns, and current pattern				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous	habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can resu decreased growth and productivity, decreased fitness for marine migration, and direct mortality.					
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous						
	Addition of impervious surface		Year-round	Permanent	Continuous						

imization Measures	Resulting Effects of the Submechanism
evaluate project siting and d consider the magnitude mechanisms produced by t. Encourage selection of signs that minimize effects d geometry, flow velocity, composition, and ter exchange to the stent practicable.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness.
evaluate project siting and d consider the magnitude mechanisms produced by t. Encourage selection of signs that minimize effects ent supply, longshore drift and wave energy and tterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.

		Expo	sure							
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minim			
Lacustrine										
Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that	Carefully eva design and co of impact me the project. H			
Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common	n compose the nearshore ecosystem. in one or more of these parameters of fundamentally alter lacustrine littora potentially decreasing the suitability		project design on sediment s patterns, and current patter			
Altered sediment supply	7	Year-round	Permanent	Continuous		habitat for juvenile and migratory habitat for	current patter			
Altered substrate composition		Year-round	Permanent	Continuous		adult coastal cutthroat. This may occur through a number of specific stressors, including increased exertion and stress due to				
Altered groundwater– surface water exchange		Year-round	Permanent	Continuous	-	change in current and wave energy patterns, increased predation exposure due to reduced	1			
Addition of impervious surface		Year-round	Permanent	Continuous		cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. <u>Adults</u> : Adult cutthroat trout will generally be				
					V	less sensitive to these stressors. However, increased stress and delayed migration may reduce fitness and ultimately reduce spawning success.				
Ecosystem Fragmentation	Ecosystem Fragmentation									
Riverine		•								
Habitat loss and fragmentation	Fragmentation of side channel and floodplain habitat; change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Bank barbs and groins can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require asses effects of the permitting; av that lead to di floodplain ha			
Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No specific re			
Marine			1	1	1					
Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u> : Bank barbs and groins in the marine environment can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require struct footprint neco project object projects in art cumulative et prevalent.			
							1			

imization Measures	Posulting Efforts of the Submechanism
	Resulting Effects of the Submechanism
evaluate project siting and l consider the magnitude mechanisms produced by t. Encourage selection of signs that minimize effects nt supply, longshore drift nd wave energy and tterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
essessment of the hydraulic the project before ; avoid permitting designs o disconnection of habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
c recommendations.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
ructures with the minimal necessary to achieve jectives. Avoid permitting a reas where significant e effects are already	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.

Sub- activity Type			Expo	sure				
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minin
	Loss of LWD recruitment	Reduced availability of LWD from drift.	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend
		Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs						adjacent bea otherwise b where appro maintenanc
		Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover						
	Lacustrine							
	Habitat loss and	Change in habitat structure and	Year-round	Permanent	Continuous	Juveniles;	All exposed life-history stages: Bank barbs	Require stru
	fragmentation	habitat suitability, reduced food web complexity, and reduced habitat availability and suitability				Adults	and groins in lacustrine environments can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	footprint ne project obje projects in a cumulative prevalent.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend accumulation adjacent beat otherwise b where appro- maintenance

#### Table A-7 (continued).HPA HCP Shoreline M

imization Measures	Resulting Effects of the Submechanism
nd moving LWD tions on the structures to seaches where they would be naturally deposited, propriate during nee.	May affect juvenile survival.
ructures with the minimal necessary to achieve jectives. Avoid permitting n areas where significant e effects are already	May affect survival at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
nd moving LWD tions on the structures to weaches where they would be naturally deposited, propriate during nce.	May affect juvenile survival.

ub-			Exp	osure				Resulting Effects of the	
ctivity Sype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
etties									
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<ul> <li><u>Adults and juveniles</u>: Stressor response dependent on noise magnitude, project- specific environmental conditions; may range from:</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work-areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality o injury and/or affect survival, growth, and fitness of exposed life-history stages, depending on project-specific noise intensity and receptor exposure
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect juvenile survival, growth, and fitness due to avoidance behavior decreased foraging success, and increased predation risk. May affect adult fitness due to decreased foraging success.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated; reduced growth and fitness, and increased predation exposure. Adults: Decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality or injury t affected life-history stages. May affe survival, growth, and fitness at juvenile and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work window. Avoid use when juveniles are present.	May affect survival, growth, and fitness at juvenile life-history stage.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.	Adhere to system-specific in-water work windows.	May affect growth and fitness at juvenile life-history stage; may affect adult spawning productivity.
							<u>Adults</u> : Stress and behavioral modifications by adult spawners exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.		
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

# Table A-8. HPA HCP Shoreline Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

# Table A-8 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-			Exp	osure				Resulting Effects of the	
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Adults and juveniles</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	See effects for related stressors under Water Quality Modification.
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	Adults and juveniles: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Adults and juveniles: See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Altered migratory behavior. Decreased foraging opportunity due to short- term reduction in prey availability. Decreased growth and fitness.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.
							<u>Adults and juveniles</u> : See responses described for related stressors under Water Quality Modification.		
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Adults and juveniles</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure that project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival, growth, and fitness. Reduced adult fitness may affect spawning success.
							<u>Adults</u> : Decreased spawning success resulting from reduced fitness.		
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Adults and juveniles</u> : Mortality in acute low dissolved oxygen events due to asphyxiation. Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Avoid sediment pulses.	May affect juvenile and adult survival, growth, and fitness. Reduced adult fitness may affect spawning success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Adults and juveniles</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect juvenile and adult survival, growth, and fitness. Reduced adult fitness may affect spawning success.

# Table A-8 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

		Expo	osure				Resulting Effects of the	
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Use of creosote-treated wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Juveniles; Adults	Adults and juveniles: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated-wood particulates.	May affect juvenile and adult surviv growth, and fitness. Reduced adult fitness may affect spawning success.
Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	Adults and juveniles: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
Riparian Vegetation Modification								
Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	<u>Adults and juveniles</u> : Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of lake stratification, reservoir current patterns, wind conditions, and other factors. However, shallow littoral habitats may experience increased temperatures due to lack of shade, leading to decreased availability of refuge and forage habitat, increased competition, and increased predation exposure.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity.
Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Native trout dependence on allochthonous inputs from riparian vegetation is a data gap. However, native trout are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth, fitness, and productivity.

# Table A-8 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-			Ехро	osure	-				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival and productivity, spawning success, and overall population productivity.
	Altered groundwater- surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Native trout dependence on groundwater inflow to nearshore habitats is currently a data gap.	Avoid disturbance of vegetation along stream.	Effects of the action resulting from this impact mechanism are unknown.
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect juvenile productivity.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	<u>Adults and juveniles</u> : See related stressor responses under Water Quality Modification.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation	See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition, and resulting effects on growth and fitness.	rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring.	May affect juvenile survival and productivity.

		Expo	osure					Deculting Effects of the
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Hydraulic and Geomorphic Modification								
Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project	May affect survival and productiv juvenile life-history stage. Decre fitness may lead to reduced spaw productivity.
Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent Common in one or more of these parameters can sediment supply fundamentally alter lacustrine littoral habitats, patterns, and w	designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.				
Altered nearshore circulation patterns	-	Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		habitat for juvenile and migratory habitat for adult native trout. This may occur through a number of specific stressors, including	auterns.	
Altered sediment supply	_	Year-round	Permanent	Continuous		increased exertion and stress due to change in		
Altered substrate composition		Year-round	Permanent	Continuous		current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web		
Altered groundwater- surface water exchange		Year-round	Permanent	Continuous		alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of		
Addition of impervious surface		Year-round	Permanent	Continuous		these stressors can result in decreased growth and fitness, and direct mortality.		
						<u>Adults</u> : Adult native trout will generally be less sensitive to these stressors. However, increased stress and inhibited movement may reduce fitness and ultimately reduce spawning success.		
Ecosystem Fragmentation								
Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : Jetties can fragment nearshore lacustrine rearing habitats, forcing migrating and foraging salmonids to navigate offshore into deeper water environments. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile li history stage. Decreased fitness lead to reduced spawning produc
Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.
waters								
Construction and Maintenance Activities								

Sub- activity			Exp	osure	1	1			Resulting Effects of the
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<ul> <li><u>Adults and juveniles</u>: Stressor response dependent on noise magnitude, project-specific environmental conditions; may range from:</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work-areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality or injury and/or affect survival, growth, and fitness of exposed life-history stages, depending on project-specific noise intensity and receptor exposure.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect juvenile survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk. May affect adult fitness due to decreased foraging success.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. <u>Juveniles</u> : Increased competition once relocated; reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality or injury to affected life-history stages. May affect survival, growth, and fitness at juvenile and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work window. Avoid use when juveniles are present.	May affect survival, growth, and fitness at juvenile life-history stage.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adult spawners exposed to sediment pulses,	Adhere to system-specific in-water work windows.	May affect growth and fitness at juvenile life-history stage; may affect adult spawning productivity.
							migration delay, reduced foraging opportunities, and increased predation risk.		
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Adults and juveniles</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	See effects for related stressors under Water Quality Modification.

Sub-			Exp	osure	1				Resulting Effects of the
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	<u>Adults and juveniles</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Adults and juveniles</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Altered migratory behavior. Decreased foraging opportunity due to short- term reduction in prey availability. Decreased growth and fitness.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.
							<u>Adults and juveniles</u> : See responses described for related stressors under Water Quality Modification.		
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Adults and juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure that project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival, growth, and fitness. Reduced adult fitness may affect spawning success.
							<u>Adults</u> : Decreased spawning success resulting from reduced fitness.		
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Adults and juveniles</u> : Mortality in acute low dissolved oxygen events due to asphyxiation. Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Avoid sediment pulses.	May affect juvenile and adult survival, growth, and fitness. Reduced adult fitness may affect spawning success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Adults and juveniles</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect juvenile and adult survival, growth, and fitness. Reduced adult fitness may affect spawning success.

ub-			Expo	osure	1	1		
ctivity ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Use of creosote-treated wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Juveniles; Adults	Adults and juveniles: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Pron woo acco Avoi prod alter galva recy when woo mate or m avoid treat
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	Adults and juveniles: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Rem wood with Men place and c and c appro
	Aquatic Vegetation Modification							
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continúous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Desi footp aqua exter
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Adults and juveniles: See related stressor responses under Water Quality Modification.	<u>Cons</u> distu durir
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition, and resulting effects on growth and fitness.	
	Hydraulic and Geomorphic Modification							
	Riverine			-	-	-		
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and	Care desig impa
	Altered flow velocity	rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may	proje proje on cl subs grou
	Altered substrate composition (including placement of non- erodable substrate)		Year-round	Permanent	Continuous		lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning	exter

Minimization Measures	Resulting Effects of the Submechanism
omote removal of creosote-treated bod and prevent new uses in cordance with pertinent regulations. void use of other treated wood bolucts where practicable. Use ernative materials such as concrete, lvanized steel, plastic lumber, cycled plastics, and plastic coatings here practicable. Where treated bod is necessary, use dense-grained aterial to limit leaching. Use plastic metal cuffs at abrasion points to oid fragmentation and release of ated-wood particulates. <u>emoval</u> : Completely remove treated bod where practicable, consistent th WDNR Standard Practice emorandum. When piles are left in ace, cut off at least 2 ft below surface d cap with clean sediment. Contain d capture sawdust for disposal at proved facility.	May affect juvenile and adult survival, growth, and fitness. Reduced adult fitness may affect spawning success.
<u>esign</u> : Limit project structural otprint to minimize shading of uatic vegetation to the greatest tent practicable.	May affect juvenile productivity.
onstruction: Avoid/minimize sturbance of aquatic vegetation ring project construction.	See effects for related stressors under Water Quality Modification.
	May affect juvenile survival and productivity.
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selections of oject designs that minimize effects channel geometry, flow velocity, bstrate composition, and oundwater exchange to the greatest tent practicable.	May affect juvenile survival, growth and fitness. May affect adult spawning fitness.

			Expo	osure					<b>Resulting Effects of the</b>
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	<b>Minimization Measures</b>	Submechanism
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during juvenile rearing)	Permanent	Continuous		success.		
	Addition of impervious surface	Alteration in the magnitude, volume, and timing of peak flows	During storm events (predominantly from fall through spring)	Permanent	Common	Juveniles; Adults	<u>Adults and juveniles</u> : Because the amount of impervious surface associated with breakwaters is a relatively inconsequential component of the overall drainage area of the larger river systems that would support this type of development, the magnitude of the hydrologic modification stressor is expected to be negligible. As such, this stressor is not expected to significantly affect the riverine environment, and there will therefore be no response to the stressor.	Encourage facilities to employ modern low-impact development and stormwater treatment technology.	Impervious surface at anticipated so would not produce stressors of sufficient magnitude to adversely affect native trout at any life-history stage.
	Lacustrine			•				•	
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project	May affect survival and productivit juvenile life-history stage. Decreas fitness may lead to reduced spawni productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing	designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns. For example:	
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal	V	habitat for juvenile and migratory habitat for adult native trout. This may occur through a number of specific stressors, including	patterns. For example.	
	Altered sediment supply		Year-round	Permanent	Continuous		increased exertion and stress due to change in current and wave energy patterns, increased		
	Altered substrate composition		Year-round	Permanent	Continuous		predation exposure due to reduced cover or exposure to deep water habitat, food web		
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous		alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of		
	Addition of impervious surface		Year-round)	Permanent	Continuous		these stressors can result in decreased growth and fitness, and direct mortality.		
							<u>Adults</u> : Adult native trout will generally be less sensitive to these stressors. However, increased stress and inhibited movement may reduce fitness and ultimately reduce spawning success.		
	Ecosystem Fragmentation				1				
[	Riverine								
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile survival.
	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No specific recommendations.	May affect juvenile growth and survival, as well as spawning succ and overall population productivit

Sub-			Expe	osure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Requ footp objec in are effect
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recon accur adjace other where

Sub-			Exp	osure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile survival.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.
Groins	s and Bank Barbs	6							
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<ul> <li><u>Adults and juveniles</u>: Stressor response dependent on noise magnitude, project- specific environmental conditions; may range from:</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work-areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality or injury and/or affect survival, growth, and fitness of exposed life-history stages, depending on project-specific noise intensity and receptor exposure.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect juvenile survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk. May affect adult fitness due to decreased foraging success.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated; reduced growth and fitness, andincreased predation exposure.Adults:Decreased fitness and spawningsuccess.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality or injury to affected life-history stages. May affect survival, growth, and fitness at juvenile and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work window. Avoid use when juveniles are present.	May affect survival, growth, and fitness at juvenile life-history stage.

Table A-8 (continued).	HPA HCP Shoreline Modification Exposure and Response Matrix for Native Trout (Westslope Cutthro	oat a
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			Exp	oosure					
Mee	echanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Increased stress; decreased spawning	Limit alteration of flow conditions to minimal area.	May affect juvenile growth and fitne may affect adult spawning productivity.
							<u>Aduits</u> : increased stress; decreased spawning fitness.		
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adult spawners exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.	Adhere to system-specific in-water work windows.	May affect growth and fitness at juvenile life-history stage; may affe adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	See effects for related stressors und Water Quality Modification.
	struction/maintenanc edging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	J <mark>uvenile</mark> s; Adults	<u>Adults and juveniles</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors und Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Adults and juveniles: See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors und Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Altered migratory behavior. Decreased foraging opportunity due to short- term reduction in prey availability. Decreased growth and fitness.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	May affect juvenile growth and fith See effects for related stressors und Water Quality Modification.
							<u>Adults and juveniles</u> : See responses described for related stressors under Water Quality Modification.		

## t and Redband Trout).

Sub-			Expo	osure	1				Resulting Effects of the
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Adults and juveniles</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Decreased spawning success resulting	Ensure that project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival, growth, and fitness. Reduced adult fitness may affect spawning success.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	from reduced fitness. <u>Adults and juveniles</u> : Mortality in acute low dissolved oxygen events due to asphyxiation. Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Avoid sediment pulses.	May affect juvenile and adult survival, growth, and fitness. Reduced adult fitness may affect spawning success.
	Use of creosote-treated wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Juveniles; Adults	<u>Adults and juveniles</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated-wood particulates.	May affect juvenile and adult survival, growth, and fitness. Reduced adult fitness may affect spawning success.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	<u>Adults and juveniles</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	

		Exp	oosure		1	4		Resulting Effects of the
Mechanism of Impa	ct Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Riparian Vegetation Modification								
Riverine								
Altered riparian shadii	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	<u>Adults and juveniles</u> : Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. <u>Juveniles</u> : Altered growth and productivity caused by temperatures outside optimal	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
Altered ambient air temperature regime						growth range, and alteration of food web patterns. <u>Adults</u> : Decreased spawning fitness due to inhibited or delayed movement caused by thermal barriers.		
Altered stream bank a shoreline stability	nd Increased suspended solids; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high-flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	turbidity as described for related stressor responses under Water Quality Modification. Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of juveniles.
Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality and decreased fitness and spawning success due to decreased availability of suitable habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect survival, growth, and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
Altered groundwater surface water exchang	Reduced available suitable habitat; e reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : Decreased availability of thermal refuge habitat, resulting in increased thermal stress; increased competition for suitable habitats. <u>Adults</u> : Decrease in suitable habitat, increased competition, decreased spawning fitness and success.	Avoid permitting of projects in areas with springs, seeps, or other sources of significant groundwater recharge. Limit alteration of riparian vegetation to greatest extent practicable.	May affect juvenile survival, growth and fitness. May affect adult spawni productivity.

		Expe	osure			-		Resulting Effects of the
Mechanism of Impa	ct Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Lacustrine								
Altered riparian shadi Altered ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	<u>Adults and juveniles</u> : Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of lake stratification, reservoir current patterns, wind conditions, and other factors. However, shallow littoral habitats may experience increased temperatures due to lack of shade, leading to decreased availability of refuge and forage habitat, increased competition, and increased predation exposure.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity.
Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Native trout dependence on allochthonous inputs from riparian vegetation is a data gap. However, native trout are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth, fitness, and productivity.
Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival and productivity, spawning success, and overall population productivity.
Altered groundwater- surface water exchang	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Native trout dependence on groundwater inflow to nearshore habitats is currently a data gap.	Avoid disturbance of vegetation along stream.	Effects of the action resulting from the impact mechanism are unknown.
Aquatic Vegetation Modification								
Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect juvenile productivity.
	Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Adults and juveniles: See related stressor responses under Water Quality Modification.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	See effects for related stressors unde Water Quality Modification.
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition, and resulting effects on growth and fitness.		May affect juvenile survival and productivity.

			Expe	osure					Degulting Effects of the
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect juvenile survival, growth and fitness. May affect adult spawnin fitness.
	Altered flow velocity	rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	project. Encourage selections of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest	
	Altered substrate composition (including placement of non- erodable substrate)		Year-round	Permanent	Continuous		<u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success.	extent practicable.	
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during juvenile rearing)	Permanent	Continuous				
	Addition of impervious surface		Year-round	Permanent	Continuous				
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project	May affect survival and productivity juvenile life-history stage. Decrease fitness may lead to reduced spawnin productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing	designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns. For example:	
ľ	Altered sediment supply		Year-round	Permanent	Continuous		habitat for juvenile and migratory habitat for	patients. For example.	
	Altered substrate composition		Year-round	Permanent	Continuous		adult native trout. This may occur through a number of specific stressors, including increased exertion and stress due to change in		
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous		current and wave energy patterns, increased predation exposure due to reduced cover or		
	Addition of impervious surface		Year-round	Permanent	Continuous		exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and fitness, and direct mortality.		
					Adults:       Adult native trout will generally be less sensitive to these stressors. However, increased stress and inhibited movement may reduce fitness and ultimately reduce spawning success.				

ıb-			Ex	posure					
tivity /pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation							-	-
	Riverine								
	Habitat loss and fragmentation	Fragmentation of side channel and floodplain habitat; change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Bank barbs and groins can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No specific recommendations.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : Bank barbs and groins in lacustrine environments can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivity
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.

Sub-			Expos	ure					Resulting Effects of the
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Jetties									
	Construction and Maintenance Activities						· ·		
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<ul> <li><u>All life-history stages</u>: Stressor response, dependent on noise magnitude, project-specific environmental conditions, may range from:</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work window. Use double confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden piles where practicable.	Activity may cause direct mortality or injury, and/or affect survival, growth, and fitness, of exposed life-history stages depending on project-specific noise intensity and receptor exposure.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect juvenile survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk. May affect adult fitness due to decreased foraging success.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles:Mortality, injury, or stress from capture, handling, and relocation.Juveniles:Increased competition once relocated, reduced growth and fitness, and increased predation exposure.Adults:Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality or injury to affected life-history stages. May affect survival, growth, and fitness at juvenile and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work window. Avoid use when juveniles are present.	May affect survival and fitness at juvenile life-history stage
		Altered current and circulation conditions (marine and lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal depending on activity frequency	Juveniles; Adults	Juveniles:Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.Adults:Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness, potentially limiting survival during ocean migration; may affect adult spawning productivity.

vity			Exposu	ire					Resulting Effects of the	
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism	
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal depending on activity frequency	Eggs and alevins; Juveniles;	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance.	Adhere to system-specific in-water work window. Avoid work during egg incubation periods.	May affect egg and alevin incubation success and survival; may affect growth and fitness at juvenile life-	
						Adults	<u>Juveniles</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.		history stage; may affect adult spawning fitness.	
							<u>Adults</u> : Stress and behavioral modifications by adult spawners exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.			
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal depending on activity frequency	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, and decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.	
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal depending on activity frequency	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	See effects for related stressors under Water Quality Modification.	
-	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.	
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors unde Aquatic Vegetation Modification.	
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Altered migratory behavior; decreased foraging opportunity due to short- term reduction in prey availability; decreased growth and fitness.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	May affect juvenile growth and fitner See effects for related stressors under Water Quality Modification.	
							<u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.			
	Water Quality Modification									
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at all life-history stages. Reduced adult fitness may affect spawning success.	
							<u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.			

Sub-			Exposu	ire	-	-	_		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short-term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Stress and other physiological responses to levels outside optimal thresholds causing mortality or injury leading to reduced fitness.	Avoid sediment pulses.	Egg and alevin exposure is unlikely as bull trout and Dolly Varden spawning habitat is typically in areas unsuitable for jetty development. May affect survival, growth, and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
		Altered pH levels.	Dependent on contributing mechanism of impact	Temporary to short-term depending on contributing mechanism of impact	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid curing of concrete or discharge of concrete leachate to surface waters.	Egg and alevin exposure is unlikely as bull trout and Dolly Varden spawning habitat is typically in areas unsuitable for jetty development. May affect survival, growth, and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
	Use of creosote-treated Wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Juveniles; Adults	<u>Adults and juveniles</u> : Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.	Egg and alevin exposure is unlikely as bull trout and Dolly Varden spawning habitat is typically in areas unsuitable for jetty development. May affect survival, growth, and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
	Use of ACZA and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	Adults and juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at sub-acute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Removal: Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	

			Expos	ure					Resulting Effects of the
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Riparian Vegetation Modification							-	
ľ	Marine								
it	Altered shading, solar nput, ambient air emperature	Expansion of thermal regime (i.e., increased localized summer temperatures)	Year-round (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Adults and juveniles: Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, adult char trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence have been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	May affect growth and fitness of juveniles and adults. Reduced adu fitness may lead to decreased spawning success.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	Adults and juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect growth and fitness of juveniles and adults. Reduced ad fitness may lead to decreased spawning success.
	Altered allochthonous nputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduced organic matter inputs. Reduced large woody debris recruitment affecting habitat complexity (see below)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Char dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, the dependence on terrestrial insect fall as a food source may be limited as adult char are primarily piscivorous. Indirect effects on food web productivity may decrease foraging opportunities, leading to decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect growth and fitness of juveniles and adults. Reduced ad fitness may lead to decreased spawning success.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect growth and fitness of juveniles and adults. Reduced ad fitness may lead to decreased spawning success.
	Altered groundwater surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles; Adults		Avoid disturbance of vegetation along stream.	

			Exposu	ire		-			
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification						•		
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect growth and fitness at juvenile and adult life-history stages. Reduced adult fitness may affect spawning success.
	Altered habitat complexity	Reduced food web productivity, foraging opportunity, available cover, and available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Adult and juveniles</u> : Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from propeller wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	May affect survival, growth, and fitness at juvenile and adult life-histor stages. Reduced adult fitness may affect spawning success.
	Lacustrine	•							
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Char dependence on littoral lacustrine vegetation is relatively limited as this species tends to occupy cold water river habitats and deepwater lacustrine	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect growth and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	habitats in the photic or profundal zone where aquatic vegetation is limited or non-existent. Therefore, modification of aquatic vegetation may have limited direct effects on this species. However, such alterations may limit the	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation	
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	productivity of prey species for native char, leading to decreased foraging opportunity and decreased growth and fitness.	rules to limit submerged aquatic vegetation damage from propeller wash, grounding and anchoring.	

			Exposu	ire			4		Resulting Effects of the
Mechanism	n of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Hydraulic an Geomorphic Modification	с								
Marine									
Altered wave	e energy	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round, with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of	May affect survival and productivity juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
Altered curre velocities	ent		Year-round, with variable effects depending on site-specific current dynamics and project configuration	Permanent	Intermittent		compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of foraging habitats for adult char. This may	project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	
Altered nears circulation pa			Year-round, with seasonally variable effects depending on site-specific, geography and bathymetry and project configuration	Permanent	Seasonal		occur through a number of specific stressors, including change in current and wave energy patterns, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and fitness, and potentially decreased survival due to predation exposure.		
Altered sedir	ment supply		Year-round, beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
Altered subst composition			Year-round, beginning with project installation and becoming more pronounced over time (e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching)	Permanent	Continuous				
Altered group surface water			Year-round	Permanent	Continuous	_			
Addition of i surface	impervious		Year-round	Permanent	Continuous				
Lacustrine									
Altered wave (short-period		Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round, with predominant effects from fall through spring when wind driven waves are most pronounced	Permanent	Continuous	Juveniles: Adults	<u>Juveniles and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project	May affect survival at juvenile li history stage. May affect result i decreased growth and fitness at a life-history stage.
Altered curre velocities	ent		Year-round, with effects more predominant in reservoirs versus natural lakes	Permanent	Common		compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats.	designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	
Altered nears circulation pa			Year-round, with variable effects by season (e.g., circulation patterns)	Permanent	Seasonal		Use of these habitats by adult char is limited, as these species tend to utilize cold, deepwater habitats in the photic and profundal zone. However, reduction in nearshore habitat productivity may affect abundance of potential prey species, reducing adult foraging opportunity and leading to decreased growth and fitness.	panoins.	
Altered sedir	ment supply		Year-round	Permanent	Continuous	1			
Altered subst	strate		Year-round	Permanent	Continuous				
Altered group surface water		Ye	Year-round	Permanent	Continuous	and fitness.			
Addition of i surface	impervious		Year-round	Permanent	Continuous				

			Exposi	ire	-	_	_		
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	-						-	-
]	Marine								
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u> : Jetties can fragment nearshore marine rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity a juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Loss of LWD recruitment	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.
	Lacustrine						1	I	
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : Jetties can fragment nearshore lacustrine rearing habitats, forcing migrating and foraging salmonids to navigate offshore into deeper water environments. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivity.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.

### Sub-Exposure activity **Mechanism of Impact Response to Stressor** When Duration Life-history Form Туре Stressor Frequency **Breakwaters** Construction and **Maintenance Activities** All life-history stages: Stressor response, Pile driving Increased underwater noise levels During project construction and Temporary Interannual to Juveniles; Av (auditory masking) decadal (during dependent on noise magnitude, projectimp maintenance activities Adults to short-term specific environmental conditions, may range NÖ project construction (hearing threshold and maintenance) hat from: effects) dri Fatal injury or permanent auditory tissue do damage limiting to survival. red Increased predation risk and decreased con foraging success due to auditory masking En and/or temporary hearing threshold an effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. Increased or altered ambient noise Interannual to Juveniles; Adults and juveniles: Auditory masking or Av Construction vessel During project construction and Temporary operation decadal (during temporary hearing threshold effects may levels maintenance activities (auditory masking) lim Adults to short-term project construction increase risk of predation and/or decrease ves (hearing threshold and maintenance) foraging efficiency due to decreased ability to ant effects) sense predators and/or prey. pra Juveniles; Adults and juveniles: Mortality, injury, or Us Channel/work area Fish removal, relocation, and During project construction and Short-term Interannual to decadal (depending stress from capture, handling, and relocation. Fis dewatering exclusion maintenance activities Adults on activity av Juveniles: Increased competition once frequency) relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success. Entrainment in pumps or During project construction and Short-term Interannual to Juveniles Juveniles: Injury or mortality from Ins impingement on pump screens maintenance activities decadal (depending entrainment or impingement. con on activity Ad frequency) WO juv Li Altered flow conditions (riverine) During project construction and Short-term Interannual to Juveniles; Juveniles: Altered habitat suitability, decadal (depending increased stress, increased competition, maintenance activities miı Adults decreased growth and fitness. on activity frequency) Adults: Delayed migration, increased stress, decreased spawning fitness. During project construction and Juveniles: Altered habitat suitability, Liı Altered current and circulation Short-term Interannual to Juveniles; decadal depending on conditions (marine and lacustrine) maintenance activities increased stress, increased competition, cire Adults activity frequency decreased growth and fitness. pra Adults: Delayed migration, increased stress, decreased spawning fitness

Minimization Measures	Resulting Effects of the Submechanism
void pile-driving noise in excess of npact thresholds established by OAA Fisheries and USFWS in abitats used by species. Limit pile riving to in-water work window. Use puble confined bubble curtain to educe sound pressure, or work within onfined or dewatered work areas. ncourage use of vibratory hammers and wooden piles where practicable.	Activity may cause direct mortality or injury, and/or affect survival, growth, and fitness, of exposed life-history stages depending on project-specific noise intensity and receptor exposure.
void/minimize propeller cavitation to mit noise intensity. Promote use of essels equipped with antinoise/ ntivibration technology where racticable.	May affect juvenile survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk. May affect adult fitness due to decreased foraging success.
se protocols established by NOAA isheries and WDFW/WSDOT to yoid and minimize impacts.	May cause direct mortality or injury to affected life-history stages. May affect survival, growth, and fitness at juvenile and adult life-history stages.
stall and maintain pump screens onsistent with WDFW protocols. dhere to system-specific in-water ork window. Avoid use when veniles are present.	May affect survival and fitness at juvenile life-history stage
imit alteration of flow conditions to inimal area.	May affect survival, growth, and fitness during egg and alevin life- history stage; may affect juvenile growth and fitness; may affect adult spawning fitness.
imit alteration of current and rculation patterns to greatest extent racticable to minimal area.	May affect juvenile growth and fitness, potentially limiting survival during ocean migration; may affect adult spawning productivity.

<b>)-</b>			Exposu	ire		•			Describing Effects of the
ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal depending on activity frequency	Eggs and alevins; Juveniles;	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance.	Adhere to system-specific in-water work window. Avoid work during egg incubation periods.	May affect egg and alevin incubation success and survival; may affect growth and fitness at juvenile life-
						Adults	<u>Juveniles</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.		history stage; may affect adult spawning fitness.
							<u>Adults</u> : Stress and behavioral modifications by adult spawners exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.		
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal depending on activity frequency	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, and decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal depending on activity frequency	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	See effects for related stressors under Water Quality Modification.
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Altered migratory behavior; decreased foraging opportunity due to short- term reduction in prey availability; decreased growth and fitness.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	May affect juvenile growth and fitness See effects for related stressors under Water Quality Modification.
							<u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.		
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at all life-history stages. Reduced adult fitness may affect spawning success.
							<u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.		

Sub-			Exposu	ire		1			<b>Resulting Effects of the</b>
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short-term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Stress and other physiological responses to levels outside optimal thresholds causing mortality or injury leading to reduced fitness.	Avoid sediment pulses.	Egg and alevin exposure is unlikely as bull trout and Dolly Varden spawning habitat is typically in areas unsuitable for breakwater development May affect survival, growth, and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short-term depending on contributing mechanism of impact	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid curing of concrete or discharge of concrete leachate to surface waters.	Egg and alevin exposure is unlikely as bull trout and Dolly Varden spawning habitat is typically in areas unsuitable for breakwater development. May affect survival, growth, and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
	Use of creosote-treated Wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Juveniles; Adults	Adults and juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of	Egg and alevin exposure is unlikely as bull trout and Dolly Varden spawning habitat is typically in areas unsuitable for breakwater development. May affect survival, growth, and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
	Use of ACZA and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	<u>Adults and juveniles</u> : Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at sub-acute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	

			Exposu	ire		4		Resulting Effects of the	
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Aquatic Vegetation Modification								
F	Riverine								
	Altered autochthonous roduction	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. Construction: Avoid/minimize disturbance of aquatic vegetation	May affect juvenile growth and fitness.
								during project construction.	
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
Δ	Altered habitat	Reduced food web productivity,	growth is most extensive) Year-round	Short-term to	Continuous	Juveniles;	Juveniles: Decreased refuge habitat		M (C ( ' ') ') (
	complexity	reduced foraging opportunity, reduction in available cover	i cai-iouna	permanent	Continuous	Adults	availability and foraging opportunities,		May affect juvenile survival, growth, and fitness, as well as adult spawning
		reduction in available cover		(dependent on nature of			leading to increased competition and resulting effects on growth and fitness.		productivity.
				activity)		60	<u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable		productivity.
							migratory and spawning habitat.		
	Marine	I	1	1			T	1	1
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> :	May affect growth and fitness at juvenile and adult life-history stages. Reduced adult fitness may affect spawning success.
	Altered habitat complexity	Reduced food web productivity, foraging opportunity, available cover, and available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from propeller wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	May affect survival, growth, and fitness at juvenile and adult life-histo stages. Reduced adult fitness may affect spawning success.
Ι	Lacustrine		·						
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Char dependence on littoral lacustrine vegetation is relatively limited as this species tends to occupy cold water river habitats and deepwater lacustrine	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> :	May affect growth and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
		Altered dissolved oxygen levels	Year-round (most pronounced in	Permanent	Seasonal	Juveniles;	habitats in the photic or profundal zone where aquatic vegetation is limited or non-existent.	Avoid/minimize disturbance of aquatic vegetation during project construction.	
		due to reduced photosynthesis	spring and summer when vegetation growth is most extensive)			Adults	Therefore, modification of aquatic vegetation may have limited direct effects on this species.	<u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic	
	Altered habitat	Reduced food web productivity,	Year-round	Short-term to	Continuous	Juveniles;	However, such alterations may limit the productivity of prey species for native char,	vegetation damage from propeller wash, grounding and anchoring.	
c	complexity	reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)		permanent (dependent on nature of activity)		Adults	leading to decreased foraging opportunity and decreased growth and fitness.	and anothing.	

			Exposu	re	1	T	4		Resulting Effects of the
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced	Year-round	Permanent	Continuous	Juveniles Adults	<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect juvenile survival, growth and fitness. May affect adult spawn fitness. Effects on spawning and
	Altered flow velocity	spawning and rearing habitat availability and suitability	Year-round, with stressor exposure occurring during high flow events, fall through spring	Permanent	Seasonal		changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and	freshwater rearing habitat are unlikely, however, as the cold water streams preferred by these species are unsuitable sites for breakwater development.
	Altered substrate composition (including placement of non- erodable substrate)		Year-round	Permanent	Continuous		<u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning	groundwater exchange to the greatest extent practicable.	
	Altered groundwater- surface water exchange		Year-round, with stressor exposure occurring during egg incubation and juvenile rearing	Permanent	Continuous		success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		
	Addition of impervious surface	Alteration in the magnitude, volume, and timing of peak flows	During storm events, predominantly from fall through spring	Permanent	Common	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Because the amount of impervious surface associated with breakwaters is a relatively inconsequential component of the overall drainage area of the larger river systems that would support this type of development, the magnitude of the hydrologic modification stressor is expected to be negligible. As such, this stressor is not expected to significantly affect the riverine environment, and there will therefore be no response to the stressor.	Encourage facilities to employ modern low impact development and stormwater treatment technology.	Impervious surface at anticipated sca would not produce stressors of sufficient magnitude to adversely affect char at any life-history stage. Effects on spawning and freshwater rearing habitat are also unlikely as th cold water streams preferred by these species are unsuitable sites for breakwater development.
_	Marine			L	· · · · · · · · · · · · · · · · · · ·		Also see Water Quality Modification above.		
-	Altered wave energy	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round, with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of	May affect juvenile and adult survivand growth.
	Altered current velocities		Year-round, with variable effects depending on site-specific current dynamics and project configuration	Permanent	Intermittent		compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of	project Encountge scheenons of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	
	Altered nearshore circulation patterns		Year-round, with seasonally variable effects depending on site-specific, geography and bathymetry and project configuration	Permanent	Seasonal		foraging habitats for adult char. This may occur through a number of specific stressors, including change in current and wave energy patterns, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The		
	Altered sediment supply		Year-round, beginning with project installation and becoming more pronounced over time	Permanent	Continuous		combined effect of these stressors can result in decreased growth and fitness, and potentially decreased survival due to predation exposure.	ly	

_			Exposu	ire				
ity	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered substrate composition		Year-round, beginning with project installation and becoming more pronounced over time (e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching)	Permanent	Continuous			
	Altered groundwater – surface water exchange		Year-round	Permanent	Continuous			
	Addition of impervious surface		Year-round	Permanent	Continuous			
	Lacustrine							
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round, with predominant effects from fall through spring when wind driven waves are most pronounced	Permanent	Continuous	Juveniles: Adults	Juveniles and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that	Care desi imp proj
	Altered current velocities		Year-round, with effects more predominant in reservoirs versus natural lakes	Permanent	Common		compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats. Use of these habitats by adult char is limited,	desi sedi patt patt
	Altered nearshore circulation patterns		Year-round, with variable effects by season (e.g., circulation patterns)	Permanent	Seasonal		as these species tend to utilize cold, deepwater habitats in the photic and profundal zone. However, reduction in nearshore habitat	pan
	Altered sediment supply		Year-round	Permanent	Continuous		productivity may affect abundance of potential prey species, reducing adult foraging	
	Altered substrate composition		Year-round	Permanent	Continuous	•	opportunity and leading to decreased growth and fitness.	
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous			
	Addition of impervious surface		Year-round	Permanent	Continuous			
	Ecosystem Fragmentation							
	Riverine							
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Req foot obje in a effe
	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No
	Marine							
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Req foot obje in a effe

Minimization Measures	Resulting Effects of the Submechanism
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on liment supply, longshore drift terns, and wave energy and current terns.	May affect juveniles and adult growth and fitness.
quire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative jects are already prevalent.	May affect juvenile survival.
specific recommendations.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	May affaat invanila1
quire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative jects are already prevalent.	May affect juvenile survival.

			Exp	osure	-	-		
ctivity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Loss of LWD recruitment	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Reco accur adjac other where
		to reduced organic matter inputs Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover						
	Lacustrine	•						
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile salmonids in the vicinity of the structure, leading to decreased survival.	Requi footp objec in are effect
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recon accum adjace other where

Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<ul> <li><u>All life-history stages</u>: Stressor response, dependent on noise magnitude, project- specific environmental conditions, may range from:         <ul> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul> </li> </ul>
Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.

Minimization Measures	Resulting Effects of the Submechanism
Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.
Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile survival.
Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.
Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work window. Use double confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden piles where practicable.	Activity may cause direct mortality or injury, and/or affect survival, growth, and fitness, of exposed life-history stages depending on project-specific noise intensity and receptor exposure.
Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect juvenile survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk. May affect adult fitness due to decreased foraging success.

Table A-9 (continued).	HPA HCP Shoreline Modification Exposure and Response Matrix for Bull Trout and Dolly Va	rden (
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•	-		Exposi	ıre	I	I			Resulting Effects of the
ity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. <u>Juveniles</u> : Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality or injury to affected life-history stages. May affec survival, growth, and fitness at juvenile and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work window. Avoid use when juveniles are present.	May affect survival and fitness at juvenile life-history stage
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival, growth, and fitness during egg and alevin life- history stage; may affect juvenile growth and fitness; may affect adult spawning fitness.
		Altered current and circulation conditions (marine and lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal depending on activity frequency	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect juvenile growth and fitness potentially limiting survival during ocean migration; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal depending on activity frequency	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance.Juveniles:Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.Adults:Stress and behavioral modifications by adult spawners exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.	Adhere to system-specific in-water work window. Avoid work during egg incubation periods.	May affect egg and alevin incubation success and survival; may affect growth and fitness at juvenile life- history stage; may affect adult spawning fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal depending on activity frequency	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, and decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal depending on activity frequency	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	See effects for related stressors under Water Quality Modification.
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.

## n (Native Char).

Sub-			Exposi	ure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Altered migratory behavior; decreased foraging opportunity due to short- term reduction in prey availability; decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at all life-history stages. Reduced adult fitness may affect spawning success.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short-term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Juveniles and adults</u> : Stress and other physiological responses to levels outside optimal thresholds causing mortality or injury leading to reduced fitness.	Avoid sediment pulses.	May affect survival, growth, and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
		Altered pH levels.	Dependent on contributing mechanism of impact	Temporary to short-term depending on contributing mechanism of impact	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid curing of concrete or discharge of concrete leachate to surface waters.	May affect survival, growth, and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.

• .			Exposu	ire	1				Resulting Effects of the
vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Use of creosote-treated Wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Juveniles; Adults	Adults and juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated	May affect survival, growth, and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
	Use of ACZA and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	Adults and juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at sub-acute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
	Riparian Vegetation Modification								
	Riverine								
	Altered shading, solar input, ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Juveniles: Altered growth and fitness caused by temperatures outside optimal growth range, and alteration of food web patterns.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
							<u>Adults</u> : Decreased spawning fitness due to migration delays caused by thermal barriers.		
	Altered streambank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high- flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
	Altored allock there are	Deduced recruitment of terrest.	Vaar round	Domenont	Continuous	Invarilas	<u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of	May affaat auguinal arough as 1
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduction in organic matter inputs.	Year-round	Permanent	Continuous	Juveniles	Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of juveniles.

,			Exposu	ire	I	4		<b>Resulting Effects of the</b>	
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality, and decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect survival, growth, and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
	Altered groundwater- surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Adults	<u>Adults</u> : Decreased availability of thermal refuge habitat, resulting in increased thermal stress, and increased competition for suitable habitats.	Avoid permitting of projects that disturb groundwater inflow areas with springs, seeps, or sources of significant groundwater recharge. Limit alteration of riparian vegetation to greatest extent practicable.	May affect adult survival, growth, a fitness. Reduced fitness may affect spawning success.
	Marine	•	•					•	
	Altered shading, solar input, ambient air temperature	Expansion of thermal regime (i.e., increased localized summer temperatures)	Year-round (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	<u>Adults and juveniles</u> : Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, adult char trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence have been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	May affect growth and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	<u>Adults and juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect growth and fitness of juveniles and adults. Reduced adul fitness may lead to decreased spawning success.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduced organic matter inputs. Reduced large woody debris recruitment affecting habitat complexity (see below)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Char dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, the dependence on terrestrial insect fall as a food source may be limited as adult char are primarily piscivorous. Indirect effects on food web productivity may decrease foraging opportunities, leading to decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect growth and fitness of juveniles and adults. Reduced adul fitness may lead to decreased spawning success.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect growth and fitness of juveniles and adults. Reduced adul fitness may lead to decreased spawning success.

		Exposu	ire	1		Resulting Effects of the		
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Altered groundwater surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and Adults</u> : Char dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along stream.	Effects of the action resulting from the impact mechanism are unknown.
Aquatic Vegetation Modification								
Riverine								
Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect juvenile growth and fitne
							<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	
	Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival, growth and fitness, as well as adult spawnin productivity.
						<u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		
Marine								
Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect growth and fitness at juvenile and adult life-history stages Reduced adult fitness may affect spawning success.
Altered habitat complexity	Reduced food web productivity, foraging opportunity, available cover, and available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Adult juveniles</u> : Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect survival, growth, and fitness at juvenile and adult life-histo stages. Reduced adult fitness may affect spawning success.
Lacustrine	•	•						•
Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Char dependence on littoral lacustrine vegetation is relatively limited as this species tends to occupy cold water river habitats and deepwater lacustrine	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> :	May affect growth and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
	Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	habitats in the photic or profundal zone where aquatic vegetation is limited or non-existent. Therefore, modification of aquatic vegetation may have limited direct effects on this species. However, such alterations may limit the	Avoid/minimize disturbance of aquatic vegetation during project construction.	
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	However, such alterations may limit the productivity of prey species for native char, leading to decreased foraging opportunity and decreased growth and fitness.		

			Exposi	ire				<b>Resulting Effects of the</b>				
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism			
	Hydraulic and Geomorphic Modification											
	Riverine											
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced	Year-round	Permanent	Continuous	Juveniles Adults	<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect juvenile survival, grow and fitness. May affect adult spaw fitness.			
	Altered flow velocity	spawning and rearing habitat availability and suitability	Year-round, with stressor exposure occurring during high flow events, fall through spring	Permanent	Seasonal		changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and				
	Altered substrate composition (including placement of non- erodable substrate)		Year-round	Permanent	Continuous		<u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning	groundwater exchange to the greatest extent practicable.				
	Altered groundwater- surface water exchange		Year-round, with stressor exposure occurring during egg incubation and juvenile rearing	Permanent	Continuous		success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to					
	Addition of impervious surface		Year-round	Permanent	Continuous		decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.					
	Marine			<b>I</b>								
	Altered wave energy	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round, with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of				
	Altered current velocities		Year-round, with variable effects depending on site-specific current dynamics and project configuration	Permanent	Intermittent		compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of foraging habitats for adult char. This may	project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.				
	Altered sediment supply		Year-round, beginning with project installation and becoming more pronounced over time	Permanent	Continuous		occur through a number of specific stressors, including change in current and wave energy patterns, food web alterations and decreased					
	Altered substrate composition		Year-round, beginning with project installation and becoming more pronounced over time (e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching)	Permanent	Continuous		foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and fitness, and potentially decreased survival due to predation exposure.					
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous							
	Addition of impervious surface		Year-round	Permanent	Continuous							

• /			Exposi	ire							
ity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor				
	Lacustrine										
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round, with predominant effects from fall through spring when wind driven waves are most pronounced	Permanent	Continuous	Juveniles: Adults	<u>Juveniles and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that	Care desig impa proje			
	Altered current velocities		Year-round, with effects more predominant in reservoirs versus natural lakes	Permanent	Common		compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats. Use of these habitats by adult char is limited,	desig sedir patte			
	Altered sediment supply	1	Year-round	Permanent	Continuous		as these species tend to utilize cold, deepwater	patte			
	Altered substrate composition		Year-round	Permanent	Continuous		habitats in the photic and profundal zone. However, reduction in nearshore habitat productivity may affect abundance of potential				
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous		prey species, reducing adult foraging opportunity and leading to decreased growth				
	Addition of impervious surface		Year-round	Permanent	Continuous		and fitness.				
	Ecosystem Fragmentation										
	Riverine										
	Habitat loss and fragmentation	Fragmentation of side channel and floodplain habitat; change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Bank barbs and groins can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Requ effec avoid disco			
	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No sj			
	Marine										
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u> : Bank barbs and groins in the marine environment can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor	Requ footp object in are effect			

Resulting Effects of the Submechanism
May affect juveniles and adult growth and fitness.
May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
May affect juvenile growth and survival, as well as spawning success and overall population productivity.
May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.

Sub-			Exposu	ire				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	
	Loss of LWD recruitment	Reduced availability of LWD from drift. Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Reccu accu adjac other when
	Lacustrine	cover						
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : Bank barbs and groins in lacustrine environments can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Requ footp object in are effect
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Reco accu adjac other when

Minimization Measures	Resulting Effects of the Submechanism
commend moving LWD cumulations on the structures to jacent beaches where they would nerwise be naturally deposited, nere appropriate during maintenance.	May affect juvenile survival.
quire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative fects are already prevalent.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivity.
commend moving LWD cumulations on the structures to jacent beaches where they would nerwise be naturally deposited, nere appropriate during maintenance.	May affect juvenile survival.

ıb-				Exposure					
tivity ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
etties									
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	<ul> <li><u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Rupture of egg membrane.</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work-areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles, Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitations to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles:Mortality, injury, or stressfrom capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, increasedpredation exposure.Adults:Delayed local migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival and productivity at juvenile and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival and fitness at juvenile life-history stage.
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect survival and productivity during egg and larvae life-history stage, may affect juvenile productivity; may affect adult spawning productivity.

# Table A-10. HPA HCP Shoreline Modification Exposure and Response Matrix for Pygmy Whitefish.

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## Table A-10 (continued).HPA HCP Shoreline Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-				Exposure					
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larvae survival due to turbidity exposure and substrate disturbance. Juveniles and adults: Stress and behavioral modifications by juveniles and adults exposed to sediment pulses, reduced foraging opportunities, and increased predation risk.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth at all life- history stages.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and productivity at juvenile life- history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses described above under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual-decadal	Eggs and larvae; Juveniles; Adults	<u>Juveniles and Adults</u> : Decreased foraging opportunity due to short-term reduction in prey availability. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile productivity and fitness. See effects for related stressors under Water Quality Modification.
	Water Quality Modification		-	· · · · ·					
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.

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Sub-				Exposure					
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short-term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation.(dissolved oxygen levels should be >5 ppm). <u>Juveniles and adults</u> : Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Avoid sediment pulses.	May affect juvenile survival and adult survival, and spawning productivity.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	<u>All life-history stages:</u> Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid sediment pulses.	May affect survival of all life- history stages.
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote- treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at	May affect survival of all life- history stages.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	

Sub-				Exposure					
ctivity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Riparian and Shoreline Vegetation Modification								
	Altered shading, solar input, ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures). Pygmy whitefish depend on cold water of 50°F or less. Therefore, increased temperatures will limit suitable habitat.	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of currents, wind conditions, and other factors. However, juveniles trapped in habitats with isolated water level changes may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Pygmy whitefish are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high- quality habitat features.	May affect juvenile survival and productivity, spawning success, and overall population productivity.
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Whitefish dependence upon groundwater inflow is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown.

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y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Actio
	Aquatic Vegetation Modification	-		-					
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. Construction: Avoid/minimize	May affect juvenile productivit
		Altered DO levels due to reduced photosynthesis.	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Alteration.	disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from	See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	prop wash, grounding, and anchoring.	May affect juvenile survival an adult spawning productivity.
	Hydraulic and Geomorphic Modification								
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with predominant effects from fall through spring when wind- driven waves are most pronounced)	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May decrease survival of eggs and larvae. May affect surviva and productivity at juvenile lif history stage. Decreased adult fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		fundamentally alter lacustrine littoral habitats, potentially leading to direct mortality and decreased survival of eggs and larvae (lacustrine spawning whitefish) and decreasing the suitability of rearing habitat for juvenile and adult whitefish. This may occur through a	patterns, and wave energy and current patterns.	
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to		
	Altered groundwater inputs		Year-round	Permanent	Continuous		deep water habitat, food web alterations and		
	Altered sediment supply		Year-round	Permanent	Continuous		decreased foraging opportunity, and increased competition for suitable habitats. The combined		
	Altered substrate composition		Year-round	Permanent	Continuous		effect of these stressors can result in decreased growth, fitness, and productivity, as well as direct mortality.		

ub-				Exposure					
tivity ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Ecosystem Fragmentation		-	-					
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Jetties can fragment nearshore lacustrine habitats. Larval and juvenile pygmy whitefish are known to occur in these habitat types, but knowledge of dependence on these habitats is limited. Given prevalence in these habitat types, however, stressor exposure may affect juvenile survival, growth, and fitness if habitat access is impaired.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile survival, growth, and fitness.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.
	Construction and Maintenance Activities			Τ_					
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	<ul> <li><u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Rupture of egg membrane.</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work-areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Effects on incubating eggs are unlikely as spawning occurs in habitats that are unsuitable for breakwater development.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles, Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitations to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.

				Exposure					
ty e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, increased predation exposure. Adults: Delayed local migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival and productivity at juvenile and adu life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival and fitness at juvenile life-history stage.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential substrate scour/or sedimentation, resulting in decreased incubation success. <u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration to spawning stream, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival and productivity during egg and juvenile life-history stages, may affect adult spawning productivity.
		Altered current and circulation conditions (lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larvae survival due to altered current and circulation conditions. <u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect survival and productivity during egg and larvae life-history stage, may affect juvenile productivity; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larvae survival due to turbidity exposure and substrate disturbance. Juveniles and adults: Stress and behavioral modifications by juveniles and adults exposed to sediment pulses, reduced foraging opportunities, and increased predation risk.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth at all life- history stages.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and productivity at juvenile life- history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described above under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.

Sub-				Exposure					
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality or injury from entrainment. Juveniles and Adults: Decreased foraging opportunity due to short-term reduction in prey availability. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile productivity and fitness. See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile growth and fitness and adult productivity and spawning success.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short-term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation.(dissolved oxygen levels should be >5 ppm). Juveniles and adults: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Avoid sediment pulses.	May affect juvenile survival and adult survival, and spawning productivity.

				Exposure					
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	<u>All life-history stages:</u> Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid sediment pulses.	May affect survival of juveniles and adults.
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote- treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at	May affect survival of juveniles and adults.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize	May affect juvenile productivity.
		Altered DO levels due to reduced photosynthesis.	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : See related stressor responses under Water Quality Alteration.	disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged	See effects for related stressors under Water Quality Modification.

Sub-				Exposure					
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	aquatic vegetation damage from prop wash, grounding, and anchoring.	May affect juvenile survival and adult spawning productivity.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae Juveniles Adults	Eggs and larvae: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased egg incubation success and survival. Pygmy whitefish dependence on groundwater inflow for incubation success is currently a data gap.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity,	May affect survival and productivity at egg, larvae, and juvenile life-history stages. May affect spawning productivity. Note that stressor exposure is unlikely to occur, as riverine habitats used by this species are
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events fall through spring)	Permanent	Seasonal		<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition	substrate composition, and groundwater exchange to the greatest extent practicable.	typically unsuitable for breakwater development.
	Altered substrate composition (including placement of non-erodable substrate)		Year-round	Permanent	Continuous		for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a		
	Altered groundwater inputs		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of spawning areas) if potential spawning habitat is affected		
	Addition of impervious surface	Alteration in the magnitude, volume, and timing of peak flows	During storm events (predominantly from fall through spring)	Permanent	Common	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : Because the amount of impervious surface associated with breakwaters is a relatively inconsequential component of the overall drainage area of the larger river systems that would support this type of development, the magnitude of the hydrologic modification stressor is expected to be negligible. As such, this stressor is not expected to significantly affect the riverine environment, and there will be no response to the stressor.	Encourage facilities to employ modern low-impact development and stormwater treatment technology.	Depending on the size of the additional impervious surface, the additional amount of impervious surface may not affect the streamflow at a scale to become a stressor for whitefish.

b-				Exposure					
vity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Lacustrine								
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with predominant effects from fall through spring when wind- driven waves are most pronounced)	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	All life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May decrease survival of eggs and larvae. May affect survival and productivity at juvenile life history stage. Decreased adult fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		fundamentally alter lacustrine littoral habitats, potentially leading to direct mortality and decreased survival of eggs and larvae (lacustrine spawning whitefish) and decreasing the suitability of rearing habitat for juvenile and	patterns, and wave energy and current patterns	
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		adult whitefish. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to		
	Altered groundwater inputs		Year-round	Permanent	Continuous		deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, fitness, and productivity, as well as direct mortality.		
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous			1	
	Ecosystem Fragmentation			1			uncer morunty.		
- Ē	Riverine								
	Alteration of predator/prey dynamics	Increased predation exposure	NA	NA	NA	NA	NA	NA	NA
	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	NA	NA	NA	NA	NA	NA	NA
	Lacustrine				·	·	•	•	
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for whitefish in the vicinity of the structure, leading to decreased survival.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile and adult survival.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.

-				Exposure					
vity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
oins	and Bank Barbs								
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	<ul> <li><u>All life-history stages</u>: Stressor response dependent on noise magnitude and project- specific environmental conditions; may range from:</li> <li>Rupture of egg membrane.</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work-areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may affect survival at all life-history stages, dependin on project-specific noise intensity and receptor exposure
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitations to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles:Mortality, injury, or stressfrom capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, increasedpredation exposure.Adults:Delayed local migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival and productivity at juvenile and adu life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May affect survival and fitness at juvenile life-history stage.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential substrate scour/or sedimentation, resulting in decreased incubation success. <u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration to spawning stream, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival and productivity during egg and juvenile life-history stages, may affect adult spawning productivity.

Sub-				Exposure					
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
		Altered current and circulation conditions (lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	May affect survival and productivity during egg and larvae life-history stage, may affect juvenile productivity; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larvae survival due to turbidity exposure and substrate disturbance. <u>Juveniles and adults</u> : Stress and behavioral modifications by juveniles and adults exposed to sediment pulses, reduced foraging opportunities, and increased predation risk.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth at all life- history stages.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and productivity at juvenile life- history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described above under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual-decadal	Eggs and larvae; Juveniles; Adults	<u>Juveniles and Adults</u> : Decreased foraging opportunity due to short-term reduction in prey availability. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile productivity and fitness. See effects for related stressors under Water Quality Modification.

Sub-				Exposure					
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May lead to direct mortality and decreased survival of eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short-term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation.(dissolved oxygen levels should be >5 ppm). Juveniles and adults: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Avoid sediment pulses.	May affect juvenile survival and adult survival, and spawning productivity.

Sub-				Exposure					
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs and larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	May affect survival of juveniles and adults.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.		
	Riparian and Shoreline Vegetation Modification								
	Riverine								
	Altered shading, solar input, ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Direct mortality due to winterice formation and scour.Juveniles:Altered growth and productivitycaused by temperatures outside optimal growthrange, and alteration of food web patterns(optimal range 50°F or less).Adults and juveniles:Direct mortality causedby exposure to temperatures in excess oftolerance thresholds.Adults:Decreased spawning fitness due tomigration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect larval, juvenile, and adult growth and fitness.

Sub-				Exposure					
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Altered stream bank and shoreline stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. <u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults</u> : Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival during incubation, rearing, and spawning.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles	Pygmy whitefish dependency upon allochthonous input is a data gap. However, Pygmy whitefish feed on zooplankton and aquatic insects that could be associated with terrestrial riparian inputs. Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile rearing growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Decreased foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased pool availability and availability of suitable spawning habitat.	Encourage project designs that limit permanent alteration of high- quality habitat features.	May affect larval and juvenile survival, growth, and productivity. May affect adult spawning productivity.
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults	Eggs and larvae: Decreased incubation success. <u>Adults</u> : Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and larvae and adult spawning productivity.

Sub-				Exposure					
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Lacustrine								
	Altered riparian shading Altered ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures). Pygmy whitefish depend on cold water of 50°F or less. Therefore, increased temperatures will limit suitable habitat.	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of currents, wind conditions, and other factors. However, juveniles trapped in habitats with isolated water level changes may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Pygmy whitefish are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Decreased foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased pool availability and availability of suitable spawning habitat.	Encourage project designs that limit permanent alteration of high- quality habitat features.	May affect larval and juvenile survival and productivity, spawning success, and overall population productivity.
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Eggs and larvae; Juveniles	<u>Juveniles</u> : Whitefish dependence upon groundwater inflow is currently a data gap. <u>However, may result in a d</u> ecrease in incubation success and a decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown.

Sub-				Exposure					
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Aquatic Vegetation Modification	•	-	•		•		•	
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize	May affect juvenile productivity.
		Altered DO levels due to reduced photosynthesis.	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Alteration.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival and adult spawning productivity.

			-	Exposure					
Mechai	nism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
Hydraulio Geomorp	c and hic Modification								
Riverine									
Altered ch	nannel geometry	Change in habitat structure and habitat suitability, reduced food	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms	May affect survival and productivity at egg, larvae, and juvenile life-history stages. M
Altered flo	ow velocity	web complexity, reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events fall through spring)	Permanent	Seasonal		stability, leading to decreased egg incubation success and survival. Pygmy whitefish dependence on groundwater inflow for incubation success is currently a data gap. <u>Juveniles</u> : Altered channel geometry, flow	produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and	affect spawning productivity.
	on (including t of non-erodable		Year-round	Permanent	Continuous		velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased	groundwater exchange to the greatest extent practicable.	
	oundwater- ater exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning		
Addition of surface	of impervious		Year-round	Permanent	Continuous		success. Changes in uccreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of spawning areas) if potential spawning habitat is affected		
Lacustrin	ie								
Altered way	ave energy (short- ves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with predominant effects from fall through spring when wind- driven waves are most pronounced)	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May decrease survival of eggs and larvae. May affect surviva and productivity at juvenile lif history stage. Decreased adult fitness may lead to reduced spawning productivity.
	irrent velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		fundamentally alter lacustrine littoral habitats, potentially leading to direct mortality and decreased survival of eggs and larvae (lacustrine spawning whitefish) and decreasing the suitability of rearing habitat for juvenile and adult whitefish. This may occur through a	patterns, and wave energy and current patterns.	
surface wa	oundwater- ater exchange	4	Year-round	Permanent	Continuous		number of specific stressors, including increased exertion and stress due to change in current and		
Altered se	diment supply		Year-round	Permanent	Continuous				

Sh				Exposure					
Sub- Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Altered substrate composition		Year-round	Permanent	Continuous		wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, fitness, and productivity, as well as direct mortality.		
	<b>Ecosystem Fragmentation</b>								
I	Riverine								
	Habitat loss and fragmentation	Fragmentation of side channel and floodplain habitat; change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Larvae; Adults	Larvae and adults: Bank barbs and groins can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor is unlikely to significantly affect pygmy whitefish, which spawn in the mainstems of small, swift rivers and the larvae are transported to oligotrophic lakes for rearing to adulthood.	Require assessment of the hydraulic effects of the project before permitting and avoid permitting designs that lead to disconnection of floodplain habitat.	Stressor may affect larval and adult pygmy whitefish, but is unlikely to adversely affect these species.
	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No specific recommendations.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Lacustrine						·		
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Bank barbs and groins can fragment nearshore lacustrine habitats. Larval and juvenile pygmy whitefish are known to occur in these habitat types, but knowledge of dependence on these habitats is limited. Given prevalence in these habitat types, however, stressor exposure may affect juvenile survival, growth, and fitness if habitat access is impaired.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile survival, growth, and fitness.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.

y				Exposure	F	1	_		Demiking Ffrate of the
r	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
es									
	Construction and Maintenance Activities								
]	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	NA	NA	NA	This species does not occur in habitats suitable for jetty development; therefore, there is
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	NA	NA	NA	potential for exposure to construction-related impact mechanisms and related stresso
	Channel/work area lewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	
		Altered current and circulation conditions (lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	NA	NA	NA	
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	
		Increased suspended solids.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	
	Navigation/ maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	NA	NA	NA	
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	NA	NA	NA	]
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	NA	NA	NA	

# Table A-11. HPA HCP Shoreline Modification Exposure and Response Matrix for Olympic Mudminnow.

## HPA HCP Shoreline Modification Exposure and Response Matrix for Olympic Mudminnow. Table A-11 (continued).

			Ex	xposure		•				
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Water Quality Modification									
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual– decadal (dependent on contributing mechanism of impact)	NA	NA	NA	This species does not occur in habitats suitable for jetty development; therefore, there is n potential for exposure to related	
		impact t		Temporary to short-term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	NA	NA	NA	water quality modification impact mechanisms and stressors.	
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual– decadal (dependent on contributing mechanism of impact)	NA	NA	NA		
1	Use of creosote-treated wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in freshwater. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	NA	NA	NA		
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	NA	NA			

# Table A-11 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Olympic Mudminnow.

		Ex	posure	1	1			<b>Resulting Effects of the</b>
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Riparian Vegetation Modification								
Lacustrine								
Altered riparian shading	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures).	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	NA	NA	NA	This species does not occur in habitats suitable for jetty development, therefore there is potential for exposure to relate riparian vegetation modification
Altered ambient air temperature regime								impact mechanisms and stresso
Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	NA	NA	NA	
Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	NA	NA	NA	
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	NA	NA	NA	
Altered groundwater-surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	NA	NA	NA	
Aquatic Vegetation Modification								
Lacustrine								
Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	NA	NA	NA	This species does not occur in habitats suitable for jetty development; therefore, there
	Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	NA	NA		potential for exposure to relate aquatic vegetation modificatio impact mechanisms and stress
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	NA	NA		

Table A-11 (continued).	HPA HCP Shoreline Modification	Exposure and Response	Matrix for Olympic Mudminne
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)-			E	xposure					
ty e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Lacustrine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, reduced spawning and	Year-round	Permanent	Continuous	NA	NA	NA	This species does not occur in habitats suitable for jetty development; therefore, there is no potential for exposure to related hydraulic and geomorphic modification impact mechanisms and stressors.
	Altered flow velocity	rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events fall through spring)	Permanent	Seasonal				
	Altered substrate composition (including placement of non-erodable substrate)	_	Year round	Permanent	Continuous				
	Altered groundwater inputs		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Addition of impervious surface		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	NA	NA	NA	NA	NA	NA	NA
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	NA	NA	NA	NA	NA	NA	NA



## now.

# Table A-11 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Olympic Mudminnow.

				Exposure		-			
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Submechanism
ŚŴ	aters								
	Construction and Iaintenance Activities								
Р	ile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	NA	NA	NA	This species does not occur in habitats suitable for breakwater development; therefore, there is
	Construction vessel peration	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	NA	NA	NA	potential for exposure to construction-related impact mechanisms and related stresso
	Channel/work area ewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	
		Altered current and circulation conditions (lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	-
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	NA	NA	NA	
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	
		Increased suspended solids.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	
	lavigation/ maintenance redging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	NA	NA	NA	
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	NA	NA	NA	
	E in re	Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual-decadal	NA	NA	NA	

## Table A-11 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Olympic Mudminnow.

			E	xposure	1	1	4		Resulting Effects of the
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual– decadal (dependent on contributing mechanism of impact)	NA	NA	NA	This species does not occur in habitats suitable for breakwate development; therefore, there potential for exposure to relate
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short-term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	NA	NA	NA	water quality modification imp mechanisms and stressors.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual– decadal (dependent on contributing mechanism of impact)	NA	NA	NA	
U	Use of creosote-treated wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in freshwater. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	NA	NA	NA	
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	NA	NA		
	Aquatic Vegetation Modification								
]	Riverine and Lacustrine				-			-	
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	NA	NA	NA	This species does not occur in habitats suitable for breakwate development; therefore, there
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	NA	NA		potential for exposure to relate aquatic vegetation modification impact mechanisms and stress
1	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	NA	NA		

## Table A-11 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Olympic Mudminnow.

,			ŀ	xposure					Resulting Effects of the
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
]	Hydraulic and Geomorphic Modification								
]	<b>Riverine and Lacustrine</b>								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, reduced spawning and	Year-round	Permanent	Continuous	NA	NA	NA	This species does not occur in habitats suitable for breakwate development; therefore, there
	Altered flow velocity	rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events fall through spring)	Permanent	Seasonal				potential for exposure to relate hydraulic and geomorphic modification impact mechanist and stressors.
1	Altered substrate composition (including placement of non-erodable substrate)		Year round	Permanent	Continuous				
	Altered groundwater inputs		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Addition of impervious surface		Year-round	Permanent	Continuous				
]	Ecosystem Fragmentation								
]	Riverine								
	Alteration of predator/prey dynamics	Increased predation exposure	NA	NA	NA	NA	NA	NA	NA
	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	NA	NA	NA	NA	NA	NA	NA
	Lacustrine								
	Alteration of predator/prey dynamics	Increased predation exposure	NA	NA	NA	NA	NA	NA	NA
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	NA	NA	NA	NA	NA	NA	NA

# Table A-11 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Olympic Mudminnow.

			E	kposure					Resulting Effects of the
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
IS	and Bank Barbs								
	Construction and Maintenance Activities								
]	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	NA	NA	NA	This species does not occur in habitats suitable for groin and b barb development; therefore, the
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	NA	NA	NA	no potential for exposure to construction-related impact mechanisms and related stresso
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	
		Altered current and circulation conditions (lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	NA	NA	NA	
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	
		Increased suspended solids.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	NA	NA	NA	
	Navigation/ maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	NA	NA	NA	
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	NA	NA	NA	
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual-decadal	NA	NA	NA	

## HPA HCP Shoreline Modification Exposure and Response Matrix for Olympic Mudminnow. Table A-11 (continued).

			Ex	xposure					
у	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual– decadal (dependent on contributing mechanism of impact)	NA	NA	NA	This species does not occur in habitats suitable for groin and bank barb development; therefore, there no potential for exposure to related
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short-term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	NA	NA	NA	water quality modification impact mechanisms and stressors.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual– decadal (dependent on contributing mechanism of impact)	NA	NA	NA	
	Use of creosote-treated wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in freshwater. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	NA	NA	NA	
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	NA	NA		

## Table A-11 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Olympic Mudminnow.

			E	kposure	1	1			<b>Resulting Effects of the</b>
_	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Riparian and Shoreline Vegetation Modification								
]	Riverine								
	Altered riparian shading	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	NA	NA	NA	This species does not occur in habitats suitable for groin and b barb development; therefore, th
	Altered ambient air emperature regime								no potential for exposure to rel riparian vegetation modificatio impact mechanisms and stresso
	Altered stream bank and horeline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	NA	NA	NA	
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	NA	NA	NA	
I	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	NA	NA	NA	
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	NA	NA	NA	
I	Lacustrine				·			·	
ł	Altered riparian shading	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures).	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	NA	NA	NA	This species does not occur in habitats suitable for groin and t barb development, therefore the no potential for exposure to rel- riparian vegetation modificatio
	Altered ambient air emperature regime								impact mechanisms and stresso
	Altered shoreline and bluff tability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	NA	NA	NA	
I	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	NA	NA	NA	
P	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	NA	NA	NA	
	Altered groundwater–surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	NA	NA	NA	

# Table A-11 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Olympic Mudminnow.

,			E	Exposure			_		Degulting Effects of the
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Aodification								
F	Riverine and Lacustrine								
	Altered autochthonous oroduction	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	NA	NA	NA	This species does not occur in habitats suitable for groin and bank barb development; therefore, there i
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	NA	NA		no potential for exposure to related aquatic vegetation modification impact mechanisms and stressors.
Α	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	NA	NA		
	Iydraulic and Geomorphic Aodification				_				
F	Riverine and Lacustrine								
A	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, reduced spawning and	Year-round	Permanent	Continuous	NA	NA	NA	This species does not occur in habitats suitable for groin and bank barb development; therefore, there is
A	Altered flow velocity	rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events fall through spring)	Permanent	Seasonal				no potential for exposure to relate hydraulic and geomorphic modification impact mechanisms and stressors.
c p	Altered substrate omposition (including lacement of non-erodable ubstrate)		Year round	Permanent	Continuous				
A	Altered groundwater inputs		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Addition of impervious urface		Year-round	Permanent	Continuous				
E	<b>Ecosystem Fragmentation</b>								
F	Riverine								
	Habitat loss and ragmentation	Fragmentation of side channel and floodplain habitat; change in habitat structure, availability, and suitability; reduced food web complexity	NA	NA	NA	NA	NA	NA	NA
L	loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	NA	NA	NA	NA	NA	NA	NA

Sub-				Exposure					
ctivity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	NA	NA	NA	NA	NA	NA	NA
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	NA	NA	NA	NA	NA	NA	NA

## Table A-11 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Olympic Mudminnow.

y				Exposure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
S									
	Construction and Maintenance Activities								
1	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs, Juveniles; Adults	<ul> <li><u>All life-history stages</u>: Stressor response dependent on noise magnitude; project-specific environmental conditions may range from:</li> <li>Egg mortality due to membrane rupture.</li> <li>Barotraumas causing fatality or permanent auditory tissue damage leading to impairment limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> <li>Note that specific data on the noise sensitivity of these species are limited; therefore, the effects of stressor exposure are uncertain.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by these species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work-areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality at all life-history st May affect survival, growth, fitness at all life-history stag depending on project-specific noise intensity and receptor exposure.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles, Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, fitness due to avoidance beha as well as potentially decreas foraging success and increas predation exposure.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Mortality due to dewatering. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Small juvenile dace may be difficult to capture and relocate, leading to higher incidence of mortality. Increased competition once relocated, and reduced growth and fitness; increased predation exposure.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality ar injury. May affect survival, growth, and fitness at juvenil adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles	Eggs and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential substrate scour/or sedimentation, resulting in decreased incubation success. <u>Juveniles and adults</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	Limit alteration of flow conditions to minimal area.	May affect survival, growth, fitness during egg and juven life-history stages. May affe adult spawning growth and fitness.
		Altered current and circulation conditions (lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juvenile and adults</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	To greatest extent practicable, limit alteration of current and circulation patterns to minimal area.	May affect juvenile and adul survival, growth, and productivity.

# Table A-12. HPA HCP Shoreline Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

# Table A-12 (continued).HPA HCP Shoreline Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

				Exposure					
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential decreased survival due to turbidity exposure and substrate disturbance. <u>Juveniles and adults</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, reduced foraging opportunities, and increased predation risk, leading to decreased survival, growth, and fitness. See responses to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect egg survival. May affect juvenile and adult survival, growth, and fitness. See effects of related stressor exposure under Water Quality Modification.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles and adults</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect juvenile and adult growth and fitness.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
	Construction/ maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs; Juveniles; Adults	All life-history stages: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs; Juveniles; Adults;	Eggs and juveniles:Eggs and immobile juvenilesentrained during dredging may experience direct mortality or injury.Juveniles and adults:Juveniles and adults:Decreased foraging opportunity due to short-term reduction in prey availability.Decreased growth and fitness.All life-history stages:See responses described for related stressors under Water Quality Modification.	Avoid dredging in shallow water margin areas preferred by these species.	May affect juvenile productivity and fitness. See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Daily, temporary, or short-term (dependent on contributing mechanism of impact)	Daily to intermittent and interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.

# Table A-12 (continued).

HPA HCP Shoreline Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

			Exposure	1		4		Resulting Effects of the
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Altered dissolved oxygen and temperature levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	<u>All exposed life-history stages</u> : Alteration of water temperatures leading to increases or decreases beyond optimal ranges may affect growth and fitness of dace and sucker. Optimal temperatures range from 59–64°F for dace and 55–70°F for mountain sucker. Exposure to higher temperatures may lead to direct mortality or sufficient stress to affect survival. Acute low dissolved oxygen events may cause direct mortality of eggs, juveniles, and adults by asphyxiation. Juveniles and adults may exhibit temporary avoidance behavior, increased stress, increased predation exposure, and decreased foraging opportunities.	Avoid sediment pulses.	May affect survival of incubatin eggs. May affect juvenile and adult survival, growth, and fitness.
	Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term depending on contributing mechanism of impact	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness. Mobile juveniles and adults may exhibit temporary avoidance behavior, increased stress, increased predation exposure, and decreased foraging opportunities.	Avoid curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality or physiological injury in acute events. May affect survival of eggs and immobile juveniles. May affect juvenile and adult growth and fitness.
Use of creosote-treated wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs; Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft	May cause direct mortality. May affect survival, growth, and fitness across all life-history stages. Reduced fitness may affect adult spawning productivity.
Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	below surface and cap with clean sediment.	
Riparian Vegetation Modification								
Altered shading, solar input, ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures). Therefore, increased temperatures will limit suitable habitat	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a relatively minor effect on deep lacustrine water temperatures relative to the dominant influence of currents, wind conditions, and other factors. However, protected nearshore habitats favored by dace may be sensitive to temperature extremes. Lack of suitable thermal refuge habitat may lead to decreased survival.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness at all life-history stages. Mountain sucker prefer deeper water environments and are likel to be less sensitive to these effects.

Table A-12 (continued).

HPA HCP Shoreline Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

ıb-				Exposure	-				
ctivity ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs (dace); Juveniles; Adults	Eggs: Dace may experience decreased egg survival in lacustrine spawning environments due to turbidity effects. Juveniles and adults: Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect dace egg survival. See effects for related stressors under Water Quality Modification.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Dace and suckers prey upon terrestrial insects recruited from riparian zone. Alteration of vegetation will result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect growth, fitness, and productivity.
	Altered habitat complexity	Reduced recruitment of large woody debris. Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles and adults:</u> Alteration of habitat complexity may affect the suitability of spawning, rearing, and refuge habitat for dace and suckers, leading to reduced survival, growth, and fitness. Reduced habitat complexity may affect the availability of suitable spawning habitats for dace. Likelihood of effects on sucker spawning habitat is more limited due to preference for shallow riffle habitats unsuitable for jetty development.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect survival, growth, and fitness during juvenile and adult life-history stages. Reduced habitat complexity may affect spawning productivity.
	Altered groundwater–surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	Juveniles: Dependence on groundwater–surface water exchange by these fish species is a data gap. However, lack of suitable thermal refuge habitat may lead to decreased survival during temperature extremes.	Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	Effects resulting from this impact mechanism are uncertain, as dace and sucker sensitivity to stressor exposure is currently a data gap. However, lack of suitable thermal refuge habitat may affect dace survival.
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Reduced foraging opportunities due to decreased food web productivity, leading to decreased growth and fitness. Primary forage for suckers includes algae and aquatic invertebrates, which may be affected by decreased autochthonous production.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project	May affect survival, growth, and productivity of juvenile and adult life-history stages.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles and adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition, increased predation exposure, and resulting effects on survival, growth, and fitness.	construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring.	May affect survival, growth, and productivity of juvenile and adult life-history stages.

# Table A-12 (continued).HPA HCP Shoreline Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

		1	Exposure				
Mechanism of Impa	act Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
Hydraulic and Geomo Modification	rphic						
Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Eggs (dace); Juveniles; Adults	All exposed life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can	Ca an m En m
Altered current velocitie	es suitability	Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juveniles and adults. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased	lo an
Altered nearshore circul patterns	lation	Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for	
Altered groundwater – surface water exchange		Year-round	Permanent	Continuous		suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness, or mortality.	
Altered sediment supply	7	Year-round	Permanent	Continuous		indicative.	
Altered substrate composition		Year-round	Permanent	Continuous			
Ecosystem Fragmenta	tion						
Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Eggs (dace); Juveniles (dace and mountain suckers); Adults (dace and mountain suckers)	Eggs: Adult dace spawning habitat availability may be limited by the structural footprint of jetties, and by limitations on movement in the nearshore zone. Increased egg density may in turn increase potential egg losses from predation, localized water quality impacts, or other mechanisms, limiting egg survival and/or incubation success. <u>Juveniles and adults</u> : Jetties can fragment nearshore lacustrine habitats, forcing juvenile fish moving along the shoreline to migrate into deeper water. Dace, which prefer shallow water habitats, would experience increased predation exposure and increased stress and exertion as a result. Concentration in nearshore habitats due to restricted movement may limit foraging opportunities. Exposure to these stressors may limit survival, growth, and fitness. Reduced adult fitness may affect spawning productivity. Juvenile and adult suckers will experience similar stressor exposure but are less prone to the resulting effects due to their benthic orientation. Margined sculpins are found predominantly in small rivers and streams in the Tucannon and Walla Walla River drainages. The likelihood of occurrence in lakes is limited, which in turn limits the potential for stressor exposure in lacustrine environments.	Ref foo ob area area
Loss of LWD recruitme	ent Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Re on the de ma

Minimization Measures	Resulting Effects of the Submechanism			
Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at all exposed life-history stages. Decreased fitness may lead to reduced spawning productivity.			
Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile and adult survival, growth, and fitness. May affect egg survival and/or incubation success.			
Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.			

# Table A-12 (continued).HPA HCP Shoreline Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

b- tivity pe	Mechanism of Impact		Exposure						
		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
akv	waters								
	Construction and Maintenance Activities								_
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs, Juveniles; Adults	<ul> <li><u>All life-history stages</u>: Stressor response dependent on noise magnitude; project-specific environmental conditions may range from:</li> <li>Egg mortality due to membrane rupture.</li> <li>Barotraumas causing fatality or permanent auditory tissue damage leading to impairment limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> <li>Note that specific data on the noise sensitivity of these species are limited; therefore, the effects of stressor exposure are uncertain.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by these species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work-areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality at all life-history stag May affect survival, growth, ar fitness at all life-history stages, depending on project-specific noise intensity and receptor exposure.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles, Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, an fitness due to avoidance behav as well as potentially decreased foraging success and increased predation exposure.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Mortality due to dewatering. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Small juvenile dace may be difficult to capture and relocate, leading to higher incidence of mortality. Increased competition once relocated, and reduced growth and fitness; increased predation exposure.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality and injury. May affect survival, growth, and fitness at juvenile adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles	Eggs and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential substrate scour/or sedimentation, resulting in decreased incubation success. <u>Juveniles and adults</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	Limit alteration of flow conditions to minimal area.	May affect survival, growth, and fitness during egg and juvenile life-history stages. May affect adult spawning growth and fitness.
		Altered current and circulation conditions (lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juvenile and adults</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	To greatest extent practicable, limit alteration of current and circulation patterns to minimal area.	May affect juvenile and adult survival, growth, and productivity.

				Exposure					
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential decreased survival due to turbidity exposure and substrate disturbance. <u>Juveniles and adults</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, reduced foraging opportunities, and increased predation risk, leading to decreased survival, growth, and fitness. See responses to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect egg survival. May affect juvenile and adult survival, growth, and fitness. See effects of related stressor exposure under Water Quality Modification.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles and adults</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect juvenile and adult growth and fitness.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
	Construction/ maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs; Juveniles; Adults	All life-history stages: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs; Juveniles; Adults;	Eggs and juveniles:Eggs and immobile juvenilesentrained during dredging may experience direct mortality or injury.Juveniles and adults:Juveniles and adults:Decreased foraging opportunity due to short-term reduction in prey availability.Decreased growth and fitness.All life-history stages:See responses described for related stressors under Water Quality Modification.	Avoid dredging in shallow water margin areas preferred by these species.	May affect juvenile productivity and fitness. See effects for relate stressors under Water Quality Modification.
	Water Quality Modification	1							I
		Increased suspended solids	Dependent on contributing mechanism of impact	Daily, temporary, or short-term (dependent on contributing mechanism of impact)	Daily to intermittent and interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival.Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.

#### Table A-12 (continued).

,			1	Exposure	1	1	-		<b>Resulting Effects of the</b>
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Altered dissolved oxygen and temperature levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	<u>All exposed life-history stages</u> : Alteration of water temperatures leading to increases or decreases beyond optimal ranges may affect growth and fitness of dace and sucker. Optimal temperatures range from 59–64°F for dace and 55–70°F for mountain sucker. Exposure to higher temperatures may lead to direct mortality or sufficient stress to affect survival. Acute low dissolved oxygen events may cause direct mortality of eggs, juveniles, and adults by asphyxiation. Juveniles and adults may exhibit temporary avoidance behavior, increased stress, increased predation exposure, and decreased foraging opportunities.	Avoid sediment pulses.	May affect survival of incubatin eggs. May affect juvenile and adult survival, growth, and fitness.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term depending on contributing mechanism of impact	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness. Mobile juveniles and adults may exhibit temporary avoidance behavior, increased stress, increased predation exposure, and decreased foraging opportunities.	Avoid curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality or physiological injury in acute events. May affect survival of eggs and immobile juveniles. May affect juvenile and adult growth and fitness.
Us	se of creosote-treated wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs; Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When	May cause direct mortality. May affect survival, growth, and fitness across all life-history stages. Reduced fitness may affect adult spawning productivity.
	se of ACZA- and CCA pe C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	high surface area.Leaching begins uponinstallation, with highestlevels occurring within 7months of initialimmersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
	quatic Vegetation lodification								
	ltered autochthonous roduction	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Reduced foraging opportunities due to decreased food web productivity, leading to decreased growth and fitness. Primary forage for suckers includes algae and aquatic invertebrates, which may be affected by decreased autochthonous production.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project	May affect survival, growth, and productivity of juvenile and adu life-history stages.
A	ltered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition, increased predation exposure, and resulting effects on survival, growth, and fitness.	construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring.	May affect survival, growth, and productivity of juvenile and adu life-history stages.

ub-				Exposure				
ctivity ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Hydraulic and Geomorphic Modification	-						-
	Riverine							
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity,	Year-round	Permanent	Continuous	Eggs; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased egg incubation success and survival. Likelihood of sucker exposure to these stressors	Can and me End
	Altered flow velocity	reduced spawning and rearing habitat availability and	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		is limited, given preference for spawning in areas unsuitable for breakwater development. <u>Juveniles</u> : Altered channel geometry, flow velocity, and	mir velo gro
	Altered substrate       s         composition (including       placement of non-erodable         substrate)       Altered groundwater inputs	suitability	Year round	Permanent	Continuous		substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. Dace are associated with low to moderate flows, which may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness,	pra
	Altered groundwater inputs		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and	
	Addition of impervious surface		Year-round	Permanent	Continuous	2	decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	
	Lacustrine							
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Eggs (dace); Juveniles; Adults	<u>All exposed life-history stages</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can	Can and me Enc mir
	Altered current velocities	suitability	Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juveniles and adults. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased	lon and
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for	
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous		suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness, or mortality.	
	Altered sediment supply		Year-round	Permanent	Continuous		nucess, or mortanty.	
	Altered substrate composition		Year-round	Permanent	Continuous			

Minimization Measures	Resulting Effects of the Submechanism
Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth, and fitness at egg and juvenile life- history stages. May affect spawning productivity.
Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at all exposed life-history stages. Decreased fitness may lead to reduced spawning productivity.

Sub-				Exposure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Ecosystem Fragmentation			<u>-</u>	- <u>-</u>	_	•	
	Riverine							
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles; Adults (dace)	<u>Juveniles and adults (dace)</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile suckers and juvenile and adult dace in the vicinity of the structure, leading to decreased survival. Margined sculpins do not occur in riverine environments suitable for breakwaters, therefore there is no potential for stressor exposure.	R fc ol ar ar
	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	N
	Lacustrine			L				4
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles; Adults (dace and lake chub)	Juveniles and adults (dace): Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for juvenile suckers and juvenile and adult dace and lake chub in the vicinity of the structure, leading to decreased survival. Margined sculpins do not occur in lacustrine environments	Ro fo ot ar ar
							therefore there is no potential for stressor exposure.	
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Ro or th de m

Minimization Measures	Resulting Effects of the Submechanism
Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile survival of suckers. May affect juvenile and adult survival of dace.
No specific recommendations.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile survival of suckers. May affect juvenile and adult survival of dace and lake chub.
Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.

у				Exposure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
ns	and Bank Barbs								
	Construction and Maintenance Activities								_
1	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs, Juveniles; Adults	<ul> <li><u>All life-history stages</u>: Stressor response dependent on noise magnitude; project-specific environmental conditions may range from:</li> <li>Egg mortality due to membrane rupture.</li> <li>Barotraumas causing fatality or permanent auditory tissue damage leading to impairment limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> <li>Note that specific data on the noise sensitivity of these species are limited; therefore, the effects of stressor exposure are uncertain.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by these species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work-areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality at all life-history sta May affect survival, growth, a fitness at all life-history stage: depending on project-specific noise intensity and receptor exposure.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles, Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, fitness due to avoidance beha as well as potentially decreas foraging success and increase predation exposure.
	Channel/work area lewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Mortality due to dewatering. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Small juvenile dace may be difficult to capture and relocate, leading to higher incidence of mortality. Increased competition once relocated, and reduced growth and fitness; increased predation exposure.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality an injury. May affect survival, growth, and fitness at juvenile adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles	Eggs and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential substrate scour/or sedimentation, resulting in decreased incubation success. <u>Juveniles and adults</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	Limit alteration of flow conditions to minimal area.	May affect survival, growth, fitness during egg and juveni life-history stages. May affect adult spawning growth and fitness.
		Altered current and circulation conditions (lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juvenile and adults</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	To greatest extent practicable, limit alteration of current and circulation patterns to minimal area.	May affect juvenile and adul survival, growth, and productivity.

Sub-			1	Exposure					Descritting Effects of the
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Streambed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential decreased survival due to turbidity exposure and substrate disturbance.Juveniles and adults: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, reduced foraging opportunities, and increased predation risk, leading to decreased survival, growth, and fitness. See responses to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect egg survival. May affect juvenile and adult survival, growth, and fitness. See effects of related stressor exposure under Water Quality Modification.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles and adults</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect juvenile and adult growth and fitness.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
	Construction/ maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs; Juveniles; Adults	All life-history stages: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs; Juveniles; Adults;	Eggs and juveniles:Eggs and immobile juvenilesentrained during dredging may experience direct mortality or injury.Juveniles and adults:Juveniles and adults:Decreased foraging opportunity due to short-term reduction in prey availability.Decreased growth and fitness.All life-history stages:See responses described for related stressors under Water Quality Modification.	Avoid dredging in shallow water margin areas preferred by these species.	May affect juvenile productivity and fitness. See effects for related stressors under Water Quality Modification.



y	Mechanism of Impact			Exposure			Doppongo to Stunggor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Increased suspended solids	Dependent on contributing mechanism of impact	Daily, temporary, or short-term (dependent on contributing mechanism of impact)	Daily to intermittent and interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubatir eggs. May affect juvenile and adult survival, growth, and fitness.
		Altered dissolved oxygen and temperature levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	All exposed life-history stages: Alteration of water temperatures leading to increases or decreases beyond optimal ranges may affect growth and fitness of dace and sucker. Optimal temperatures range from 59–64°F for dace and 55–70°F for mountain sucker. Exposure to higher temperatures may lead to direct mortality or sufficient stress to affect survival. Acute low dissolved oxygen events may cause direct mortality of eggs, juveniles, and adults by asphyxiation. Juveniles and adults may exhibit temporary avoidance behavior, increased stress, increased predation exposure, and decreased foraging opportunities.	Avoid sediment pulses.	May affect survival of incubatin eggs. May affect juvenile and adult survival, growth, and fitness.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term depending on contributing mechanism of impact	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness. Mobile juveniles and adults may exhibit temporary avoidance behavior, increased stress, increased predation exposure, and decreased foraging opportunities.	Avoid curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality or physiological injury in acute events. May affect survival of eggs and immobile juveniles. May affect juvenile and adult growth and fitness.
Ī	Use of creosote-treated wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs; Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft	May cause direct mortality. Ma affect survival, growth, and fitness across all life-history stages. Reduced fitness may affect adult spawning productivity.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	

				Exposure					Resulting Effects of the
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Riparian and Shoreline Vegetation Modification								
Ripa         Rive         Rive         Alter         ambi         Alter         Alter	Riverine								
	Altered shading, solar input, mbient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs; Juveniles; Adults	Eggs: High water temperatures may decrease egg survival. Juveniles: Reduced growth and fitness caused by temperatures outside optimal growth range, and alteration of food web patterns. <u>Adults and juveniles</u> : May reduce the availability of suitable refuge and foraging habitat, leading to reduced survival, growth, and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness at all life-history stages. Mountain sucker prefer deeper water environments and are likel to be less sensitive to these effects.
							<u>Adults</u> : Spawning is temperature dependent; alteration of nearshore temperature may affect spawning success and productivity.		
	Altered stream bank and horeline stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat	Year-round (with specific stressors prominent during high-flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Juveniles; Adults	Eggs: Decreased incubation success due to turbidity effects as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness at all life-history stages
		complexity (e.g., filling of pools)					<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
							<u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
A	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Dace feed on terrestrial insects. While less dependent, suckers are opportunistic feeders dependent on overall food web productivity. Reduced allochthonous inputs may affect food web productivity, leading to decreased foraging opportunities and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect growth and fitness at juvenile and adult life-history stages.
A	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Decreased availability of suitable foraging and refuge habitat, leading to decreased foraging opportunities, increased competition, increased predation exposure, collectively affecting survival, growth, and fitness. Reduction in suitable spawning habitat area may affect spawning productivity.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile and adult survival, growth, and fitness. May affect adult spawning productivity.
	Altered groundwater–surface vater exchange	Reduced available thermal refuge habitat	Year-round	Permanent	Continuous	Eggs; Juveniles; Adults	<u>All exposed life-history stages:</u> Dace and sucker dependency on groundwater is currently a data gap. However, decreased availability of thermal refuge may affect survival during temperature extremes.	Avoid disturbance of vegetation along stream.	Effects resulting from this impact mechanism are uncertain, as dace and sucker sensitivity to stressor exposure is currently a data gap. However, lack of suitable therma refuge habitat may affect dace survival.

HPA HCP Shoreline Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker. Table A-12 (continued).

			Exposure	1		4		Resulting Effects of the
Mechanism of Imp	oact Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Altered shading, solar i and ambient air tempera		Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a relatively minor effect on deep lacustrine water temperatures relative to the dominant influence of currents, wind conditions, and other factors. However, protected nearshore habitats favored by dace may be sensitive to temperature extremes. Lack of suitable thermal refuge habitat may lead to decreased survival.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, a fitness at all life-history stages Mountain sucker prefer deeper water environments and are lik to be less sensitive to these effects.
Altered shoreline stabil	lity Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs (dace); Juveniles; Adults	Eggs: Dace may experience decreased egg survival in lacustrine spawning environments due to turbidity effects. Juveniles and adults: Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect dace egg survival. effects for related stressors und Water Quality Modification.
Altered allochthonous i	inputs Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Dace and suckers prey upon terrestrial insects recruited from riparian zone. Alteration of vegetation will result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect growth, fitness, and productivity.
Altered habitat complex	xity Reduced recruitment of large woody debris. Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles and adults:</u> Alteration of habitat complexity may affect the suitability of spawning, rearing, and refuge habitat for dace and suckers, leading to reduced survival, growth, and fitness. Reduced habitat complexity may affect the availability of suitable spawning habitats for dace. Likelihood of effects on sucker spawning habitat is more limited due to preference for shallow riffle habitats unsuitable for groin and bank barb development.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect survival, growth, a fitness during juvenile and adu life-history stages. Reduced habitat complexity may affect spawning productivity.
Altered groundwater-so water exchange	web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Dependence on groundwater–surface water exchange by these fish species is a data gap. However, lack of suitable thermal refuge habitat may lead to decreased survival during temperature extremes.	Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	Effects resulting from this imp mechanism are uncertain, as d and sucker sensitivity to stress exposure is currently a data ga However, lack of suitable ther refuge habitat may affect dace survival.
Aquatic Vegetation Modification								
Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Reduced foraging opportunities due to decreased food web productivity, leading to decreased growth and fitness. Primary forage for suckers includes algae and aquatic invertebrates, which may be affected by decreased autochthonous production.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.Construction: Avoid/minimize disturbance of aquatic vegetation during project	May affect survival, growth, a productivity of juvenile and a life-history stages.
Altered habitat complex	xity Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles and adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition, increased predation exposure, and resulting effects on survival, growth, and fitness.	construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring.	May affect survival, growth, productivity of juvenile and a life-history stages.

b-			1	Exposure				
tivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Hydraulic and Geomorphic Modification						-	
	Riverine							
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced	Year-round	Permanent	Continuous	Eggs; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased egg incubation success and	C an m
	Altered flow velocity	food web complexity, reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Aduns	survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity.	Er m ve gr pr
	Altered substrate composition (including placement of non-erodable substrate)	Suruonky	Year round	Permanent	Continuous		Dace are associated with low to moderate flows, which may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	P1
	Altered groundwater inputs		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel	
	Addition of impervious surface		Year-round	Permanent	Continuous		geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations, egg burial, etc.) if potential spawning habitat is affected.	
	Lacustrine		·	·	·			
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Eggs (dace); Juveniles; Adults	<u>All exposed life-history stages</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can	Ca an me En mi
	Altered current velocities	suitability	Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juveniles and adults. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased	loi an
	Altered groundwater Inputs		Year-round	Permanent	Continuous		predation exposure due to reduced cover or exposure to	
	Altered sediment supply		Year-round	Permanent	Continuous		deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for	
	Altered substrate composition		Year-round	Permanent	Continuous		suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness, or mortality.	

Minimization Measures	Resulting Effects of the Submechanism
Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth, and fitness at egg and juvenile life- history stages. May affect spawning productivity.
Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at all exposed life-history stages. Decreased fitness may lead to reduced spawning productivity.

				Exposure	-	I		
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Ecosystem Fragmentation						•	
	Riverine							
	Habitat loss and fragmentation	Fragmentation of side channel and floodplain habitat; change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs (dace); Juveniles; Adults	Eggs: Adult dace spawning habitat availability may be limited by the structural footprint of groins and bank barbs, and by limitations on movement in the nearshore zone. Increased egg density may in turn increase potential egg losses from predation, localized water quality impacts, or other mechanisms, limiting egg survival and/or incubation success. <u>Juveniles</u> : Disconnection of floodplain habitats can lead to decreased availability and suitability of rearing habitat, and changes in food web complexity. Moderate gradient stream systems preferred by sculpins may limit the extent of suitable habitat area. Disconnection of sloughs and similar slow-flowing floodplain habitats in lower gradient systems may limit habitat area preferred by dace and juvenile suckers. These stressors may thereby result in decreased foraging opportunities and increased competition for suitable habitats, affecting survival, growth, and fitness. <u>Adults</u> : Disconnection of sloughs and similar slow-water rearing habitats may limit the availability of suitable foraging and spawning habitat for dace. In moderate gradient habitats, disconnection of floodplain habitats may limit the availability and suitability of spawning habitat for mountain sucker, and foraging and spawning habitat for margined sculpins. These stressors may thereby result in decreased foraging opportunities, and increased competition for suitable habitats, disconnection of floodplain habitats may limit the availability and suitability of spawning habitat for mountain sucker, and foraging and spawning habitat for margined sculpins. These stressors may thereby result in decreased foraging opportunities, and increased competition for suitable habitats, affecting survival, growth, fitness, and by extension, spawning productivity.	
L	oss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	

Minimization Measures	Resulting Effects of the Submechanism
Require assessment of the hydraulic effects of the project before permitting and avoid permitting designs that lead to disconnection of floodplain habitat.	May affect egg survival. May affect juvenile and adult survival, growth, and fitness. May affect adult spawning productivity.
No specific recommendations.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.

Sub-				Exposure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Lacustrine							
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Eggs (dace); Juveniles (dace and mountain suckers); Adults (dace and mountain suckers)	Eggs: Adult dace spawning habitat availability may be limited by the structural footprint of groins and bank barbs, and by limitations on movement in the nearshore zone. Increased egg density may in turn increase potential egg losses from predation, localized water quality impacts, or other mechanisms, limiting egg survival and/or incubation success. Juveniles and adults: Bank barbs and groins can fragment nearshore habitats, forcing juvenile fish moving along the shoreline to migrate into deeper water. Dace, which prefer shallow water habitats, would experience increased predation exposure and increased stress and exertion as a result. Concentration in nearshore habitats due to restricted movement may limit foraging opportunities. Exposure to these stressors may limit survival, growth, and fitness. Reduced adult fitness may affect spawning productivity. Juvenile and adult suckers will experience similar stressor exposure but are less prone to the resulting effects due to their benthic orientation. Margined sculpins are found predominantly in small rivers and streams in the Tucannon and Walla Walla River drainages. The likelihood of occurrence in lakes is limited, which in turn limits the potential for stressor exposure in lacustrine environments.	R fc ol an an
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Ro or th de m



Minimization Measures	Resulting Effects of the Submechanism
Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile and adult survival, growth, and fitness. May affect egg survival and/or incubation success.
Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.

Sub-			Expos	sure	T	I			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Jetties									
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Ammocoetes; Transforming adults; Adults	<u>All life-history stages</u> : Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Little is known about the effects of anthropogenic sounds on lamprey.
	Construction vessel operation	Increased or altered ambient noise levels.	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Transforming adults, Adults	<u>Adults and transforming adults</u> : Very little is known of the effects of anthropogenic sounds on lamprey at any life-history stage.	Although little is known about the effects of anthropogenic sounds on lamprey, it is prudent to avoid/ minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	Little is known about the effects of anthropogenic sounds on lamprey.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Ammocoetes; Transforming adults; Adults	Ammocoetes: Mortality, injury, and stress, during dewatering (when buried in riverine sediments).Adults and transforming adults: Mortality, injury, or stress from capture, handling, and relocation.Transforming adults: Increased competition once relocated, and reduced growth and fitness; increased predation exposure.Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival, growth, and fitness at ammocoete, transforming adult, and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	<u>Transforming adults</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when transforming adults are present.	May affect survival and fitness at transforming adult life-history stage.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Ammocoetes; Transforming adults; Adults	Ammocoetes:Potential nest scour and/or sedimentation, resulting in decreased incubation success.Transforming adults:Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.Adults:Delayed migration, increased stress, and decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during ammocoete life-history stages; may affect transforming adult growth and fitness; may affect adult spawning success.
		Altered current and circulation conditions (marine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults; Adults	Transforming adults:Altered habitat suitability,increased stress, increased competition, decreasedgrowth and fitness.Adults:Delayed migration, increased stress, anddecreased spawning fitness.	To greatest extent practicable, limit alteration of current and circulation patterns to minimal area.	May affect transforming adult survival, growth, and fitness. May affect adult spawning fitness.

Sub-			Expo	osure		1			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stream bed disturbance, increased turbidity (associated with site rewatering).	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Ammocoetes; Transforming adults; Adults	<u>Ammocoetes</u> : Potential decreased ammocoete survival due to turbidity exposure and substrate disturbance. <u>Transforming adults and adults</u> : For Pacific and river lamprey, decreased populations of host fish such as salmon could decrease available habitat.	Adhere to system-specific in-water work windows. Avoid work during ammocoete stages.	May affect survival of ammocoetes. May affect growth and fitness at transforming adult and adult life- history stages.
		Localized alteration in host fish abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	<u>Transforming adults and adults</u> : For Pacific and river lamprey, short-term reductions in host fish due to increased competition, decreased growth, and fitness are expected to affect growth and survival for these life-stages.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at transforming adult life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Ammocoetes; Transforming adults; Adults	All life-history-stages: See responses to related stressors under Water Quality Modification. Water quality effects to ammocoetes are a data gap. However, as Pacific and river lamprey feed on host fish, effects of suspended solids on host fish could affect them. As western brook lamprey are filter feeders, this may not be a stressor for transforming adults and adults.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Ammocoetes; Transforming adults; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Transforming adults; Adults	<u>Transforming adults and adults</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual-decadal	Ammocoetes; Transforming adults; Adults	<u>Ammocoetes:</u> Ammocoetes of Pacific and river lamprey mature buried in fine substrates in the lower reaches and estuaries of larger rivers for extended periods and are therefore vulnerable to direct injury and mortality from dredging entrainment. <u>Transforming adults</u> : Decreased foraging opportunity due to short-term reduction in prey	Avoid turbidity effects above background levels.	May cause direct mortality or injury to ammocoetes. May affect transforming adult growth and fitness. See effects for related stressors under Water Quality Modification.
							availability. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.		

Sub-			Expos	ure		1			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Ammocoetes; Transforming adults; Adults	Ammocoetes: Turbidity sufficient to cause fine sediment embeddedness or increased burial depth may lead to direct mortality and decreased survival of ammocoetes. <u>Transforming adults and adults</u> : Not a direct stressor to the lamprey. For Pacific and river lamprey, responses depend on stressor magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure that project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of ammocoetes. May affect transforming adult growth and fitness, as well as adult fitness and spawning success.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Ammocoetes; Transforming adults; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Effects on host fish are stressors to Pacific and river lamprey. <u>Transforming adults and adults</u> : A physiological response to exposure at toxic levels causing mortality or injury leading to reduced fitness is a data gap. However, effects on host fish are known and would affect Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality. This is a data gap.	Avoid sediment pulses.	May affect survival of ammocoetes. May affect transforming adult survival growth, and fitness, as well as adult survival, productivity, and spawning success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Transforming adults; Adults	<u>Transforming adults and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness of host fish for Pacific and river lamprey.	Avoid curing of concrete or discharge of concrete leachate to surface waters.	May affect survival, growth, and fitness of transforming adults and adults.

			Expos	sure					
у	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Use of creosote-treated wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Ammocoetes; Transforming adults; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness for Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.	May affect survival, growth, and fitness of all exposed life-history stages.
-	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Ammocoetes; Transforming adults; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
	Riparian and Shoreline Vegetation Modification								
	Marine								
	Altered shading, solar input, ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Transforming adults; Adults	Transforming adults: Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, transforming adult Pacific and river lamprey trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress. Similar effects on Pacific and river lamprey host fish may affect foraging success. <u>Adults</u> : River lamprey adults are found in nearshore environments and may experience similar effects as described above. Similar effects on river lamprey host fish may affect foraging success, leading to decreased growth and spawning fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of transforming adult Pacific and river lamprey, as well as adult river lamprey.

Sub-			Expos	sure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Transforming adults; Adults	<u>Transforming adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness of Pacific and river lamprey host fish. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of transforming adult Pacific and river lamprey, as well as adult river lamprey.
							<u>Adults</u> : River lamprey adults are found in nearshore environments and may experience similar effects as described above. Similar effects on river lamprey host fish may affect foraging success, leading to decreased growth and spawning fitness.		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduced organic matter inputs.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Transforming adults; Adults	Transforming adults: Pacific and river lamprey host fish depend on allochthonous inputs from marine riparian vegetation. Effects on host fish survival growth and fitness may in turn affect lamprey growth and fitness. Those host fish that feed on benthic organisms (such as mollusks and amphipods) are likely linked to allochthonous material inputs. <u>Adults</u> : Adult river lamprey experience same	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	For Pacific and river lamprey, effects would be related only to host fish dependence on allochthonous inputs. Western brook lamprey have no marine life-history stage.
							effects as above.		
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults	<u>Transforming adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness of host fish for Pacific and river lamprey.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect transforming adult survival, growth, and fitness; adult spawning success; and overall population productivity.
		in available cover					<u>Adults</u> : Adult river lamprey experience same effects as above.		
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Transforming adults; Adults	<u>Transforming adults and adults (river lamprey)</u> : Lamprey dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown.
	Lacustrine	•					1		•
	Altered shading, solar input, ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Ammocoetes; Transforming adults; Adults	<u>Ammocoetes</u> : Larval western brook, river, and potentially Pacific lamprey are found in sheltered nearshore lacustrine habitats, buried in substrates. Altered water temperatures due to riparian modification could limit habitat suitability, affecting survival, growth, and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect ammocoete survival, growth, and fitness. May affect growth and fitness of adults and transforming adults.
							<u>Adults and transforming adults</u> : Adult lamprey dependence on nearshore lacustrine habitats is currently a data gap. However, transforming adult host fish of Pacific and river lamprey may become trapped in isolated habitats, which may increase temperatures and potentially lead to mortality or increased thermal stress and decreased fitness of host fish, affecting foraging opportunities for adults and transforming adults.		

Sub-			Expos	sure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Ammocoetes; Transforming adults; Adults	Ammocoetes: Larval western brook, river, and potentially Pacific lamprey are found in sheltered nearshore lacustrine habitats, buried in substrates. Alteration of shoreline stability could lead to increased sedimentation and burial, affecting larval survival. <u>Adults and transforming adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness for Pacific and river lamprey host fish. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect ammocoete survival. May affect growth and fitness of adults and transforming adults.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Ammocoetes; Transforming adults; Adults	under Water Quality Modification. <u>All life-history stages</u> : Lamprey dependence on allochthonous inputs from shoreline riparian vegetation is a data gap. However, Pacific and river lamprey ammocoete benthic filter feeding stage and the filter feeding of the western brook lamprey could be affected. This could be a stressor to the extent the host fish is stressed by this mechanism of impact.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect ammocoete, transforming adult, and adult growth and fitness, depending on species.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Ammocoetes; Transforming adults; Adults	Ammocoetes: Decrease in availability of suitable rearing habitat, leading to decreased survival, growth, and fitness. <u>Transforming adults and adults</u> : Decreased refuge habitat availability and foraging opportunities for host fish, potentially leading to decreased foraging opportunities for Pacific and river lamprey with resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect ammocoete survival, growth, and fitness. May affect adult growth, fitness, and spawning productivity due to effects on host fish.
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Ammocoetes; Transforming adults; Adults	<u>All life-history stages</u> : Lamprey dependence on groundwater inflow in lacustrine habitats is currently a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	Effects of the action resulting from this impact mechanism are unknown.

			Expos	ure									
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism				
	Aquatic Vegetation Addification												
I	Marine												
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Transforming adults; Adults	<u>Transforming adults and adults</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness of Pacific and river lamprey host fish. Effects on host fish in nearshore habitats would also affect adult river lamprey forage opportunities.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect river lamprey transformin adult and adult growth and fitness, as well as productivity of Pacific and river lamprey host fish.				
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults	Transforming adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure resulting in decreased survival, growth, and fitness of Pacific and river lamprey host fish.		May affect transforming adult surviva and productivity. May affect adult growth and spawning productivity of Pacific and river lamprey host fish. Other effects on adult river lamprey				
						0	<u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity, with resulting decreased growth and reproductive fitness of Pacific and river lamprey. River lamprey use nearshore habitats during this life-history phase, but dependence on habitat complexity remains a data gap.		are a data gap.				
]	Lacustrine						-	-					
	Altered autochthonous production	Reduced food web productivity.	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Ammocoetes; Transforming adults	<u>Ammocoetes and transforming adults</u> : Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness of Pacific and river lamprey host fish, and decreased prey resources for filter-feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete life-history stages are a data gap. Although effects of altered autochthonous inputs for western brook lamprey are a data gap, alterations could be expected to affect prey resource availability.	Design:Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.Construction:Avoid/minimize disturbance of aquatic vegetation during project construction.Operation:Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring.	May affect ammocoete and transforming adult growth and fitness				
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Transforming adults; Adults	<u>Transforming adults and adults</u> : See related stressor responses under Water Quality Alteration. Effects are related to host fish effects for both Pacific and river lamprey.		See effects for related stressors under Water Quality Modification.				
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Ammocoetes; Transforming adults; Adults	All exposed life-history stages: Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness of Pacific and river lamprey host fish, and decreased prey resources for filter feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete life-history stages are a data gap. Although effects of altered autochthonous inputs on Western brook lamprey are a data gap, alterations could be expected to affect prey resource availability.		Lamprey dependence on habitat complexity provided by freshwater aquatic vegetation is a data gap.				

Sub-			Expos	sure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring in spring and summer when transforming adults occupy nearshore habitats for rearing)	Permanent	Continuous	Transforming adults; Adults (river lamprey)	<u>Transforming adults and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for lamprey host fish, leading to decreased foraging opportunities for transforming adult Pacific and river lamprey, and adult river lamprey.	patterns, and wave energy and current patterns.	May affect growth and fitness at transforming adult life-history stages through effects on host fish. River lamprey are also known to use nearshore habitats during the adult life- history stage and will be subject to
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent				these effects during this period. Direc dependence on nearshore habitat characteristics for both species is a data gap. Decreased growth and fitness may affect survival and productivity during ocean migration life-history phase for both species. Western brook lamprey are non- anadromous and will not be exposed to these stressors.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous					
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Altered groundwater inputs		Year-round	Permanent	Continuous				

			Expos	sure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine		•						
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Ammocoetes; Transforming adults; Adults	Ammocoetes: Rearing lamprey ammocoetes are found buried in nearshore lacustrine sediments. Modification of hydraulic and geomorphic conditions may alter habitat suitability, leading to limitations on the amount of available habitat and	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects	May affect survival, growth, and fitness at ammocoete life-history sta Effects on host fish may decrease survival, growth, and fitness of transforming adult and adult lampre
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		affecting survival, growth, and fitness at this life- history stage. <u>Transforming adults and adults</u> : Wave energy, current velocity, sediment supply, substrate	on sediment supply, longshore drift patterns, and wave energy and current patterns.	and spawning productivity of adult lamprey.
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally		
	Altered groundwater Inputs		Year-round	Permanent	Continuous		alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for host		
	Altered sediment supply		Year-round	Permanent	Continuous		fish, leading to decreased foraging opportunities for adults and transforming adults. Decreased foraging		
	Altered substrate composition		Year-round	Permanent	Continuous		opportunities may cause decreased growth and fitness, affecting survival during marine migration and spawning productivity.		
	Ecosystem Fragmentation								
	Marine								
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Transforming adults; Adults	All exposed life-history stages: Jetties can fragment nearshore marine habitat, forcing migrating and foraging river lamprey to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness. Pacific lamprey exposure to these stressors is minimal, as they primarily reside in offshore habitats during the transforming adult and adult life-history stages. Brook lamprey do not occur in the marine environment.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival and productive transforming adult life-history stag Decreased fitness may affect survi and productivity during ocean migration life-history phase.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Transforming adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect transforming adult surv
ľ	Lacustrine		1	1	1		•	1	1
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Ammocoetes; Transforming adults; Adults	All exposed life-history stages: Jetties can fragment nearshore lacustrine rearing habitat, potentially affecting transport to and the suitability of these habitats for Pacific and river lamprey ammocoetes. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness. Western brook lamprey do not typically occur in lacustrine environments; therefore, the likelihood of stressor exposure is limited.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival, growth, and fitness at ammocoete life-history s Effects on host fish may decrease survival, growth, and fitness of transforming adult and adult lamp and spawning productivity of adul lamprey.

Sub-			Expos	sure	1	1			
activity Гуре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Transforming adults; Adults	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect survival of transforming adult growth and survival, as well as spawning success and overall population productivity.
Break	waters								
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history stages</u> : Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Little is known about the effects of anthropogenic sounds on lamprey.
	Construction vessel operation	Increased or altered ambient noise levels.	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Transforming adults, Adults	<u>Adults and transforming adults</u> : Very little is known of the effects of anthropogenic sounds on lamprey at any life-history stage.	Although little is known about the effects of anthropogenic sounds on lamprey, it is prudent to avoid/ minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	Little is known about the effects of anthropogenic sounds on lamprey.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Ammocoetes; Transforming adults; Adults	Ammocoetes:Mortality, injury, and stress, during dewatering (when buried in riverine sediments).Adults and transforming adults:Mortality, injury, or stress from capture, handling, and relocation.Transforming adults:Increased competition once relocated, and reduced growth and fitness; increased predation exposure.Adults:Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival, growth, and fitness at ammocoete, transforming adult, and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	<u>Transforming adults</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when transforming adults are present.	May affect survival and fitness at transforming adult life-history stage.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes:       Potential nest scour and/or sedimentation, resulting in decreased incubation success.         Transforming adults:       Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.         Adults:       Delayed migration, increased stress, and decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and ammocoete life-history stages; may affect transforming adult growth and fitness; may affect adult spawning success.

Sub-			Expo	sure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered current and circulation conditions (marine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults; Adults	<u>Transforming adults</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, and decreased spawning fitness.	To greatest extent practicable, limit alteration of current and circulation patterns to minimal area.	May affect transforming adult survival, growth, and fitness. May affect adult spawning fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering).	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Potential decreased egg incubation success and ammocoete survival due to turbidity exposure and substrate disturbance. <u>Transforming adults and adults</u> : For Pacific and river lamprey, decreased populations of host fish such as salmon could decrease available habitat.	Adhere to system-specific in-water work windows. Avoid work during egg incubation and ammocoete stages.	May affect survival of eggs and ammocoetes. May affect growth and fitness at transforming adult and adult life-history stages.
		Localized alteration in host fish abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	Transforming adults and adults: For Pacific and river lamprey, short-term reductions in host fish due to increased competition, decreased growth, and fitness are expected to affect growth and survival for these life-stages.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at transforming adult life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history-stages</u> : See responses to related stressors under Water Quality Modification. Water quality effects to ammocoetes are a data gap. However, as Pacific and river lamprey feed on host fish, effects of suspended solids on host fish could affect them. As western brook lamprey are filter feeders, this may not be a stressor for transforming adults and adults.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Transforming adults; Adults	Transforming adults and adults: See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and ammocoetes; Transforming adults; Adults	<u>Ammocoetes:</u> Ammocoetes of Pacific and river lamprey mature buried in fine substrates in the lower reaches and estuaries of larger rivers for extended periods and are therefore vulnerable to direct injury and mortality from dredging entrainment.	Avoid turbidity effects above background levels.	May cause direct mortality or injury to ammocoetes. May affect transforming adult growth and fitness. See effects for related stressors under Water Quality Modification.
							<u>Transforming adults</u> : Decreased foraging opportunity due to short-term reduction in prey availability. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.		

# Pacific Lamprey.

Sub-			Expos	ure	1	1			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Turbidity sufficient to cause fine sediment embeddedness or increased burial depth may lead to direct mortality and decreased survival of eggs and ammocoetes. <u>Transforming adults and adults</u> : Not a direct stressor to the lamprey. For Pacific and river lamprey, responses depend on stressor magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure that project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult growth and fitness, as well as adult fitness and spawning success.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Effects on host fish are stressors to Pacific and river lamprey. <u>Transforming adults and adults</u> : A physiological response to exposure at toxic levels causing mortality or injury leading to reduced fitness is a data gap. However, effects on host fish are known and would affect Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality. This is a data gap.	Avoid sediment pulses.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult survival, growth, and fitness, as well as adult survival, productivity, and spawning success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Transforming adults; Adults	<u>Transforming adults and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness of host fish for Pacific and river lamprey.	Avoid curing of concrete or discharge of concrete leachate to surface waters.	May affect survival, growth, and fitness of transforming adults and adults.

ub-			Expos	sure					
ctivity `ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Use of creosote-treated wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs and ammocoetes; Transforming adults; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness for Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.	May affect survival, growth, and fitness of all exposed life-history stages.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and ammocoetes; Transforming adults; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Transforming adults; Adults	Transforming adults and adults: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness of Pacific and river lamprey host fish. Effects on host fish in nearshore habitats would also affect adult river lamprey forage opportunities.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect river lamprey transforming adult and adult growth and fitness, as well as productivity of Pacific and river lamprey host fish.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults	Transforming adults:Decreased refuge habitatavailability and foraging opportunities, leading toincreased competition and predation exposureresulting in decreased survival, growth, and fitnessof Pacific and river lamprey host fish.Adults:Decreased foraging opportunity due todecreased food web productivity, with resultingdecreased growth and reproductive fitness ofPacific and river lamprey.River lamprey usenearshore habitats during this life-history phase,but dependence on habitat complexity remains adata gap.		May affect transforming adult survival and productivity. May affect adult growth and spawning productivity of Pacific and river lamprey host fish. Other effects on adult river lamprey are a data gap.

Sub-			Expos	sure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine and Lacustrine								
	Altered autochthonous production	Reduced food web productivity.	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Ammocoetes; Transforming adults	Ammocoetes and transforming adults: Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness of Pacific and river lamprey host fish, and decreased prey resources for filter-feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete life-history stages are a data gap. Although effects of altered autochthonous inputs for western brook lamprey are a data gap, alterations could be expected to affect prey resource availability.	Design:Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.Construction:Avoid/minimize disturbance of aquatic vegetation during project construction.Operation:Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring.	May affect ammocoete and transforming adult growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Transforming adults; Adults	Transforming adults and adults: See related stressor responses under Water Quality Alteration. Effects are related to host fish effects for both Pacific and river lamprey.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Ammocoetes; Transforming adults; Adults	All exposed life-history stages: Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness of Pacific and river lamprey host fish, and decreased prey resources for filter feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete life-history stages are a data gap. Although effects of altered autochthonous inputs on Western brook lamprey are a data gap, alterations could be expected to affect prey resource availability.		Lamprey dependence on habitat complexity provided by freshwater aquatic vegetation is a data gap.



Sub-			Expos	sure					
ictivity Гуре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification		-						
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and	Year-round	Permanent	Continuous	Eggs and ammocoetes; Transforming	<ul> <li>Eggs and ammocoetes: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and ammocoete survival. Pacific and river lamprey ammocoetes are particularly vulnerable to impact mechanisms that cause scour, deposition, or other forms of substrate modification when buried in fine substrates during rearing periods, which can last for several years.</li> <li>Transforming adults: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, as well as changes in food web complexity. These may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.</li> </ul>	on channel geometry, flow velocity, substrate composition, and groundwater exchange to the	May affect survival, growth, and fitness at egg and ammocoete stages and egg and transforming adult life-
	Altered flow velocity	rearing habitat availability and suitability.	Year-round (with stressor exposures occurring during high flow events, fall through spring)	Permanent	Seasonal	adults; Adults			history stages for host fish of Pacific and river lamprey. May also affect spawning productivity.
	Altered substrate composition (including placement of non- erodable substrate)		Year round	Permanent	Continuous				
	Altered groundwater inputs		Year-round, with stressor exposure occurring during egg incubation and transforming adult rearing.	Permanent	Continuous				
							<u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected		
	Addition of impervious surface	Alteration in the magnitude, volume, and timing of peak flows	During storm events, (predominantly from fall through spring)	Permanent	Common	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history stages</u> : Because the amount of impervious surface associated with marinas is a relatively inconsequential component of the overall drainage area of the larger river systems that would support this type of development, the magnitude of the hydrologic modification stressor is expected to be negligible. As such, this stressor is not expected to significantly affect the riverine environment, and there will be no response to the stressor.	Encourage facilities to employ modern low-impact development and stormwater treatment technology.	Impervious surface at anticipated scale should not produce stressors of sufficient magnitude to adversely affect lamprey at any life-history stage.

		Expos	sure					
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Marine								
Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring in spring and summer when transforming adults occupy nearshore habitats for rearing)	Permanent	Continuous	Transforming adults; Adults (river lamprey)	<u>Transforming adults and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect growth and fitness at transforming adult life-history sta through effects on host fish. Rive lamprey are also known to use nearshore habitats during the adul history stage and will be subject t
Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for lamprey host fish, leading to decreased foraging opportunities for transforming adult Pacific and river lamprey, and adult river lamprey.	current patterns.	these effects during this period. I dependence on nearshore habitat characteristics for both species is data gap. Decreased growth and fitness may affect survival and
Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				productivity during ocean migrat life-history phase for both species Western brook lamprey are non- anadromous and will not be expo these stressors.
Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
Altered groundwater inputs		Year-round	Permanent	Continuous				
Lacustrine								
Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Ammocoetes; Transforming adults; Adults	<u>Ammocoetes</u> : Rearing lamprey ammocoetes are found buried in nearshore lacustrine sediments. Modification of hydraulic and geomorphic conditions may alter habitat suitability, leading to limitations on the amount of available habitat and	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects	May affect survival, growth, and fitness at ammocoete life-history Effects on host fish may decreas survival, growth, and fitness of transforming adult and adult lam
Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		affecting survival, growth, and fitness at this life- history stage. <u>Transforming adults and adults</u> : Wave energy, current velocity, sediment supply, substrate	on sediment supply, longshore drift patterns, and wave energy and current patterns.	and spawning productivity of adulamprey.
Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally		
Altered groundwater Inputs		Year-round	Permanent	Continuous		alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for host		
Altered sediment supply		Year-round	Permanent	Continuous		fish, leading to decreased foraging opportunities for adults and transforming adults. Decreased foraging		
Altered substrate composition		Year-round	Permanent	Continuous		adults and transforming adults. Decreased foraging opportunities may cause decreased growth and fitness, affecting survival during marine migration and spawning productivity.		

			Expo	sure		1	1		
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation				-		•		•
	Riverine								
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Ammocoetes	Ammocoetes: Breakwaters provide three dimensional structure potentially attractive to lie- in-wait predators, potentially increasing predation exposure for Pacific and river lamprey ammocoetes in the vicinity of the structure, leading to decreased survival. Western brook lamprey do not occur in habitats suitable for breakwater development, therefore they have effectively no risk of stressor exposure.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect ammocoete survival.
	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Transforming adults; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No specific recommendations.	May affect survival of transforming adult growth and survival, as well as spawning success and overall population productivity.
	Marine								
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Transforming adults; Adults	Transforming adults, adults: Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators, potentially increasing predation exposure for transforming adult Pacific and river lamprey in the vicinity of the structure, leading to decreased survival. Adult river lamprey utilize nearshore habitats and may experience similar exposure (however they may also experience increased foraging opportunities as well). Pacific lamprey adults primarily occur in offshore habitats and are unlikely to experience stressor exposure.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival of transforming adult Pacific and river lamprey. M affect survival (negatively), growth and productivity (positively) of adu river lamprey.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Transforming adults; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect survival of transforming adult growth and survival, as well a spawning success and overall population productivity.
	Lacustrine	•			I	1			I
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Ammocoetes	Ammocoetes: Breakwaters provide three dimensional structure potentially attractive to lie- in-wait predators, potentially increasing predation exposure for Pacific and river lamprey ammocoetes in the vicinity of the structure, leading to decreased survival. Western brook lamprey do not occur in habitats suitable for breakwater development, therefore they	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect ammocoete survival.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Transforming adults; Adults	have effectively no risk of stressor exposure. See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect survival of transformin adult growth and survival, as well spawning success and overall population productivity.

			Expo	osure	1				
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
ns	and Bank Barbs	5							
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Little is known about the effects of anthropogenic sounds on lamprey.
	Construction vessel operation	Increased or altered ambient noise levels.	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Transforming adults, Adults	Adults and transforming adults: Very little is known of the effects of anthropogenic sounds on lamprey at any life-history stage.	Although little is known about the effects of anthropogenic sounds on lamprey, it is prudent to avoid/ minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	Little is known about the effects or anthropogenic sounds on lamprey.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Ammocoetes; Transforming adults; Adults	Ammocoetes: Mortality, injury, and stress, during dewatering (when buried in riverine sediments).Adults and transforming adults: Mortality, injury, or stress from capture, handling, and relocation.Transforming adults: Increased competition once relocated, and reduced growth and fitness; increased predation exposure.Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival, growth, and fitness at ammocoete, transformin adult, and adult life-history stages
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	<u>Transforming adults</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when transforming adults are present.	May affect survival and fitness at transforming adult life-history sta
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes:       Potential nest scour and/or sedimentation, resulting in decreased incubation success.         Transforming adults:       Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.         Adults:       Delayed migration, increased stress, and decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and ammocoete life-history stages; ma affect transforming adult growth a fitness; may affect adult spawning success.
		Altered current and circulation conditions (marine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults; Adults	Transforming adults:       Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.         Adults:       Delayed migration, increased stress, and decreased spawning fitness.	To greatest extent practicable, limit alteration of current and circulation patterns to minimal area.	May affect transforming adult sur growth, and fitness. May affect ac spawning fitness.

Table A-13 (continued).	HPA HCP Shoreline Modification Exposure and Response Matrix for Western Brook, River, and Pac

Sub-	Mechanism of Impact		Expo	sure				Minimization Measures	Resulting Effects of the Submechanism
activity Type		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor		
		Stream bed disturbance, increased turbidity (associated with site rewatering).	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Potential decreased egg incubation success and ammocoete survival due to turbidity exposure and substrate disturbance. <u>Transforming adults and adults</u> : For Pacific and river lamprey, decreased populations of host fish such as salmon could decrease available habitat.	Adhere to system-specific in-water work windows. Avoid work during egg incubation and ammocoete stages.	May affect survival of eggs and ammocoetes. May affect growth and fitness at transforming adult and adult life-history stages.
		Localized alteration in host fish abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	<u>Transforming adults and adults</u> : For Pacific and river lamprey, short-term reductions in host fish due to increased competition, decreased growth, and fitness are expected to affect growth and survival for these life-stages.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at transforming adult life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	All life-history-stages: See responses to related stressors under Water Quality Modification. Water quality effects to ammocoetes are a data gap. However, as Pacific and river lamprey feed on host fish, effects of suspended solids on host fish could affect them. As western brook lamprey are filter feeders, this may not be a stressor for transforming adults and adults.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Transforming adults; Adults	<u>Transforming adults and adults</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual-decadal	Eggs and ammocoetes; Transforming adults; Adults	<u>Ammocoetes:</u> Ammocoetes of Pacific and river lamprey mature buried in fine substrates in the lower reaches and estuaries of larger rivers for extended periods and are therefore vulnerable to direct injury and mortality from dredging entrainment. <u>Transforming adults</u> : Decreased foraging opportunity due to short-term reduction in prey availability. All life-history stages: See responses described for	Avoid turbidity effects above background levels.	May cause direct mortality or injury to ammocoetes. May affect transforming adult growth and fitness. See effects for related stressors under Water Quality Modification.
							All life-history stages: See responses described for related stressors under Water Quality Modification.		

# Pacific Lamprey.

Sub-			Expos	sure	1	1			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Turbidity sufficient to cause fine sediment embeddedness or increased burial depth may lead to direct mortality and decreased survival of eggs and ammocoetes. <u>Transforming adults and adults</u> : Not a direct stressor to the lamprey. For Pacific and river lamprey, responses depend on stressor magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure that project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult growth and fitness, as well as adult fitness and spawning success.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Effects on host fish are stressors to Pacific and river lamprey. <u>Transforming adults and adults</u> : A physiological response to exposure at toxic levels causing mortality or injury leading to reduced fitness is a data gap. However, effects on host fish are known and would affect Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality. This is a data gap.	Avoid sediment pulses.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult survival, growth, and fitness, as well as adult survival, productivity, and spawning success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Transforming adults; Adults	<u>Transforming adults and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness of host fish for Pacific and river lamprey.	Avoid curing of concrete or discharge of concrete leachate to surface waters.	May affect survival, growth, and fitness of transforming adults and adults.

		Expos	sure					
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Use of creosote-treated wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs and ammocoetes; Transforming adults; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness for Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.	May affect survival, growth, and fitness of all exposed life-history stages.
Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and ammocoetes; Transforming adults; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
Riparian Vegetation Modification								
Riverine								
Altered riparian shading Altered ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes:       Direct mortality when exposed to temperatures over 68°F for continuous periods.         Transforming adults:       Altered growth and fitness when exposed to temperatures outside optimal growth range, and alteration of food web patterns, including food web supporting Pacific and river lamprey host fish.         Adults and transforming adults:       Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during incubation, rearing, spawning. Likelihood of stressor exposure is limited, however, as n settings suitable for groin and ban barb development are in larger riv environments where riparian vegetation has less effect on temperature conditions.
						tolerance thresholds. <u>Adults</u> : Decreased spawning fitness due to migration delays caused by thermal barriers.		

Sub-			Expos	ure					
ictivity Гуре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered stream bank and shoreline stability	Increased suspended solids and burial of benthic ammocoetes or eggs.	Year-round (with specific stressors prominent during high-flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: success due to burial or scour of eggs and rearing ammocoetes. Decreased availability of host fish for Pacific and river lamprey.Transforming adults: Transforming adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness for Pacific and river lamprey host fish. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.Adults: Potential effects on migration and spawning productivity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during incubation and transforming adult and adult fitness of host fish for Pacific and river lamprey.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduction in organic matter inputs.	Year-round	Permanent	Continuous	Ammocoetes; Transforming adults	<u>Transforming adults and ammocoetes:</u> Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect growth and fitness of ammocoetes and transforming adults.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults	Transforming adults:Decreased refuge habitatavailability and foraging opportunities, leading toincreased competition and resulting effects ongrowth and fitness of host fish for Pacific and riverlamprey.Adults:Increased mortality; decreased fitness andspawning success due to decreased availability ofsuitable migratory and spawning habitat for hostfish of Pacific and river lamprey.Decreasedsuitable lamprey spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect growth and fitness of transforming adults. May affect adult spawning success.
	Altered groundwater– surface water exchange	Decreased thermal refuge, decreased substrate dissolved oxygen	Year-round	Permanent	Continuous	Eggs and ammocoetes; Adults	Lamprey responses to groundwater exchange are a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Lamprey dependence on groundwater exchange is currently a data gap. Therefore, the effects of stressor exposure are unknown.

		Expos	ure								
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
Marine											
Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Transforming adults; Adults	<u>Transforming adults</u> : Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, transforming adult Pacific and river lamprey trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress. Similar effects on Pacific and river lamprey host fish may affect foraging success.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of transforming adult Pacific and river lamprey, as well as adult river lamprey.			
						Adults: River lamprey adults are found in nearshore environments and may experience similar effects as described above. Similar effects on river lamprey host fish may affect foraging success, leading to decreased growth and spawning fitness.					
Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Transforming adults; Adults	<u>Transforming adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness of Pacific and river lamprey host fish. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of transforming adult Pacific and river lamprey, as well as adult river lamprey.			
						Adults: River lamprey adults are found in nearshore environments and may experience similar effects as described above. Similar effects on river lamprey host fish may affect foraging success, leading to decreased growth and spawning fitness.					
Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduced organic matter inputs.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Transforming adults; Adults	<u>Transforming adults</u> : Pacific and river lamprey host fish depend on allochthonous inputs from marine riparian vegetation. Effects on host fish survival growth and fitness may in turn affect lamprey growth and fitness. Those host fish that feed on benthic organisms (such as mollusks and amphipods) are likely linked to allochthonous material inputs.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	For Pacific and river lamprey, effects would be related only to host fish dependence on allochthonous inputs. Western brook lamprey have no marine life-history stage.			
						<u>Adults</u> : Adult river lamprey experience same effects as above.					
Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults	<u>Transforming adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness of host fish for Pacific and river lamprey.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect transforming adult surviva growth, and fitness; adult spawning success; and overall population productivity.			
	in available cover					<u>Adults</u> : Adult river lamprey experience same effects as above.					

		Expo	sure									
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism				
Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Transforming adults; Adults	<u>Transforming adults and adults (river lamprey)</u> : Lamprey dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown.				
Lacustrine												
Altered shading, solar input, ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Ammocoetes; Transforming adults; Adults	<u>Ammocoetes</u> : Larval western brook, river, and potentially Pacific lamprey are found in sheltered nearshore lacustrine habitats, buried in substrates. Altered water temperatures due to riparian modification could limit habitat suitability, affecting survival, growth, and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect ammocoete survival, growth, and fitness. May affect growth and fitness of adults and transforming adults.				
						Adults and transforming adults: Adult lamprey dependence on nearshore lacustrine habitats is currently a data gap. However, transforming adult host fish of Pacific and river lamprey may become trapped in isolated habitats, which may increase temperatures and potentially lead to mortality or increased thermal stress and decreased fitness of host fish, affecting foraging opportunities for adults and transforming adults.						
Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Ammocoetes; Transforming adults; Adults	<u>Ammocoetes</u> : Larval western brook, river, and potentially Pacific lamprey are found in sheltered nearshore lacustrine habitats, buried in substrates. Alteration of shoreline stability could lead to increased sedimentation and burial, affecting larval survival.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect ammocoete survival. May affect growth and fitness of adults and transforming adults.				
						<u>Adults and transforming adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness for Pacific and river lamprey host fish. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.						
Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Ammocoetes; Transforming adults; Adults	<u>All life-history stages</u> : Lamprey dependence on allochthonous inputs from shoreline riparian vegetation is a data gap. However, Pacific and river lamprey ammocoete benthic filter feeding stage and the filter feeding of the western brook lamprey could be affected. This could be a stressor to the extent the host fish is stressed by this mechanism of impact.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect ammocoete, transforming adult, and adult growth and fitness, depending on species.				
Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Ammocoetes; Transforming adults; Adults	<u>Ammocoetes</u> : Decrease in availability of suitable rearing habitat, leading to decreased survival, growth, and fitness. <u>Transforming adults and adults</u> : Decreased refuge habitat availability and foraging opportunities for host fish, potentially leading to decreased foraging opportunities for Pacific and river lamprey with resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect ammocoete survival, growth, and fitness. May affect adult growth, fitness, and spawning productivity due to effects on host fisl				

Sub-			Expo	sure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Ammocoetes; Transforming adults; Adults	<u>All life-history stages</u> : Lamprey dependence on groundwater inflow in lacustrine habitats is currently a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	Effects of the action resulting from this impact mechanism are unknown.
	Aquatic Vegetation Modification								
	Marine Littoral								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Transforming adults; Adults	<u>Transforming adults and adults</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness of Pacific and river lamprey host fish. Effects on host fish in nearshore habitats would also affect adult river lamprey forage opportunities.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect river lamprey transforming adult and adult growth and fitness, as well as productivity of Pacific and river lamprey host fish.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults	Transforming adults:Decreased refuge habitatavailability and foraging opportunities, leading to increased competition and predation exposure resulting in decreased survival, growth, and fitness of Pacific and river lamprey host fish.Adults:Decreased foraging opportunity due to decreased food web productivity, with resulting decreased growth and reproductive fitness of Pacific and river lamprey. River lamprey use nearshore habitats during this life-history phase, but dependence on habitat complexity remains a data gap.		May affect transforming adult survival and productivity. May affect adult growth and spawning productivity of Pacific and river lamprey host fish. Other effects on adult river lamprey are a data gap.



Sub-			Expos	sure				Minimization Measures	Resulting Effects of the Submechanism
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor		
	Riverine and Lacustrine								
	Altered autochthonous production	Reduced food web productivity.	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Ammocoetes; Transforming adults	<u>Ammocoetes and transforming adults</u> : Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness of Pacific and river lamprey host fish, and decreased prey resources for filter-feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete life-history stages are a data gap. Although effects of altered autochthonous inputs for western brook lamprey are a data gap, alterations could be expected to affect prey resource availability.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect ammocoete and transforming adult growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Transforming adults; / Adults	Transforming adults and adults: See related stressor responses under Water Quality Alteration. Effects are related to host fish effects for both Pacific and river lamprey.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Ammocoetes; Transforming adults; Adults	All exposed life-history stages: Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness of Pacific and river lamprey host fish, and decreased prey resources for filter feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete life-history stages are a data gap. Although effects of altered autochthonous inputs on Western brook lamprey are a data gap, alterations could be expected to affect prey resource availability.		Lamprey dependence on habitat complexity provided by freshwater aquatic vegetation is a data gap.



Sub-			Expos	sure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification					-			-
	Riverine								
	Altered channel geometry	exposures occ during high fl fall through s	Year-round	Permanent	Continuous	Eggs and ammocoetes; Transforming	Eggs and ammocoetes: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and ammocoete survival. Pacific and river lamprey ammocoetes are particularly vulnerable to impact mechanisms that cause scour, deposition, or other forms of substrate modification when buried in fine	on channel geometry, flow velocity, substrate composition, and	May affect survival, growth, and fitness at egg and ammocoete stages and egg and transforming adult life-
	Altered flow velocity		Year-round (with stressor exposures occurring during high flow events, fall through spring)	Permanent	Seasonal	adults; Adults			history stages for host fish of Pacific and river lamprey. May also affect spawning productivity.
	Altered substrate composition (including placement of non- erodable substrate)       Year round       Permanent       Continuous       substrate         Altered groundwater       Year-round, with stressor       Permanent       Continuous       substrate	substrates during rearing periods, which can last for several years. <u>Transforming adults</u> : Altered channel geometry, flow velocity, and substrate composition can result	greatest extent practicable.						
	Altered groundwater inputs	exposure occurring during egg incubation and transforming adult rearing.	exposure occurring during egg incubation and	Permanent	Continuous		in decreased rearing habitat suitability, as well as changes in food web complexity. These may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth,		
	Addition of impervious surface			fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected					

			Expos	sure					
vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine	•	-			-			
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring in spring and summer when transforming adults occupy nearshore habitats for rearing)	Permanent	Continuous	adults; Adults (river lamprey)	current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect growth and fitness at transforming adult life-history stages through effects on host fish. River lamprey are also known to use nearshore habitats during the adult life history stage and will be subject to
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent			patterns, and wave energy and current patterns.	these effects during this period. Direct dependence on nearshore habitat characteristics for both species is a data gap. Decreased growth and fitness may affect survival and
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				productivity during ocean migration life-history phase for both species. Western brook lamprey are non- anadromous and will not be exposed
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				these stressors.
	Altered groundwater inputs		Year-round	Permanent	Continuous	_			
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Ammocoetes; Transforming adults; Adults	<u>Ammocoetes</u> : Rearing lamprey ammocoetes are found buried in nearshore lacustrine sediments. Modification of hydraulic and geomorphic conditions may alter habitat suitability, leading to limitations on the amount of available habitat and	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects	May affect survival, growth, and fitness at ammocoete life-history sta Effects on host fish may decrease survival, growth, and fitness of transforming adult and adult lampre
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common	affecting survival, growth, and fitness at this life-history stage. <u>Transforming adults and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for host fish, leading to decreased foraging opportunities for adults and transforming adults. Decreased foraging opportunities may cause decreased growth and	history stage. <u>Transforming adults and adults</u> : Wave energy,	on sediment supply, longshore drift patterns, and wave energy and current patterns.	and spawning productivity of adult lamprey.
	Altered groundwater Inputs		Year-round	Permanent	Continuous		composition, and groundwater inputs are core ecosystem processes and characteristics that		
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous		alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for host fish, leading to decreased foraging opportunities for adults and transforming adults. Decreased foraging opportunities may cause decreased growth and fitness, affecting survival during marine migration		

ıb-			Ex	posure				
tivity /pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Ecosystem Fragmentation				•		•	
	Riverine							
	Habitat loss and fragmentation	Fragmentation of side channel and floodplain habitat; change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and Ammocoetes; Transforming adults; Adults	All exposed life-history stages: Bank barbs and groins can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and larval rearing habitat for lamprey species. Depending on configuration, these structures may also affect the transport of lamprey ammocoetes to suitable rearing habitats, potentially affecting ammocoete survival. Decreased habitat availability may lead to density-dependent effects on adult spawning success. Adult brook lamprey may also be affected by decreased availability of suitable foraging habitat.	Rec effe per des floc
	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Transforming adults; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No
	Marine							
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Transforming adults; Adults	<u>All exposed life-history stages</u> : Bank barbs and groins in the marine environment can fragment nearshore habitat, forcing migrating and foraging river lamprey to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness. Pacific lamprey exposure to these stressors is minimal, as they primarily reside in offshore habitats during the transforming adult and adult life-history stages. Brook lamprey do not occur in the marine environment.	Rec foo pro cun pre
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Transforming adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	Rec acc adja othe whe mai

Minimization Measures	Resulting Effects of the Submechanism
Require assessment of the hydraulic effects of the project before permitting and avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, ammocoete, and transforming adult life-history stages. May affect spawning productivity.
No specific recommendations.	May affect transforming adult growth and survival, as well as spawning success and overall population productivity.
Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity at transforming adult life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect transforming adult survival.

Sub-			Expo	sure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Transforming adults; Adults	All exposed life-history stages: Bank barbs and groins in lacustrine environments can fragment nearshore rearing habitat, potentially affecting transport to and the suitability of nearshore rearing habitats for Pacific and river lamprey ammocoetes. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness. Western brook lamprey do not typically occur in lacustrine environments; therefore, the likelihood of stressor exposure is limited.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity at transforming adult life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Transforming adults;	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect Transforming adult survival.

ub-			Expos	sure	-				
ctivity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
letties									
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<ul> <li><u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Fatal injury or permanent auditory tissue damage caused by barotraumas limiting to larval, juvenile, and adult survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness</li> <li>Note that actual sound sensitivity of primitive fish species such as sturgeon is currently a data gap, so actual harm thresholds are unknown.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work-areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May cause direct mortality or injury at all life-history stages. May affect survival, growth, and fitness at the juvenile life-history stage. Actual effects are uncertain as the sensitivity of these species to noise related stressors is currently a data gap.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Juveniles</u> : Auditory masking may affect ability to avoid predators, leading to effects on survival. Behavioral responses may lead to habitat avoidance, affecting growth and fitness. <u>Adults</u> : May cause avoidance behavior. Note: While these responses are possible, very little is known of the effects of anthropogenic sounds on sturgeon at any life-history stage, so the actual effects of stressor exposure are uncertain.	Although, little is known about the effects of anthropogenic sounds on sturgeon, it is prudent to avoid/ minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect juvenile survival due to avoidance behavior, decreased foraging success, and increased predation risk. May cause adult avoidance behavior. Actual effects are unknown as stressor sensitivity is currently a data gap.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	<u>Juveniles and larvae</u> : Mortality, injury, or stress from capture, handling, and relocation. Sturgeon larvae may be too small to capture effectively, leading to mortality or injury from asphyxiation.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality or injury to larvae and juveniles. Stress from relocation may affect survival, growth, and fitness.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae and juveniles: Injury or mortality from pump entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality of larvae and juveniles.

Sub-			Expo	sure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juvenile (over 1 ft length-[marine]) and adults:</u> Because of the limited temporal and spatial extent of alteration to sturgeon marine habitat, project effects on marine circulation are a relatively inconsequential component. Therefore, the magnitude of project hydrologic modification is expected to be negligible. As such, this stressor is not expected to significantly affect the marine environment, and there will be no response to the stressor.	To greatest extent practicable, limit alteration of current and circulation patterns to minimal area.	Effects from exposure to this stressor are expected to be insignificant and discountable.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : May cause avoidance behavior, potentially delaying migration.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect juvenile survival, growth, and productivity. May cause adult avoidance behavior, potentially delaying migration and limiting spawning productivity; however, actual sensitivity to these stressors is a data gap.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	<u>All life-history stages</u> : See responses under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	Juveniles and adults:Decreased growth and fitness due to stress and exertion caused by avoidance behavior and decreased foraging opportunity caused by short-term reduction in prey availability.All life-history stages:See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile and adult growth and fitness. See effects for related stressors under Water Quality Modification.

Sub-			Expo	sure		1			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification	-							
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure that project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile productivity and adult productivity and spawning success. May cause direct mortality or injury in acute events.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Juveniles and adults</u> : Physiological responses to exposure at levels exceeding tolerance thresholds, causing mortality or injury leading to reduced fitness. Avoidance behavior during subacute events.	Avoid sediment pulses.	May affect juvenile and adult survival, growth, and fitness.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Prevent in-water curing of concrete and discharge of concrete leachate to surface waters.	May affect survival and productivity of juveniles and adults.

### HPA HCP Shoreline Modification Exposure and Response Matrix for Green and White Sturgeon. Table A-14 (continued).

### Table A-14 (continued).

HPA HCP Shoreline Modification Exposure and Response Matrix for Green and White Sturgeon.

			Expos	sure	1	<b>-</b>			
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Use of creosote-treated wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in freshwater. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Due to their long lifespan and high age at maturity, adult sturgeon are at risk from adverse effects from bioaccumulation of contaminants. Chronic exposure to contaminants may affect adult survival, growth, fitness, and spawning productivity.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.	May affect survival, growth, and fitness of all exposed life-history stages.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults		<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
	Riparian Vegetation Modification								
	Marine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Adults	<u>Adults</u> : Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. Adult use of nearshore marine habitats is limited; therefore, stressor exposure is unlikely to occur.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Effects of stressor exposure on ad sturgeon are expected to be insignificant and discountable.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Adults	<u>Adults:</u> Adult use of nearshore marine habitats is limited; therefore, stressor exposure is unlikely to occur.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Effects of stressor exposure on ad sturgeon are expected to be insignificant and discountable.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Adults	<u>Adults</u> : Sturgeon dependence on allochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure is currently a data gap; therefore, the effects of the action from this imp mechanism are unknown.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Adults	Adults: Adult use of nearshore marine habitats is limited; therefore, stressor exposure is unlikely to occur.	Encourage project designs that limit permanent alteration of high-quality habitat features.	Effects of stressor exposure on ad sturgeon are expected to be insignificant and discountable.
			1	Permanent	Continuous	Adults	Adult: Sturgeon dependence on groundwater	Avoid/minimize disturbance of	Sensitivity to stressor exposure is

-			Expos	sure					Resulting Effects of the Submechanism
vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	
	Lacustrine								
	Altered riparian shading	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of turnover time, stratification patterns, wind conditions, and other	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitnes
	Altered ambient air temperature regime						factors. However, the suitability of some protected habitats such as isolated embayments may be affected, leading to decreased rearing habitat availability and increased competition, leading to decreased growth and fitness.		
	Altered shoreline and bluff stability		Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	Juveniles: Sturgeon dependence on allochthonous inputs from lacustrine riparian vegetation is a data gap. However, juvenile sturgeon are opportunistic feeders. Loss of terrestrial insect-fall could lead to decreased foraging opportunities, affecting growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitnes
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and fitness
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Sturgeon dependence on groundwater inflow to nearshore lacustrine habitats is currently a data gap. However, juveniles are dependent on water temperatures less than 75°F (24°C) for optimal growth. Reduction in thermal refuge habitat may lead to avoidance behavior, decreased growth, and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	Effects of action resulting from this impact mechanism are unknown, as sturgeon dependence on lacustrine groundwater inflow is a data gap. However, loss of thermal refuge habitat may affect juvenile growth and fitness.

Sub-			Expos	sure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Aquatic Vegetation Modification	•				-		-
	Marine							
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Adults	Adults: Adult sturgeon dependence on nearshore aquatic vegetation is a data gap. However, this species feeds on mollusks, fish, and invertebrate species dependent on nearshore food web productivity. Therefore, this stressor could indirectly affect adult growth and fitness.	Avoi ripari appro the g
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Adults	<u>Adults</u> : Adult sturgeon dependence on nearshore habitat complexity is limited. However, effects on habitat complexity may limit the availability and productivity of prey species; therefore, this stressor could indirectly affect adult growth and fitness. Given the extended marine foraging habitats used by sturgeon, localized effects are likely to be insignificant.	
	Lacustrine							1
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Juvenile sturgeon are known to feed opportunistically upon benthic prey organisms and fish dependent upon autochthonous material; reducing autochthonous production may decrease foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Desig footp aquat exten <u>Cons</u> distur durin
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Reduced aquatic habitat complexity may limit the availability of suitable refuge and foraging habitat, leading to increased predation exposure and decreased foraging opportunities, affecting survival, growth, and fitness.	<u>Opera</u> rules veget grour

Minimization Measures	Resulting Effects of the Submechanism
roid/minimize disturbance of arian vegetation. Maintain system- propriate riparian buffer widths to greatest extent possible.	May affect adult growth and fitness. However, localized effects are likely to be insignificant.
sign: Limit project structural otprint to minimize shading of aatic vegetation to the greatest ent practicable.	May affect juvenile productivity.
nstruction: Avoid/minimize turbance of aquatic vegetation ring project construction.	
<u>veration</u> : Enforce vessel operation es to limit submerged aquatic getation damage from prop wash, bunding, and anchoring.	May affect juvenile survival, growth, and fitness.

Table A-14 (continued).	HPA HCP Shoreline Modification Exposure and Response Matrix for Green and White Stur
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Sub-			Expos	sure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification	-							
	Marine								
	Altered current velocities Altered nearshore circulation patterns	habitat suitability, reduced food web complexity, habitat availability and suitabilityexposure occuring in spring and summer when juveniles occupy nearshore habitats for rearing)Year-round (with variable effects depending on site- specific current dynamics and project configuration)Year-round (with variable effects depending on site- specific geography and bathymetry and project configuration)	and summer when juveniles occupy nearshore habitats for	Permanent	Continuous	Adults	<u>Adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing marine food web productivity and availability of prey species. This could lead to decreased adult growth and fitness, however incremental effects may not be significant considering the wide ranging marine habitats of adult sturgeon.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects	May affect adult growth and fitness.
			effects depending on site- specific current dynamics and	Permanent	Intermittent			on sediment supply, longshore drift patterns, and wave energy and current patterns.	
			variable effects depending on site-specific geography and bathymetry and project	Permanent	Seasonal				
	Altered sediment supply		project installation and becoming more pronounced	Permanent	Continuous				
	Altered substrate composition		Permanent	Continuous					
	Altered groundwater inputs		Year-round	Permanent	Continuous				

### irgeon.

		Expos	sure					
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Lacustrine			•	·		•	·	
Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of	May affect survival at larval life- history stage. May affect growth a fitness at juvenile life-history stage May affect adult growth and fitness
Altered current velocities		Year-round (with effects more predominant in reservoir versus natural lakes)	Permanent	Common		nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of juvenile rearing habitat. This	project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	and adult spawning productivity.
Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		may occur through increased predation exposure, food web alterations, and decreased foraging opportunity. Alteration of current and circulation	1	
Altered groundwater inputs		Year-round	Permanent	Continuous		patterns may prevent larvae transport to suitable rearing environments. The combined effect of these stressors can result in decreased survival,		
Altered sediment supply		Year-round	Permanent	Continuous		growth, and fitness at larval and juvenile life- history stages.		
Altered substrate composition		Year-round	Permanent	Continuous		Adults: Adult sturgeon are generally less sensitive to these stressors. However, food web productivity in large reservoir environments may be affected by these impact mechanisms. This could lead to reduced adult foraging opportunities in residualized populations, and decreased growth, fitness, and spawning productivity.		
Ecosystem Fragmentation								
Marine								
Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Adults	<u>All exposed life-history stages</u> : Jetties can fragment nearshore rearing and foraging habitats. Sturgeon dependence on these habitat types is currently a data gap; therefore, the effects of this stressor are unknown.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	Sensitivity to stressor exposure is currently a data gap; therefore, the effects of the action from this imp mechanism are unknown.
Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	Effects of stressor exposure on adustrigeon are expected to be insignificant and discountable.
Lacustrine								
Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Jetties can fragment nearshore lacustrine habitat, forcing foraging larval and juvenile sturgeon to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life history stage. Decreased fitness n lead to reduced spawning product
Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.

Sub-			Expos	sure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Break	waters								
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs; Larvae; Juveniles; Adults	<ul> <li><u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from;</li> <li>Egg mortality due to membrane rupture.</li> <li>Fatal injury or permanent auditory tissue damage caused by barotraumas limiting to larval, juvenile, and adult survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness</li> <li>Note that actual sound sensitivity of primitive fish species such as sturgeon is currently a data gap, so actual harm thresholds are unknown.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work-areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May cause direct mortality or injury at all life-history stages. May affect survival, growth, and fitness at larval and juvenile life-history stages. Actual effects are uncertain as the sensitivity of these species to noise related stressors is currently a data gap.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Juveniles</u> : Auditory masking may affect ability to avoid predators, leading to effects on survival. Behavioral responses may lead to habitat avoidance, affecting growth and fitness. <u>Adults</u> : May cause avoidance behavior. Note: While these responses are possible, very little is known of the effects of anthropogenic sounds on sturgeon at any life-history stage, so the actual effects of stressor exposure are uncertain.	Although, little is known about the effects of anthropogenic sounds on sturgeon, it is prudent to avoid/ minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect juvenile survival due to avoidance behavior, decreased foraging success, and increased predation risk. May cause adult avoidance behavior. Actual effects are unknown as stressor sensitivity is currently a data gap.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	<u>Juveniles and larvae</u> : Mortality, injury, or stress from capture, handling, and relocation. Sturgeon larvae may be too small to capture effectively, leading to mortality or injury from asphyxiation.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality or injury to larvae and juveniles. Stress from relocation may affect survival, growth, and fitness.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae and juveniles: Injury or mortality from pump entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality of larvae and juveniles.

Sub-			Expo	sure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juvenile (over 1 ft length [marine]) and adults: Because of the limited temporal and spatial extent of alteration to sturgeon marine habitat, project effects on marine circulation are a relatively inconsequential component. Therefore, the magnitude of project hydrologic modification is expected to be negligible. As such, this stressor is not expected to significantly affect the marine environment, and there will be no response to the stressor.	To greatest extent practicable, limit alteration of current and circulation patterns to minimal area.	Effects from exposure to this stressor are expected to be insignificant and discountable.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. <u>Juveniles</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : May cause avoidance behavior,	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival during egg and larval life-history stages. May affect juvenile survival, growth, and productivity. May cause adult avoidance behavior, potentially delaying migration and limiting spawning productivity; however, actual sensitivity to these stressors is a data gap.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	potentially delaying migration. <u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses above under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: may experience injury or mortality from dredge entrainment.Juveniles and adults: Decreased growth and fitness due to stress and exertion caused by avoidance behavior and decreased foraging opportunity caused by short-term reduction in prey availability.All life-history stages: for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May cause direct injury or mortality of eggs and larvae. May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.

Sub-			Expo	sure	1	1			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity may lead to direct mortality and decreased survival of eggs and larvae. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure that project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of eggs and larvae May affect juvenile productivity and adult productivity and spawning success. May cause direct mortality o injury in acute events.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Juveniles and adults</u> : Physiological responses to exposure at levels exceeding tolerance thresholds, causing mortality or injury leading to reduced fitness. Avoidance behavior during subacute events.	Avoid sediment pulses.	May affect survival of incubating egg and larvae. May affect juvenile and adult survival, growth, and fitness.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Prevent in-water curing of concrete and discharge of concrete leachate to surface waters.	May affect survival and productivity of juveniles and adults.

### Table A-14 (continued).

HPA HCP Shoreline Modification Exposure and Response Matrix for Green and White Sturgeon.

			Expos	sure	1	-			
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Use of creosote-treated wood Use of ACZA- and CCA type C-treated wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in freshwater. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Due to their long lifespan and high age at maturity, adult sturgeon are at risk from adverse effects from bioaccumulation of contaminants. Chronic exposure to contaminants may affect adult survival, growth, fitness, and spawning productivity.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.	May affect survival, growth, and fitness of all exposed life-history stages.	
		Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and larvae; Juveniles; Adults		Removal: Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
	Aquatic Vegetation Modification				-				
ľ	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Adults	<u>Adults</u> : Adult sturgeon dependence on nearshore aquatic vegetation is a data gap. However, this species feeds on mollusks, fish, and invertebrate species dependent on nearshore food web productivity. Therefore, this stressor could indirectly affect adult growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect adult growth and fitne However, localized effects are like be insignificant.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Adults	<u>Adults</u> : Adult sturgeon dependence on nearshore habitat complexity is limited. However, effects on habitat complexity may limit the availability and productivity of prey species; therefore, this stressor could indirectly affect adult growth and fitness. Given the extended marine foraging habitats used by sturgeon, localized effects are likely to be insignificant.		
	Riverine and Lacustrine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Juvenile sturgeon are known to feed opportunistically upon benthic prey organisms and fish dependent upon autochthonous material; reducing autochthonous production may decrease foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile productivity.

ub-			Expos	sure					
ctivity ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, reduced spawning	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles	<u>Eggs and larvae</u> : Sturgeon are believed to spawn in swift current environments in part because the high velocities protect eggs from predation.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg and larval life-history stages. May affect juvenile growth and fitness. May affect adult
	Altered flow velocity	and rearing habitat availability and suitability	Year-round (with stressor exposures occurring during high-flow events, fall through spring)	Permanent	Seasonal	- Adults	Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success, and potentially increased predation exposure. Changes in flow regime	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest	spawning productivity.
	Altered substrate composition (including placement of non- erodable substrate)		Year-round	Permanent	Continuous		may cause larvae to be transported to environments unfavorable for survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in	extent practicable.	
	Altered groundwater inputs		Year-round, with stressor exposure occurring during egg incubation and juvenile rearing.	Permanent	Continuous	0	decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Juvenile dependence on groundwater exchange is a data gap; however, loss of thermal refuge may decrease the availability of suitable rearing habitat, leading to decreased growth and fitness.		
							<u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations) if potential spawning habitat is affected		
		Alteration in the magnitude, volume, and timing of peak flows.	During storm events, predominantly from fall through spring.	Permanent	Common	Eggs and larvae; Juveniles Adults	<u>All life-history stages</u> : Because the amount of impervious surface associated with breakwaters is a relatively inconsequential component of the overall drainage area of the larger river systems that would support this type of development, the magnitude of the hydrologic modification stressor is expected to be negligible. As such, this stressor is not expected to significantly affect the riverine environment, and there will therefore be no response to the stressor.	Encourage facilities to employ modern low impact development and stormwater treatment technology.	Impervious surface at anticipated scale would not produce stressors of sufficient magnitude to adversely affect sturgeon at any life-history stage.

Sub-			Expos	sure						
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Marine									
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Permanent	Continuous	Adults	<u>Adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects	May affect adult growth and fitness.		
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		parameters can fundamentally alter marine littoral habitats, potentially decreasing marine food web productivity and availability of prey species. This could lead to decreased adult growth and fitness, however incremental effects	littoral habitats, potentially decreasing marine food web productivity and availability of prey species. This could lead to decreased adult	patterns, and wave energy and current patterns. For example: Permeable breakwaters that maintain	
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry and project configuration)	on		may not be significant considering the wide ranging marine habitats of adult sturgeon.	longshore drift patterns Suggest alternative designs for projects that fragment sources of sediment recruitment and groundwater supply Require beach nourishment to maintain			
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous			substrate and beach profile characteristics where impacts are unavoidable		
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous					
	Altered groundwater inputs		Year-round	Permanent	Continuous	]				



			Expos	ure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine							·	
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of	May affect survival at larval life- history stage. May affect growth a fitness at juvenile life-history stage May affect adult growth and fitnes
	Altered current velocities		Year-round (with effects more predominant in reservoir versus natural lakes)	Permanent	Common		nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of juyenile rearing habitat. This	project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	and adult spawning productivity.
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		may occur through increased predation exposure, food web alterations, and decreased foraging opportunity. Alteration of current and circulation		
	Altered groundwater inputs		Year-round	Permanent	Continuous		patterns may prevent larvae transport to suitable rearing environments. The combined effect of these stressors can result in decreased survival,		
	Altered sediment supply		Year-round	Permanent	Continuous		growth, and fitness at larval and juvenile life-		
	Altered substrate composition		Year-round	Permanent	Continuous		history stages. Adults: Adult sturgeon are generally less		
						0	sensitive to these stressors. However, food web productivity in large reservoir environments may be affected by these impact mechanisms. This could lead to reduced adult foraging opportunities in residualized populations, and decreased growth, fitness, and spawning productivity.		
	Ecosystem								
_	Fragmentation								
-	Riverine	· · · ·				-			
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Breakwaters provide three dimensional structure potentially attractive to lie- in-wait predators, potentially increasing predation exposure for sturgeon larvae and smaller juveniles in the vicinity of the structure, leading to decreased survival.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval and juvenile sur
	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No specific recommendations.	May affect juvenile growth and survival, as well as spawning succ and overall population productivity
	Marine			•					
	Alteration of predator/prey dynamics	Increased predation exposure	NA	NA	NA	NA	Sturgeon in the marine environment occur as sub-adults and adults, which are not vulnerable to predation by the typical range of lie-in-wait predators that associate with breakwaters and similar structures.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	The effects of exposure to this str are considered insignificant and discountable.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	Effects of stressor exposure on ac sturgeon are expected to be insignificant and discountable.

-			Expos	sure					
vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine	·					•	•	•
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Breakwaters provide three dimensional structure potentially attractive to lie- in-wait predators, potentially increasing predation exposure for sturgeon larvae and smaller juveniles in the vicinity of the structure, leading to decreased survival.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval and juvenile surviva
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.
ns	and Bank Barbs	8							
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs; Larvae; Juveniles; Adults	<ul> <li><u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Egg mortality due to membrane rupture.</li> <li>Fatal injury or permanent auditory tissue damage caused by barotraumas limiting to larval, juvenile, and adult survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness</li> <li>Note that actual sound sensitivity of primitive fish species such as sturgeon is currently a data gap, so actual harm thresholds are unknown.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work-areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May cause direct mortality or injury a all life-history stages. May affect survival, growth, and fitness at larval and juvenile life-history stages. Actu effects are uncertain as the sensitivity of these species to noise related stressors is currently a data gap.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Juveniles:Auditory masking may affect ability to avoid predators, leading to effects on survival. Behavioral responses may lead to habitat avoidance, affecting growth and fitness.Adults:May cause avoidance behavior.Note:While these responses are possible, very little is known of the effects of anthropogenic sounds on sturgeon at any life-history stage, so the actual effects of stressor exposure are uncertain.	Although, little is known about the effects of anthropogenic sounds on sturgeon, it is prudent to avoid/ minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	May affect juvenile survival due to avoidance behavior, decreased foraging success, and increased predation risk. May cause adult avoidance behavior. Actual effects a unknown as stressor sensitivity is currently a data gap.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Juveniles and larvae: Mortality, injury, or stress from capture, handling, and relocation. Sturgeon larvae may be too small to capture effectively, leading to mortality or injury from asphyxiation.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality or injury larvae and juveniles. Stress from relocation may affect survival, grow and fitness.

		Expo	osure					
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae and juveniles: Injury or mortality from pump entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality of larvae and juveniles.
	Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae: May affect settlement, leading to decreased larval survival. Juveniles and adults: Sturgeon feed opportunistically on benthic organisms, such as aquatic insect larvae and fish. Substrate effects on these prey organisms could affect prey availability, resulting in decreased growth and fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during larval life history stage. May affect juvenile an adult growth and fitness.
	Altered current and circulation conditions (marine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juvenile (over 1 ft length-[marine]) and adults: Because of the limited temporal and spatial extent of alteration to sturgeon marine habitat, project effects on marine circulation are a relatively inconsequential component. Therefore, the magnitude of project hydrologic modification is expected to be negligible. As such, this stressor is not expected to significantly affect the marine environment, and there will be no response to the stressor.	To greatest extent practicable, limit alteration of current and circulation patterns to minimal area.	Effects from exposure to this stressor are expected to be insignificant and discountable.
	Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: May cause avoidance behavior,	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival during egg and larval life-history stages. May affect juvenile survival, growth, and productivity. May cause adult avoidance behavior, potentially delaying migration and limiting spawning productivity; however, actual sensitivity to these stressors is data gap.
	Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	potentially delaying migration.         Juveniles:       Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
	Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors unde Water Quality Modification
Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors unde Hydraulic and Geomorphic Modification.
	Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.

Sub-			Expo	sure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: may experience injury or mortality from dredge entrainment.Juveniles and adults: Decreased growth and fitness due to stress and exertion caused by avoidance behavior and decreased foraging opportunity caused by short-term reduction in prey availability.All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May cause direct injury or mortality of eggs and larvae. May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.
	Water Quality Modification				· 				
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity may lead to direct mortality and decreased survival of eggs and larvae. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure that project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of eggs and larvae. May affect juvenile productivity and adult productivity and spawning success. May cause direct mortality or injury in acute events.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Juveniles and adults</u> : Physiological responses to exposure at levels exceeding tolerance thresholds, causing mortality or injury leading to reduced fitness. Avoidance behavior during subacute events.	Avoid sediment pulses.	May affect survival of incubating eggs and larvae. May affect juvenile and adult survival, growth, and fitness.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Prevent in-water curing of concrete and discharge of concrete leachate to surface waters.	May affect survival and productivity of juveniles and adults.

### Table A-14 (continued).

HPA HCP Shoreline Modification Exposure and Response Matrix for Green and White Sturgeon.

			Expos	ure	1	1			
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Use of creosote-treated wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in freshwater. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Due to their long lifespan and high age at maturity, adult sturgeon are at risk from adverse effects from bioaccumulation of contaminants. Chronic exposure to contaminants may affect adult survival, growth, fitness, and spawning productivity.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.	May affect survival, growth, and fitness of all exposed life-history stages.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and larvae; Juveniles; Adults		<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
I	Vegetation Modification Riverine						-		-
i	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures).	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Direct mortality of embryos at temperatures in excess of 68°F (20°C). <u>Juveniles</u> : Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns. Decreased growth when exposed to temperatures in excess of 75°F (24°C).	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during incubation, rearing, spawning. Likelihood of stressor exposure is limited, however, as n settings suitable for groin and ban barb development are in larger riv environments where riparian vegetation has less effect on
							<u>Adults</u> : Exposure to thermal barriers is unlikely as spawning migrations occur in mid- to late- winter and spawning occurs in turbulent river		temperature conditions.
							mainstems.		
	Altered stream bank and shoreline stability	Increased suspended solids and burial of benthic organisms (juvenile prey) or eggs attached to coarse substrate	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles;	mainstems.Eggs and larvae:Decreased incubation successand larval survival due to effects of turbidityexposure as described above under Water QualityModification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival during incuba larval dispersal, as well as surviva growth, and fitness during juvenil rearing.
		burial of benthic organisms (juvenile prey) or eggs attached to	stressors prominent during	long-term (dependent on time required for	seasonal (dependent	00	mainstems.         Eggs and larvae:       Decreased incubation success and larval survival due to effects of turbidity exposure as described above under Water Quality	riparian vegetation. Maintain system- appropriate riparian buffer widths to	larval dispersal, as well as surviva growth, and fitness during juvenil

### Table A-14 (continued). HPA HCP Shorelin

# HPA HCP Shoreline Modification Exposure and Response Matrix for Green and White Sturgeon.

		Expos	sure					
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, grow and fitness.
Altered groundwater– surface water exchange	Reduced thermal refuge, reduced substrate dissolved oxygen, altered food web productivity	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Sturgeon dependence on groundwater exchange is currently a data gap. However, juveniles are dependent on water temperatures less than 75°F (24°C) for optimal growth. Reduction in thermal refuge habitat may lead to avoidance behavior, decreased growth, and decreased fitness.	Avoid disturbance of vegetation along stream.	Effects of action resulting from the impact mechanism are unknown, sturgeon dependence on groundw surface water exchange is a data and the However, loss of thermal refuge habitat may affect juvenile growth fitness.
Marine								
Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Adults	<u>Adults</u> : Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. Adult use of nearshore marine habitats is limited; therefore, stressor exposure is unlikely to occur.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Effects of stressor exposure on ad sturgeon are expected to be insignificant and discountable.
Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Adults	<u>Adults:</u> Adult use of nearshore marine habitats is limited; therefore, stressor exposure is unlikely to occur.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Effects of stressor exposure on ad sturgeon are expected to be insignificant and discountable.
Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Adults	<u>Adults</u> : Sturgeon dependence on allochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure is currently a data gap; therefore, the effects of the action from this im- mechanism are unknown.
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Adults	<u>Adults:</u> Adult use of nearshore marine habitats is limited; therefore, stressor exposure is unlikely to occur.	Encourage project designs that limit permanent alteration of high-quality habitat features.	Effects of stressor exposure on ad sturgeon are expected to be insignificant and discountable.
Altered freshwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Adults	<u>Adult</u> : Sturgeon dependence on groundwater inflow to nearshore marine habitats is currently a data gap. However, adult use of nearshore marine habitats is limited; therefore, stressor exposure is unlikely to occur.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure is currently a data gap; therefore, th effects of the action from this im mechanism are unknown.
Lacustrine			*	-				
Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of turnover time, stratification patterns, wind conditions, and other factors. However, the suitability of some protected habitats such as isolated embayments may be affected, leading to decreased rearing habitat availability and increased competition, leading to decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and f

Table A-14	(continued).	HPA
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HCP Shoreline Modification Exposure and Response Matrix for Green and White Sturgeon.

		Expos	ure					
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness
Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Sturgeon dependence on allochthonous inputs from lacustrine riparian vegetation is a data gap. However, juvenile sturgeon are opportunistic feeders. Loss of terrestrial insect-fall could lead to decreased foraging opportunities, affecting growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and fitness
Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Sturgeon dependence on groundwater inflow to nearshore lacustrine habitats is currently a data gap. However, juveniles are dependent on water temperatures less than 75°F (24°C) for optimal growth. Reduction in thermal refuge habitat may lead to avoidance behavior, decreased growth, and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	Effects of action resulting from this impact mechanism are unknown, as sturgeon dependence on lacustrine groundwater inflow is a data gap. However, loss of thermal refuge habitat may affect juvenile growth and fitness.
Aquatic Vegetation Modification								
Marine								
Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Adults	<u>Adults</u> : Adult sturgeon dependence on nearshore aquatic vegetation is a data gap. However, this species feeds on mollusks, fish, and invertebrate species dependent on nearshore food web productivity. Therefore, this stressor could indirectly affect adult growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect adult growth and fitness. However, localized effects are likely to be insignificant.
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Adults	<u>Adults</u> : Adult sturgeon dependence on nearshore habitat complexity is limited. However, effects on habitat complexity may limit the availability and productivity of prey species; therefore, this stressor could indirectly affect adult growth and fitness. Given the extended marine foraging habitats used by sturgeon, localized effects are likely to be insignificant.		

b-			Expo	sure					
tivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine and Lacustrine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Juvenile sturgeon are known to feed opportunistically upon benthic prey organisms and fish dependent upon autochthonous material; reducing autochthonous production may decrease foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile productivity.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Reduced aquatic habitat complexity may limit the availability of suitable refuge and foraging habitat, leading to increased predation exposure and decreased foraging opportunities, affecting survival, growth, and fitness.	<u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring.	May affect juvenile survival, growth, and fitness.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, reduced spawning	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles	Eggs and larvae: Sturgeon are believed to spawn in swift current environments in part because the high velocities protect eggs from predation.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg and larval life-history stages. May affect juvenile growth and fitness. May affect adult
	Altered flow velocity	and rearing habitat availability and suitability	Year-round (with stressor exposures occurring during high-flow events, fall through spring)	Permanent	Seasonal	- Adults	Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success, and potentially increased predation exposure. Changes in flow regime	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest	spawning productivity.
	Altered substrate composition (including placement of non- erodable substrate)		Year-round	Permanent	Continuous		may cause larvae to be transported to environments unfavorable for survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in	extent practicable.	
	Altered groundwater inputs		Year-round, with stressor exposure occurring during egg incubation and juvenile rearing.	Permanent	Continuous		decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth,		
	Addition of impervious surface		Year-round	Permanent	Continuous		fitness, and survival. Juvenile dependence on groundwater exchange is a data gap; however, loss of thermal refuge may decrease the availability of suitable rearing habitat, leading to decreased growth and fitness.		
							<u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success		
							(e.g., through reduction in suitable spawning locations) if potential spawning habitat is affected		

Sub-			Expos	ure	1			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Marine							
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Adults	<u>Adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these	Care desig impa proje proje
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		parameters can fundamentally alter marine littoral habitats, potentially decreasing marine food web productivity and availability of prey species. This could lead to decreased adult growth and fitness, however incremental effects	on se patte patte
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		may not be significant considering the wide ranging marine habitats of adult sturgeon.	
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous			
	Altered groundwater inputs		Year-round	Permanent	Continuous			
	Lacustrine							
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Larvae; Juveniles; Adults	<u>Larvae and juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the	Care desig impa proje
	Altered current velocities		Year-round (with effects more predominant in reservoir versus natural lakes)	Permanent	Common		nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of juvenile rearing habitat. This	proje on se patte patte
	Altered groundwater inputs		Year-round	Permanent	Continuous		may occur through increased predation exposure, food web alterations, and decreased foraging	1
	Altered sediment supply		Year-round	Permanent	Continuous		opportunity. Alteration of current and circulation patterns may prevent larvae transport to suitable	
	Altered substrate composition		Year-round	Permanent	Continuous		rearing environments. The combined effect of these stressors can result in decreased survival, growth, and fitness at larval and juvenile life- history stages.	
							<u>Adults</u> : Adult sturgeon are generally less sensitive to these stressors. However, food web productivity in large reservoir environments may be affected by these impact mechanisms. This could lead to reduced adult foraging opportunities in residualized populations, and decreased growth, fitness, and spawning productivity.	

Minimization Measures	Resulting Effects of the Submechanism
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selections of oject designs that minimize effects sediment supply, longshore drift terns, and wave energy and current terns.	May affect adult growth and fitness.
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selections of oject designs that minimize effects sediment supply, longshore drift terns, and wave energy and current terns.	May affect survival at larval life- history stage. May affect growth and fitness at juvenile life-history stage. May affect adult growth and fitness, and adult spawning productivity.

			Ехро	sure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	•						•	
	Riverine								
	Habitat loss and fragmentation	Fragmentation of side channel and floodplain habitat; change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Bank barbs and groins can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of larval sturgeon rearing habitat. Decreased habitat availability may lead to density-dependent effects on larval and juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting, and avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affec spawning productivity.
	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No specific recommendations.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Marine								
1	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Adults	All exposed life-history stages: Bank barbs and groins in the marine environment can fragment nearshore habitat. Sturgeon dependence on these habitat types is currently a data gap; therefore, the effects of this stressor are unknown.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	Sensitivity to stressor exposure is currently a data gap; therefore, the effects of the action from this impact mechanism are unknown.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	Effects of stressor exposure on adult sturgeon are expected to be insignificant and discountable.
	Lacustrine						•		•
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : Bank barbs and groins in lacustrine environments can fragment nearshore habitat, forcing foraging larval and juvenile sturgeon to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivity.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.

ţy			Ex	posure					Resulting Effects of the
ŕ	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
es									
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs; Larvae; Juveniles; Adults	<ul> <li>Eggs and larvae: Noise of sufficient magnitude may cause direct mortality of eggs and larval smelt or permanent injury leading to decreased survival and fitness.</li> <li>Adults and juveniles: Stressor response, depending on noise magnitude and project- specific environmental conditions, may range from:</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to system-specific in-water work windows to avoid stressor exposure during spawning, incubation, and larval dispersal (November to April, depending on system). If pile driving is necessary during spawning period, use double-confined bubble curtain to attenuate sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Unlikely to affect smelt populati when activities are conducted in prescribed in-water work windo avoiding spawning, incubation, a larval dispersal. The potential fo juvenile exposure is less well known. Except for the landlock Lake Washington population of longfin smelt, juvenile habitat us these species is poorly understoo Subadults are known to migrate offshore areas on the continental shelf.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable. Limit activities to system- specific in-water work windows where practicable to avoid effects on spawning adults.	Unlikely to affect smelt populati when activities are conducted in prescribed in-water work windo avoiding spawning disruptions. Exposure to stressor may affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles (Lake Washington longfin smelt); Adults	Eggs and larvae:Channel dewatering will cause egg mortality.Juveniles:Juvenile smelt are generally believed to migrate offshore and will therefore not likely be exposed to dewatering. Lake Washington longfin smelt are an exception; potential nearshore habitat use by this population is currently a data gap.Adults:Capture, handling, and relocation are likely to cause mortality or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Limit activities to system-specific in-water work windows where practicable to avoid effects on spawning adults.	Unlikely to affect eggs, larvae, a adults if activities are conducted during in-water work windows. Capture and removal of eggs, lar and juveniles is impractical, meaning that activities occurring during incubation and emigratio periods may affect survival durin these life-history stages. Captur and removal of adults are likely affect survival and spawning productivity.

# Table A-15. HPA HCP Shoreline Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub- activity			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Eggs, larvae, and juveniles: Pump entrainment is highly likely to cause mortality of larvae and drifting eggs. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. <u>Adults</u> : Impingement is likely to cause adult mortality.	Adhere to system-specific in-water work windows; avoid use of dewatering pumps during spawning, incubation, and larval dispersal.	Unlikely to affect survival and productivity during egg and larvae and adult life-history stages if activities are conducted within in- water work windows. If activities are permitted outside in-water work windows, activity may affect adult and egg and larval survival. The potential for effects on juvenile smelt survival in marine habitats and Lake Washington are unknown because habitat use by this life- history stage is a data gap.
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Nearshore habitat use by smelt is currently a data gap, so the potential for exposure to this stressor is unknown.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	The potential for this mechanism to affect juvenile smelt is currently unknown because dependence on nearshore circulation patterns is currently a data gap.
		Stream bed disturbance, increased turbidity (associated with site rewatering).	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. <u>Adults</u> : Stress and behavioral modifications by adult spawners exposed to sediment pulses, migration delay, increased predation exposure, decreased spawning habitat suitability.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	Unlikely to affect egg survival and adult spawning productivity when activities are conducted during in- water work windows. May affect these parameters if activities occur during spawning and incubation.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : With the exception of the Lake Washington longfin population, smelt do not feed on benthic organisms in freshwater systems and will be unaffected by this stressor. In Lake Washington and in marine systems, smelt are planktonic feeders that are not likely to be affected by temporary decreases in benthic invertebrate abundance.	Limit area of dewatering to the greatest extent practicable.	Not likely to affect smelt at any life- history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	See effects for related stressors under Water Quality Modification.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs; Larvae; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.

### Table A-15 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Table A-15 (continued).	HPA HCP Shoreline Modification	on Exposure and Respon	se Matrix for Longfin Sm	elt and Eulach
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Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Incubating eggs entrained during dredging will suffer high mortality. Juveniles: The potential for juvenile exposure to these stressors is unknown because habitat use is currently a data gap. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Unlikely to affect survival of eggs and larvae if activities are conducted during in-water work windows. Likely to affect egg survival and larval survival and productivity if exposure occurs. See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile productivity, adult productivity, and spawning success.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved events due to asphyxiation. <u>Juveniles and adults</u> : Avoidance behavior and increased stress, leading to reduced growth and fitness.	Avoid sediment pulses.	May affect survival of incubating eggs. May affect juvenile survival and productivity and adult survival, productivity, and spawning success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to pH levels outside of optimal thresholds, causing direct mortality or injury leading to reduced fitness.	Avoid curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and productivity of eggs and larvae, juveniles, and adults

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# chon (Smelt).

# Table A-15 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

			Ex	posure				Demisting Effects of the			
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism		
	Use of creosote-treated wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs; Larvae; Juveniles	Eggs and larvae, juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to	May affect survival and productiv of eggs, larvae, and juveniles		
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn),	Leaching begins upon installation with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Juveniles;	Eggs and larvae, juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at sub-acute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.			
	Riparian Vegetation Modification										
Г	Marine										
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Larvae; Juveniles	Larvae and juveniles: Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. Dependence of larval and juvenile longfin smelt and eulachon on these habitats is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.		
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high-wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles	Larvae and juveniles: Dependence of larval and juvenile longfin smelt and eulachon on these habitats is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Longfin smelt and eulachon dependence on allochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.		
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Juveniles	Larvae and juveniles: Dependence of larval and juvenile smelt on these habitats is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.		

# Table A-15 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-			Exj	posure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	
	Altered groundwater- surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Dependence of larval and juvenile smelt on surface water and groundwater exchange in nearshore habitats is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	
	Lacustrine		-					
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures).	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Lake Washington longfin smelt. Larvae; Juveniles; Adults	Larvae, juveniles, and adults: Riparian shade and ambient temperature has a relatively minor effect on nearshore water temperatures relative to the dominant influence of lake stratification, reservoir current patterns, wind conditions and other factors. However, shallow littoral habitats may experience increased temperatures due to lack of shade. Dependence of juvenile longfin smelt on these habitats is currently a data gap Therefore the potential for exposure to these stressors is unknown.	
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation).	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Lake Washington longfin smelt. Larvae; Juveniles; Adults	Larvae, juveniles, and adults: Potential habitat avoidance and/or injury/mortality caused by excessive turbidity, potential for decreased foraging success leading to decreased growth and fitness as described for related stressor responses under Water Quality Modification.	
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	Larvae, juveniles, and adults: Longfin smelt dependence on allochthonous inputs from lacustrine riparian vegetation is a data gap. Therefore the potential for exposure to these stressors is unknown.	
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	Larvae, juveniles, and adults: Dependence of larval, juvenile, and adult longfin smelt on these habitats is currently a data gap, Therefore the potential for exposure to these stressors is unknown.	
	Altered groundwater surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	Larvae, juveniles, and adults: Longfin smelt dependence on groundwater inflow to nearshore lacustrine habitats is currently a data gap. Therefore the potential for exposure to these stressors is unknown.	

Minimization Measures	Resulting Effects of the Submechanism
Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from this impact mechanism are unknown.
Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult survival and productivity.
Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from this impact mechanism are unknown.
Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from this impact mechanism are unknown.
Avoid disturbance of vegetation along stream	Potential effects resulting from this impact mechanism are unknown.

### Table A-15 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

. T			Ex	posure			Resulting Effects of the		
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
	Aquatic Vegetation Modification			<u>.</u>	•		-	-	-
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Larvae; Juveniles; Adults	All exposed life-history stages: Longfin smelt and eulachon dependence on marine littoral vegetation and the nearshore marine	Design:Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.Construction:Avoid/minimize disturbance of aquatic vegetation during project construction.Operation:Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, and reduced ambient light from fine bubble profusion.	Sensitivity to stressor exposure currently a data gap for these species; therefore, the potential
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous		environment is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.		effects resulting from this impact mechanism are unknown.
ſ	Lacustrine			1				•	I
-	Altered autochthonous production	Reduced food web productivity.	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Lake Washington longfin smelt. Eggs;	<u>All exposed life-history stages</u> : Smelt dependence on freshwater submerged aquatic vegetation is currently a data gap. Therefore, the potential for exposure to	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Adults	these stressors is unknown.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring.	effects resulting from this impa mechanism are unknown.

		Ex	oosure					Resulting Effects of the			
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism			
Hydraulic and Geomorphic Modification											
Marine											
Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round, with stressor exposure occurring in spring and summer when larvae and juveniles occupy nearshore habitats for rearing	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project	May affect survival, growth, and fitness at the larval and juvenile history stages. Decreased fitnes may affect survival and producti			
Altered current velocities		Year-round, with variable effects depending on site-specific current dynamics and project configuration	Permanent	Intermittent		characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marina litteral babitot. Longfin smalt and	designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	during ocean migration life-history phase, and may affect spawning productivity.			
Altered nearshore circulation patterns		Year-round, with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration	Permanent	Seasonal		marine littoral habitats. Longfin smelt and eulachon dependence on these habitats is currently a data gap. However, alteration of current velocities and circulation patterns may cause transportation of planktonic	patterns.				
Altered sediment supply		Year-round, beginning with project installation and becoming more pronounced over time	Permanent	Continuous		larvae to unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also have					
Altered substrate composition		Year-round, beginning with project installation and becoming more pronounced over time (e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching)	Permanent	Continuous		concomitant effects on food web relationships in the offshore environment. <u>Adults</u> : Alteration of nearshore habitat parameters may affect survival and foraging opportunities at larval and juvenile life- history stages, leading to decreased adult fitness, decreased survival, and decreased spawning productivity.					
Altered groundwater inputs		Year-round	Permanent	Continuous							
Lacustrine											
Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round, with predominant effects from fall through spring when wind-driven waves are most pronounced	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles;	Larvae, juveniles, and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and	design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current	May affect productivity at larva juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.			
Altered current velocities		Year-round, with effects more predominant in reservoirs versus natural lakes	Permanent	Common	Adults	characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, with concomitant					
Altered nearshore circulation patterns		Year-round, with variable effects by season (e.g., circulation patterns)	Permanent	Seasonal		food web effects throughout the lacustrine ecosystem. Therefore, alteration of these parameters may affect foraging opportunities for longfin smelt at larval and juvenile life-history stages, leading to decreased adult fitness and decreased spawning success.					
Altered groundwater inputs		Year-round	Permanent	Continuous			1				
Altered sediment supply		Year-round	Permanent	Continuous							
Altered substrate composition		Year-round	Permanent	Continuous							

Sub-			E	xposure					Resulting Effects of the
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
	Ecosystem Fragmentation			-		•	-		<u>.</u>
	Marine								
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juvenile; Adult	All exposed life-history stages: Jetties fragment nearshore marine habitat. Eulachon and longfin smelt are known to use these habitat types during juvenile and adult life-history stages, and are likely to occur as larvae as well. Jetties may alter migration of adults toward spawning habitats, larval dispersal, and juvenile foraging, affecting survival, growth, and fitness at all life-history stages.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Larvae; Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Lacustrine							·	·
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	All exposed life-history stages: Longfin smelt dependence on nearshore habitats in Lake Washington is currently a data gap. Therefore the effects of this stressor are unknown.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivity.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	Potential effects resulting from this impact mechanism are unknown.

### Sub-Exposure activity Mechanism of Impact **Response to Stressor** Туре Stressor When Duration Frequency Life-history Form **Breakwaters Construction and Maintenance** Activities Pile driving Eggs and larvae: Noise of sufficient During project construction and Temporary (auditory Interannual to decadal Eggs; Increased underwater noise levels maintenance activities masking) to short-(during project magnitude may cause direct mortality of Larvae; term (hearing construction and eggs and larval smelt or permanent injury Juveniles; threshold effects) maintenance) leading to decreased survival and fitness. Adults Adults and juveniles: Stressor response, depending on noise magnitude and projectspecific environmental conditions, may range from: • Fatal injury or permanent auditory tissue damage limiting to survival. Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness During project construction and Increased or altered ambient Adults and juveniles: Auditory masking or Construction vessel Temporary (auditory Interannual to decadal Juveniles; noise levels masking) to short-(during project temporary hearing threshold effects may operation maintenance activities Adults construction and term (hearing increase risk of predation and/or decrease foraging efficiency due to decreased ability threshold effects) maintenance) to sense predators and/or prey. Eggs and larvae: Channel dewatering will Channel/work area Fish removal, relocation, and During project construction and Short-term Interannual to decadal Eggs; dewatering exclusion maintenance activities (depending on activity cause egg mortality. Larvae; frequency) <u>Juveniles</u>: Juvenile smelt are generally Juveniles (Lake believed to migrate offshore and will Washington longfin therefore not likely be exposed to smelt); dewatering. Lake Washington longfin Adults smelt are an exception; potential nearshore habitat use by this population is currently a data gap. Adults: Capture, handling, and relocation are likely to cause mortality or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.

### Table A-15 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Minimization Measures	Resulting Effects of the Submechanism
Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to system-specific in-water work windows to avoid stressor exposure during spawning, incubation, and larval dispersal (November to April, depending on system). If pile driving is necessary during spawning period, use double-confined bubble curtain to attenuate sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Unlikely to affect smelt populations when activities are conducted in prescribed in-water work windows, avoiding spawning, incubation, and larval dispersal. The potential for juvenile exposure is less well known. Except for the landlocked Lake Washington population of longfin smelt, juvenile habitat use by these species is poorly understood. Subadults are known to migrate to offshore areas on the continental shelf.
Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable. Limit activities to system- specific in-water work windows where practicable to avoid effects on spawning adults.	Unlikely to affect smelt populations when activities are conducted in prescribed in-water work windows, avoiding spawning disruptions. Exposure to stressor may affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.
Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Limit activities to system-specific in-water work windows where practicable to avoid effects on spawning adults.	Unlikely to affect eggs, larvae, and adults if activities are conducted during in-water work windows. Capture and removal of eggs, larvae, and juveniles is impractical, meaning that activities occurring during incubation and emigration periods may affect survival during these life-history stages. Capture and removal of adults are likely to affect survival and spawning productivity.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Eggs, larvae, and juveniles: Pump entrainment is highly likely to cause mortality of larvae and drifting eggs. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. <u>Adults</u> : Impingement is likely to cause adult mortality.	Adhere to system-specific in-water work windows; avoid use of dewatering pumps during spawning, incubation, and larval dispersal.	Unlikely to affect survival and productivity during egg and larvae and adult life-history stages if activities are conducted during in- water work windows. If activities are permitted outside in-water work windows, activity may affect adult and egg and larval survival. The potential for effects on juvenile smelt survival in marine habitats and Lake Washington are unknown because habitat use by this life- history stage is a data gap.
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Nearshore habitat use by smelt is currently a data gap, so the potential for exposure to this stressor is unknown.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	The potential for this mechanism to affect juvenile smelt is currently unknown because dependence on nearshore circulation patterns is currently a data gap.
		Stream bed disturbance, increased turbidity (associated with site rewatering).	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. <u>Adults</u> : Stress and behavioral modifications by adult spawners exposed to sediment pulses, migration delay, increased predation exposure, decreased spawning habitat suitability.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	Unlikely to affect egg survival and adult spawning productivity when activities are conducted during in- water work windows. May affect these parameters if activities occur during spawning and incubation.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : With the exception of the Lake Washington longfin population, smelt do not feed on benthic organisms in freshwater systems and will be unaffected by this stressor. In Lake Washington and in marine systems, smelt are planktonic feeders that are not likely to be affected by temporary decreases in benthic invertebrate abundance.	Limit area of dewatering to the greatest extent practicable.	Not likely to affect smelt at any life- history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	See effects for related stressors under Water Quality Modification.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs; Larvae; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.

Table A-15 (continued).	HPA HCP Shoreline Modification	on Exposure and Respon	se Matrix for Longfin Sm	elt and Eulach
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Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Incubating eggs entrained during dredging will suffer high mortality. Juveniles: The potential for juvenile exposure to these stressors is unknown because habitat use is currently a data gap. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Unlikely to affect survival of eggs and larvae if activities are conducted during in-water work windows. Likely to affect egg survival and larval survival and productivity if exposure occurs. See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile productivity, adult productivity, and spawning success.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved events due to asphyxiation. Juveniles and adults: Avoidance behavior and increased stress, leading to reduced growth and fitness.	Avoid sediment pulses.	May affect survival of incubating eggs. May affect juvenile survival and productivity and adult survival, productivity, and spawning success.

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## chon (Smelt).

Sub-			Exj	posure		-			Resulting Effects of the
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to pH levels outside of optimal thresholds, causing direct mortality or injury leading to reduced fitness.	Avoid curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and productivity of eggs and larvae, juveniles, and adults
	Use of creosote-treated wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs; Larvae; Juveniles	Eggs and larvae, juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to	May affect survival and productivity of eggs, larvae, and juveniles
	Use of ACZA and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Juveniles;	Eggs and larvae, juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at sub-acute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	

v			Ex	posure					Resulting Effects of the
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Aquatic Vegetation Modification			<u>.</u>			÷	-	-
	Marine								
	Altered autochthonous production	n spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Longfin smelt and eulachon dependence on marine littoral vegetation and the nearshore marine	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest	Sensitivity to stressor exposure currently a data gap for these species; therefore, the potential	
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Adults	environment is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, and reduced ambient light from fine bubble profusion.	effects resulting from this impa mechanism are unknown.
F	<b>Riverine and Lacustrine</b>	1						•	I
	Altered autochthonous production Altered habitat complexity	Reduced food web productivity. Reduced food web productivity, reduced foraging	Year-round (most pronounced in spring and summer when vegetation growth is most extensive) Year-round	Permanent Short-term to permanent	Continuous Continuous	Eggs; Larvae; Adults	All exposed life-history stages: Smelt dependence on freshwater submerged aquatic vegetation is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize	Sensitivity to stressor exposure currently a data gap for these species; therefore, the potentia effects resulting from this impa- mechanism are unknown.
		opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)		(dependent on nature of activity)				disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring.	

ıb- tivity			Ex	posure					Resulting Effects of the
ctivity 'ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and larval survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects	May affect survival at egg and larval life-history stages. May affect spawning productivity.
	Altered flow velocity	*	Year-round, with stressor exposure occurring during high flow events, fall through spring	Permanent	Seasonal		Larvae and juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing	on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	Altered substrate composition (including placement of non- erodable substrate)		Year round	Permanent	Continuous		habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.		
	Altered groundwater inputs		Year-round, with stressor exposure occurring during egg incubation and juvenile rearing	Permanent	Continuous		<u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		
	Addition of impervious surface	Alteration in the magnitude, volume, and timing of peak flows	During storm events, predominantly fall through spring	Permanent	Common	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Because the amount of impervious surface associated with breakwaters is a relatively inconsequential component of the overall drainage area of the larger river systems that would support this type of development, the magnitude of the hydrologic modification stressor is expected to be negligible. As such, this stressor is not expected to significantly affect the riverine environment, and there will therefore be no response to the stressor.	Encourage facilities to employ modern low impact development and stormwater treatment technology.	Impervious surface at anticipated scale would not produce stressors of sufficient magnitude to adversely affect longfin smelt and eulachon at any life-history stage.

Sub-			Exp	oosure			
ictivity Гуре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor
	Marine	-			<u>.</u>	•	·
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round, with stressor exposure occurring in spring and summer when larvae and juveniles occupy nearshore habitats for rearing	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and
	Altered current velocities		Year-round, with variable effects depending on site-specific current dynamics and project configuration	Permanent	Intermittent		characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Longfin smelt and
	Altered nearshore circulation patterns		Year-round, with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration	Permanent	Seasonal		eulachon dependence on these habitats is currently a data gap. However, alteration of current velocities and circulation patterns may cause transportation of planktonic
	Altered sediment supply		Year-round, beginning with project installation and becoming more pronounced over time	Permanent	Continuous		larvae to unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also have concomitant effects on food web
	Altered substrate composition		Year-round, beginning with project installation and becoming more pronounced over time (e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching)	Permanent	Continuous		relationships in the offshore environment. <u>Adults</u> : Alteration of nearshore habitat parameters may affect survival and foraging opportunities at larval and juvenile life- history stages, leading to decreased adult fitness, decreased survival, and decreased spawning productivity.
	Altered groundwater- surface water exchange	r I	Year-round	Permanent	Continuous		spawning productivity.
	Lacustrine					·	
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round, with predominant effects from fall through spring when wind-driven waves are most pronounced	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles;	Larvae, juveniles, and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and
	Altered current velocities	Ť	Year-round, with effects more predominant in reservoirs versus natural lakes	Permanent	Common	Adults	characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, with concomitant
	Altered nearshore circulation patterns	Ť	Year-round, with variable effects by season (e.g., circulation patterns)	Permanent	Seasonal		food web effects throughout the lacustrine ecosystem. Therefore, alteration of these parameters may affect foraging
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous		opportunities for longfin smelt at larval and juvenile life-history stages, leading to
	Altered sediment supply	•	Year-round	Permanent	Continuous		decreased adult fitness and decreased spawning success.
	Altered substrate composition		Year-round	Permanent	Continuous		sparring success.
	Ecosystem Fragmentation						
	Riverine						
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Larvae; Adults	<u>Larvae and adults</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators. However, these life history stages typically occur in large enough abundance that the related predation exposure would be insignificant relative to typical natural mortality levels.

Minimization Measures	Resulting Effects of the Submechanism
Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at the larval and juvenile life- history stages. Decreased fitness may affect survival and productivity during ocean migration life-history phase, and may affect spawning productivity.
Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect productivity at larval and juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	The effects of exposure to this stressor are considered insignificant and discountable.

			Ε	xposure					
ity	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Loss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No specific recommendations.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Marine						-		
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life history stages: Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators. Juvenile and adult eulachon and smelt may be exposed to increased predation exposure.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile and adult survival.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Larvae; Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Lacustrine		·		ŀ				
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Lake Washington longfin smelt Larvae; Juveniles; Adults	All exposed life history stages: Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators. Juvenile and adult Lake Washington longfin smelt may be exposed to increased predation exposure. Larval longfin smelt may experience similar exposure, but increased predation rates are most likely insignificant relative to natural mortality.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile and adult survival. May affect larval surviv but effects will be insignificant relative to natural mortality.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	Potential effects resulting from the impact mechanism are unknown.

			E	Exposure					<b>Resulting Effects of the</b>
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
ns	and Bank Barbs			·					
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs; Larvae; Juveniles; Adults	<ul> <li>Eggs and larvae: Noise of sufficient magnitude may cause direct mortality of eggs and larval smelt or permanent injury leading to decreased survival and fitness. Adults and juveniles: Stressor response, depending on noise magnitude and project- specific environmental conditions, may range from:</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to system-specific in-water work windows to avoid stressor exposure during spawning, incubation, and larval dispersal (November to April, depending on system). If pile driving is necessary during spawning period, use double-confined bubble curtain to attenuate sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Unlikely to affect smelt popul when activities are conducted prescribed in-water work wind avoiding spawning, incubation larval dispersal. The potential juvenile exposure is less well known. Except for the landlo Lake Washington population of longfin smelt, juvenile habitat these species is poorly unders: Subadults are known to migra offshore areas on the continen shelf.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable. Limit activities to system- specific in-water work windows where practicable to avoid effects on spawning adults.	Unlikely to affect smelt popul when activities are conducted prescribed in-water work wind avoiding spawning disruptions Exposure to stressor may affect survival and productivity due avoidance behavior, decreased foraging success, and increased predation risk.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles (Lake Washington longfin smelt); Adults	Eggs and larvae: Channel dewatering will cause egg mortality. Juveniles: Juvenile smelt are generally believed to migrate offshore and will therefore not likely be exposed to dewatering. Lake Washington longfin smelt are an exception; potential nearshore habitat use by this population is currently a data gap. <u>Adults</u> : Capture, handling, and relocation are likely to cause mortality or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Limit activities to system-specific in-water work windows where practicable to avoid effects on spawning adults.	Unlikely to affect eggs, larvae adults if activities are conduct during in-water work windows Capture and removal of eggs, and juveniles is impractical, meaning that activities occurri during incubation and emigrat periods may affect survival du these life-history stages. Capt and removal of adults are likel affect survival and spawning productivity.

• .			E	xposure					Resulting Effects of the
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Eggs, larvae, and juveniles: Pump entrainment is highly likely to cause mortality of larvae and drifting eggs. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. <u>Adults</u> : Impingement is likely to cause adult mortality.	Adhere to system-specific in-water work windows; avoid use of dewatering pumps during spawning, incubation, and larval dispersal.	Unlikely to affect survival and productivity during egg and larva and adult life-history stages if activities are conducted during ir water work windows. If activitie are permitted outside the in-wate work windows, activity may affe adult and egg and larval survival The potential for effects on juver smelt survival in marine habitats Lake Washington are unknown because habitat use by this life- history stage is a data gap.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Adults	Eggs and larvae: Potential scour of spawning substrate and/or sedimentation, resulting in decreased incubation success. Potential larval dispersal to unfavorable habitats, decreasing larval survival and productivity. <u>Adults</u> : Decreased availability of suitable spawning sites; decreased spawning success.	Adhere to system-specific in-water work windows, avoid use during spawning, incubation, and larval dispersal. Limit alteration of flow conditions to minimal area.	Unlikely to affect survival and productivity during egg and larva and adult life-history stages if activities are conducted during in water work windows. If activitie are permitted during in-water wo windows, activity may affect adu spawning productivity and egg a larval survival.
		Altered current and circulation conditions (marine and lacustrine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Nearshore habitat use by smelt is currently a data gap, so the potential for exposure to this stressor is unknown.	Limit alteration of current and circulation patterns to greatest extent practicable to minimal area.	The potential for this mechanism affect juvenile smelt is currently unknown because dependence o nearshore circulation patterns is currently a data gap.
		Stream bed disturbance, increased turbidity (associated with site rewatering).	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. <u>Adults</u> : Stress and behavioral modifications by adult spawners exposed to sediment pulses, migration delay, increased predation exposure, decreased spawning habitat suitability.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	Unlikely to affect egg survival a adult spawning productivity whe activities are conducted during in water work windows. May affect these parameters if activities occ during spawning and incubation
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : With the exception of the Lake Washington longfin population, smelt do not feed on benthic organisms in freshwater systems and will be unaffected by this stressor. In Lake Washington and in marine systems, smelt are planktonic feeders that are not likely to be affected by temporary decreases in benthic invertebrate abundance.	Limit area of dewatering to the greatest extent practicable.	Not likely to affect smelt at any history stage.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	See effects for related stressors under Water Quality Modification
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs; Larvae; Adults	All life-history stages: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorph Modification.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Incubating eggs entrained during dredging will suffer high mortality. Juveniles: The potential for juvenile exposure to these stressors is unknown because habitat use is currently a data gap. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Unlikely to affect survival of eggs and larvae if activities are conducted during in-water work windows. Likely to affect egg survival and larval survival and productivity if exposure occurs. See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile productivity, adult productivity, and spawning success.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved events due to asphyxiation. <u>Juveniles and adults</u> : Avoidance behavior and increased stress, leading to reduced growth and fitness.	Avoid sediment pulses.	May affect survival of incubating eggs. May affect juvenile survival and productivity and adult survival, productivity, and spawning success.

		Exj	posure					Resulting Effects of the
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to pH levels outside of optimal thresholds, causing direct mortality or injury leading to reduced fitness.	Avoid curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and productivity of eggs and larvae, juveniles, and adults
Use of creosote-treated wood	Leaching of polyaromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs; Larvae; Juveniles	Eggs and larvae, juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to	May affect survival and productivit of eggs, larvae, and juveniles
Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn),	Leaching begins upon installation with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Juveniles;	Eggs and larvae, juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at sub-acute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
Riparian Vegetation Modification								
Riverine								
Altered shading, solar input, ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Adults	<u>Adults</u> : Decreased spawning productivity and fitness due to migration delays caused by low water temperatures.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect spawning productivity.
Altered stream bank and shoreline stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., alteration of spawning substrate)	Year-round (with specific stressors prominent during high-flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Adults	Eggs and larvae: Decreased incubation success due to smothering of eggs as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential, migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival during egg incubation; may affect spawning fitness and productivity.
Altered allochthonous inputs	Reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Larvae	Larvae: Larval longfin smelt and eulachon feed on forage on riverine plankton following emergence and transport to estuarine and marine habitats. Reduced allochthonous inputs may affect food web productivity, leading to decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect larval growth and fitness

			Ex	posure					Resulting Effects of the
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Adults	Adults: Reduced habitat complexity may affect the availability of suitable spawning habitat leading to decreased spawning productivity.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect adult spawning productivity.
	Altered groundwater- surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Unknown	Longfin smelt and eulachon dependence on groundwater exchange is currently a data gap.	Avoid permitting of projects in areas with springs, seeps, or other sources of significant groundwater recharge. Limit alteration of riparian vegetation to greatest extent practicable.	Sensitivity to stressor exposure currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Marine								
	Altered shading, solar input, ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Larvae; Juveniles	Larvae and juveniles: Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. Dependence of larval and juvenile longfin smelt and eulachon on these habitats is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure currently a data gap for these species; therefore, the potential effects resulting from this impac mechanism are unknown.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high-wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles	Larvae and juveniles: Dependence of larval and juvenile longfin smelt and eulachon on these habitats is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure currently a data gap for these species; therefore, the potential effects resulting from this impa- mechanism are unknown.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Longfin smelt and eulachon dependence on allochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure currently a data gap for these species; therefore, the potential effects resulting from this impa mechanism are unknown.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Juveniles	<u>Larvae and juveniles</u> : Dependence of larval and juvenile smelt on these habitats is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure currently a data gap for these species; therefore, the potential effects resulting from this impa- mechanism are unknown.
	Altered freshwater inputs	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Dependence of larval and juvenile smelt on surface water and groundwater exchange in nearshore habitats is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure currently a data gap for these species; therefore, the potential effects resulting from this impa- mechanism are unknown.

			Ex	posure					Resulting Effects of the
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Ι	Lacustrine								
i	Altered shading, solar nput, ambient air emperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures).	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Lake Washington longfin smelt. Larvae; Juveniles; Adults	Larvae, juveniles, and adults: Riparian shade and ambient temperature has a relatively minor effect on nearshore water temperatures relative to the dominant influence of lake stratification, reservoir current patterns, wind conditions and other factors. However, shallow littoral habitats may experience increased temperatures due to lack of shade. Dependence of juvenile longfin smelt on these habitats is currently a data gap. Therefore the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from the impact mechanism are unknown.
A	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation).	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Lake Washington longfin smelt. Larvae; Juveniles; Adults	Larvae, juveniles, and adults: Potential habitat avoidance and/or injury/mortality caused by excessive turbidity, potential for decreased foraging success leading to decreased growth and fitness as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult survival and productivity.
	Altered allochthonous nputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	Larvae, juveniles, and adults: Longfin smelt dependence on allochthonous inputs from lacustrine riparian vegetation is a data gap. Therefore the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from th impact mechanism are unknown.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	Larvae, juveniles, and adults: Dependence of larval, juvenile, and adult longfin smelt on these habitats is currently a data gap, Therefore the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from th impact mechanism are unknown.
	Altered groundwater urface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	Larvae, juveniles, and adults: Longfin smelt dependence on groundwater inflow to nearshore lacustrine habitats is currently a data gap. Therefore the potential for exposure to these stressors is unknown.	Avoid disturbance of vegetation along stream	Potential effects resulting from the impact mechanism are unknown.
	Aquatic Vegetation Modification								
N	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Longfin smelt and eulachon dependence on marine littoral vegetation and the nearshore marine	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous		environment is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	effects resulting from this impact mechanism are unknown.

		Ex	posure					<b>Resulting Effects of the</b>
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
<b>Riverine and Lacustrine</b>								
Altered autochthonous production	Reduced food web productivity.	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Eggs; Larvae; Adults	All exposed life-history stages: Smelt dependence on freshwater submerged aquatic vegetation is currently a data gap.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest	Sensitivity to stressor exposure currently a data gap for these species; therefore, the potential
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous		Therefore, the potential for exposure to these stressors is unknown.	extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	effects resulting from this impa mechanism are unknown.
Hydraulic and Geomorphic Modification								
Riverine								
Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, reduced	Year-round	Permanent	Continuous	Eggs; Larvae;	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg and life-history stages. May affect spawning productivity.
Altered flow velocity	spawning and rearing habitat availability and suitability	Year-round, with stressor exposure occurring during high flow events, fall through spring	Permanent	Seasonal	Juveniles; Adults	stability, leading to decreased incubation success and larval survival. <u>Larvae and juveniles</u> : Altered channel	project. Encourage selections of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and	
Altered substrate composition (including placement of non- erodable substrate)		Year round	Permanent	Continuous		geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for		
Altered groundwater- surface water exchange	_	Year-round, with stressor exposure occurring during egg incubation and juvenile rearing	Permanent	Continuous		suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology		
Addition of impervious surface		Year-round	Permanent	Continuous		may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		

		Ex	posure					<b>Resulting Effects of the</b>
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
Marine								
Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round, with stressor exposure occurring in spring and summer when larvae and juveniles occupy nearshore habitats for rearing	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project	May affect survival, growth, an fitness at the larval and juvenile history stages. Decreased fitne may affect survival and produc
Altered current velocities		Year-round, with variable effects depending on site-specific current dynamics and project configuration	Permanent	Intermittent		characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Longfin smelt and	designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	during ocean migration life-his phase, and may affect spawnin productivity.
Altered sediment supply		Year-round, beginning with project installation and becoming more pronounced over time	Permanent	Continuous		eulachon dependence on these habitats is currently a data gap. However, alteration of current velocities and circulation patterns		
Altered substrate composition		Year-round, beginning with project installation and becoming more pronounced over time (e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching)	Permanent	Continuous		may cause transportation of planktonic larvae to unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also have concomitant effects on food web relationships in the offshore environment. Adults: Alteration of nearshore habitat		
Altered groundwater- surface water exchange		Year-round	Permanent	Continuous		parameters may affect survival and foraging opportunities at larval and juvenile life- history stages, leading to decreased adult fitness, decreased survival, and decreased spawning productivity.		
Lacustrine							•	
Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round, with predominant effects from fall through spring when wind-driven waves are most pronounced	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles;	Larvae, juveniles, and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project	May affect productivity at larv juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity
Altered current velocities		Year-round, with effects more predominant in reservoirs versus natural lakes	Permanent	Common	Adults	characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, with concomitant	designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	
Altered groundwater- surface water exchange		Year-round	Permanent	Continuous		food web effects throughout the lacustrine ecosystem. Therefore, alteration of these parameters may affect foraging		
Altered sediment supply		Year-round	Permanent	Continuous		opportunities for longfin smelt at larval and		
Altered substrate composition		Year-round	Permanent	Continuous		juvenile life-history stages, leading to decreased adult fitness and decreased spawning success.		
Ecosystem Fragmentation								
Riverine								
Habitat loss and fragmentation	Fragmentation of side channel and floodplain habitat; change in habitat structure, availability, and suitability; reduced food web complexity	Year-round	Permanent	Continuous	Adults	Adults: Bank barbs and groins can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor is unlikely to significantly affect mainstem spawning eulachon and longfin smelt. Planktonic larvae are carried downstream to estuarine habitats, and are not dependent on floodplain habitats.	Require assessment of the hydraulic effects of the project before permitting, and avoid permitting designs that lead to disconnection of floodplain habitat.	Unlikely to significantly affect mainstem spawning eulachon longfin smelt

				Exposure					Deputting Effects of the
Ν	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Lo	oss of LWD recruitment	Sequestration of LWD, preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No specific recommendations.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
Μ	arine			·		·	·	·	
	abitat loss and agmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juvenile; Adult	All exposed life-history stages: Bank barbs and groins in the marine environment can fragment nearshore habitat. Eulachon and longfin smelt are known to use these habitat types during juvenile and adult life-history stages, and are likely to occur as larvae as well. Groins and bank barbs may alter migration of adults toward spawning habitats, larval dispersal, and juvenile foraging, affecting survival, growth, and fitness at all life-history stages.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival and producti at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phas
Lo	oss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles.	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.
La	ocustrine								
	abitat loss and agmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	All exposed life-history stages: Longfin smelt dependence on nearshore habitats in Lake Washington is currently a data gap. Therefore the effects of this stressor are unknown.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile li history stage. Decreased fitness lead to reduced spawning productivity.
Lo	oss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.

b- tivity			Exp	osure					Resulting Effects of the
e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
tties									
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles; Adults	<ul> <li>Larvae: Noise of sufficient magnitude may cause direct mortality of larvae, or permanent injury leading to decreased survival and fitness. Eggs are unlikely to be exposed to pile driving noise due to position in intertidal environment.</li> <li>Adults and juveniles: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Where possible, avoid stressor exposure during site-specific spawn timing, incubation, and larval dispersal. Require review of available data and/or site surveys to avoid exposure of spawners to stressor. If pile driving is necessary during spawning period, use double-confined bubble curtain to attenuate sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival and productivity during larval, juvenile, and adult life history stages.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable. Limit activities to system- specific in-water work windows where practicable to avoid effects on spawning adults.	May affect survival and productivity due to avoidance behavior, decrease foraging success, and increased predation risk.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: These life-history stages will be difficult to capture and relocate effectively. <u>Adults</u> : Capture, handling, and relocation is likely to cause mortality, or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Require review of available data and/or site surveys to reduce likelihood of stressor exposure.	Capture/removal of larvae and juveniles is impractical, meaning that these activities are likely to affect larval and juvenile survival. Capture and removal of adults is likely to affe survival and spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: Pump entrainment is likely to cause mortality of drifting larvae. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. <u>Adults</u> : Impingement is likely to cause adult mortality.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Require review of available data and/or site surveys to reduce likelihood of stressor exposure.	May cause injury and mortality of larvae, juveniles, and adults. Effects are less likely to occur if activities an conducted outside of spawning sease

Sub- activity			Exp	osure		-			Resulting Effects of the
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All life-history stages: See responses described under Hydraulic and Geomorphic Modification. <u>Juveniles</u> : Nearshore habitat use by smelt is currently a data gap, so the potential for exposure to this stressor is unknown.	To greatest extent practicable, limit alteration of current and circulation patterns to minimal area.	See effects for related stressors under Hydraulic and Geomorphic Modification. The potential for this mechanism to affect juvenile smelt is currently unknown because dependence on nearshore circulation patterns is a data gap.
		Bottom disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae: Potential decreased larval foraging success due to turbidity exposure and substrate disturbance, leading to decreased growth and fitness. <u>Adults and juveniles</u> : Stress caused by avoidance behavior; decreased foraging success due to increased turbidity levels.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect larval productivity. May affect juvenile and adult survival and productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All life-history stages: Surf smelt and sand lance dependence on benthic invertebrates for forage is likely limited but is currently a data gap. Therefore, the potential effects of stressor exposure are unknown.	Limit area of dewatering to the greatest extent practicable.	Potential effects resulting from this impact mechanism are unknown.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juyeniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	See effects for related stressors under Water Quality Modification.
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Larvae; Juveniles; Adults	All life-history stages: See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Entrainment of smelt and sand lance during dredging is likely to cause mortality or injury, leading to decreased survival. See responses described for related stressors under Water Quality Modification.	Require review of available data and/or site surveys to reduce likelihood of larval and adult stressor exposure. Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Unlikely to affect survival of larvae and adults if activities are conducted during in-water work windows. Likely to affect survival at any life-history stage if exposure occurs. See effects for related stressors under Water Quality Modification.

Sub- activity			Exp	osure					Resulting Effects of the
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
	Water Quality Modification	-							-
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults and juveniles</u> : Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity at larval, juvenile, and adult life-history stages.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Avoidance behavior and increased stress, leading to reduced growth and fitness.	Avoid sediment pulses.	May affect larval, juvenile, and adult survival and productivity. Reduced adult fitness may affect spawning productivity.
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to	May affect survival and productivity of eggs, larvae, juveniles, and adults.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Larvae; Juveniles	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	

,			Exp	osure	-				Resulting Effects of the
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	<b>Minimization Measures</b>	Submechanism
	Riparian Vegetation Modification	-		•	•	-			•
i	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs	<u>Eggs</u> : Surf smelt and sand lance incubation success is demonstrably affected by microclimate conditions in the nearshore environment that are influenced by riparian vegetation. Alteration of riparian vegetation has been demonstrated to reduce egg survival and incubation success.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect egg survival, decreasing population productivity.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Juveniles; Adults	Eggs: Smothering of incubating eggs or alteration of substrate composition may decrease egg survival. Larvae and juveniles: See responses to increased turbidity exposure described under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect egg survival. May affect growth and fitness at larval and juvenile life-history stages. May affec adult spawning fitness and productivity.
							Adults: Potential reduction of suitable spawning habitat, leading to decreased spawning productivity.		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Eggs; Larvae; Juveniles;	<u>Eggs</u> : Leaf litter and other detritus may influence microclimate conditions in spawning substrates. Reduction in leaf litter may cause reduced incubation success.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs Potential effects resulting from this impact mechanism on remaining life- history stages are unknown.
		organic matter inputs				Adults	Larvae, juveniles, and adults: Dependence on allochthonous inputs from marine riparian vegetation is a data gap.		
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Altered habitat complexity is likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure is currently a data gap for these species; the potential effects resulting from this impact mechanism are unknown.
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Groundwater inflow demonstrably affects substrate temperatures, creating favorable conditions for egg incubation. Larvae and juveniles: Dependence of larval and juvenile forage fish on surface water and groundwater exchange in nearshore habitats is currently a data gap; the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect egg survival and adult spawning productivity. Potential effects resulting from this impact mechanism on larvae and juveniles are unknown.
							<u>Adults</u> : Altered groundwater inflow may affect spawning habitat suitability, leading to decreased spawning success.		

7			Exp	osure	T	I			<b>Resulting Effects of the</b>
Ŷ	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Aquatic Vegetation Modification	-							
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Eggs; Larvae; Juveniles;	Eggs: Alteration or reduction of submerged aquatic vegetation component of beach wrack may affect microclimate conditions in spawning substrates, decreasing egg survival	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect growth and fitness at egg, larval, juvenile, and adult life-history stages.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Adults	(particularly during spring and summer spawning). <u>All life-history stages</u> : Altered autochthonous production and habitat complexity are likely to	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous		affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.		
	Hydraulic and Geomorphic Modification							·	
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring in spring and summer when larvae and juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on	May affect egg incubation success, May affect survival at the larval an juvenile life-history stages. May a juvenile and adult growth and fitne Decreased fitness may affect spaw
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		in one or more of these parameters can fundamentally alter marine littoral habitats. Egg incubation success may be affected by alteration in wave energy patterns and groundwater inputs. Alteration of current velocities and circulation patterns may cause transportation of planktonic larvae to unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also have concomitant	sediment supply, longshore drift patterns, and wave energy and current patterns.	productivity.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		effects on food web relationships in the offshore environment. Therefore, alteration of these parameters may affect foraging opportunities for at larval and juvenile life- history stages, leading to decreased adult		
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		fitness, decreased survival, and decreased spawning productivity.		
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				

y			Exp	osure	1		<b>Resulting Effects of the</b>		
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Ecosystem Fragmentation			-	-		-	-	-
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Jetties fragment nearshore marine rearing habitat, forcing larval and juvenile surf-smelt and sandlance to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion. These stressors may affect survival, growth, and fitness. <u>Adults</u> : The physical footprint of jetties and their geomorphic effects on the upper intertidal zone may eliminate or decrease the	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval and juvenile surviv growth, and fitness. May affect adult survival, fitness, and spawning productivity.
1	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous	Year-round	Permanent	Continuous	Larvae;	suitability of spawning habitat, potentially limiting the spawning productivity of affected populations. See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to	Sensitivity to stressor exposure is currently a data gap for these species
		inputs and altered habitat complexity stressors under Riparian Vegetation Modification				Juveniles; Adults		adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	the potential effects resulting from th impact mechanism are unknown.
akwa	vaters								
	Construction and Maintenance Activities								
I	Pile driving	Increased underwater noise levels	During project construction	Temporary to short- term (hearing	Interannual to decadal (during	Larvae; Juveniles;	<u>Larvae</u> : Noise of sufficient magnitude may cause direct mortality of larvae, or permanent	Avoid pile-driving noise in excess of impact thresholds established by	May affect survival and productivity during larval, juvenile, and adult life

			Exp	osure	1	1			<b>Resulting Effects of the</b>	
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism	
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable. Limit activities to system- specific in-water work windows where practicable to avoid effects on spawning adults.	May affect survival and productivit due to avoidance behavior, decreas foraging success, and increased predation risk.	
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: These life-history stages will be difficult to capture and relocate effectively. <u>Adults:</u> Capture, handling, and relocation is likely to cause mortality, or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Require review of available data and/or site surveys to reduce likelihood of stressor exposure.	Capture/removal of larvae and juveniles is impractical, meaning the these activities are likely to affect larval and juvenile survival. Capturand removal of adults is likely to a survival and spawning productivity	
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: Pump entrainment is likely to cause mortality of drifting larvae. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. <u>Adults</u> : Impingement is likely to cause adult mortality.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Require review of available data and/or site surveys to reduce likelihood of stressor exposure.	May cause injury and mortality of larvae, juveniles, and adults. Effe are less likely to occur if activities conducted outside of spawning se	
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All life-history stages: See responses described under Hydraulic and Geomorphic Modification. Juveniles: Nearshore habitat use by smelt is currently a data gap, so the potential for exposure to this stressor is unknown.	To greatest extent practicable, limit alteration of current and circulation patterns to minimal area.	See effects for related stressors un Hydraulic and Geomorphic Modification. The potential for this mechanism affect juvenile smelt is currently unknown because dependence on nearshore circulation patterns is a gap.	
		Bottom disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae: Potential decreased larval foraging success due to turbidity exposure and substrate disturbance, leading to decreased growth and fitness. <u>Adults and juveniles</u> : Stress caused by avoidance behavior; decreased foraging success due to increased turbidity levels.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect larval productivity. M affect juvenile and adult survival productivity.	
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Surf smelt and sand lance dependence on benthic invertebrates for forage is likely limited but is currently a data gap. Therefore, the potential effects of stressor exposure are unknown.	Limit area of dewatering to the greatest extent practicable.	Potential effects resulting from thi impact mechanism are unknown.	
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	See effects for related stressors ur Water Quality Modification.	
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors un Hydraulic and Geomorphic Modification.	

b- tivity			Exp	osure					Resulting Effects of the
e e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Larvae; Juveniles; Adults	All life-history stages: See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Entrainment of smelt and sand lance during dredging is likely to cause mortality or injury, leading to decreased survival. See responses described for related stressors under Water Quality Modification.	Require review of available data and/or site surveys to reduce likelihood of larval and adult stressor exposure. Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Unlikely to affect survival of larvae and adults if activities are conducted during in-water work windows. Likely to affect survival at any life-history stage if exposure occurs. See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults and juveniles</u> : Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity at larval, juvenile, and adult life-history stages.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Juveniles and adults</u> : Avoidance behavior and increased stress, leading to reduced growth and fitness.	Avoid sediment pulses.	May affect larval, juvenile, and adult survival and productivity. Reduced adult fitness may affect spawning productivity.
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to	May affect survival and productivity of eggs, larvae, juveniles, and adults.

			Expe	osure			-		<b>Resulting Effects of the</b>
ty A N A	Mechanism of Impact Use of ACZA- and CCA type C-treated wood Aquatic Vegetation	Stressor Leaching of metals (Cu, As, Cr, Zn)	WhenLeaching begins upon installation, with highest levels occurring within 7 months of initial immersion. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Duration Intermediate-term	Frequency Continuous with seasonal pulses (dependent on current velocity)	Life-history Form Eggs; Larvae; Larvae; Juveniles	All life-history stages:       Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness.         Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Minimization Measures avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	Submechanism
	Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Eggs; Larvae; Juveniles;	Eggs: Alteration or reduction of submerged aquatic vegetation component of beach wrack may affect microclimate conditions in spawning substrates, decreasing egg survival	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect growth and fitness at ea larval, juvenile, and adult life-histo stages.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Adults	(particularly during spring and summer spawning). <u>All life-history stages</u> : Altered autochthonous production and habitat complexity are likely to effect food web dynamics and available	Construction: Avoid/minimize isturbance of aquatic vegetation uring project construction. Operation: Enforce vessel operation	
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	0	affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	
	Hydraulic and Geomorphic Modification								
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring in spring and summer when larvae and juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	All life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on	May affect survival at the larval an juvenile life-history stages. May a juvenile and adult growth and fitne Decreased fitness may affect spawn productivity.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		in one or more of these parameters can fundamentally alter marine littoral habitats.	sediment supply, longshore drift patterns, and wave energy and current patterns.	
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				

Sub- activity			Exp	osure					Resulting Effects of the
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		history stages, leading to decreased adult fitness, decreased survival, and decreased spawning productivity.		
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous	_			
	Ecosystem Fragmentation								
	Alteration of predator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	All exposed life history stages: Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators. Juvenile and adult Lake surf smelt and sand lance may be exposed to increased predation exposure. Larvae may experience similar exposure, but increased predation rates are most likely insignificant relative to natural mortality.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile and adult survival. May affect larval survival, but effects will be insignificant relative to natural mortality.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	Sensitivity to stressor exposure is currently a data gap for these species; the potential effects resulting from this impact mechanism are unknown.
Groins	and Bank Barbs								
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles; Adults	<ul> <li>Larvae: Noise of sufficient magnitude may cause direct mortality of larvae, or permanent injury leading to decreased survival and fitness. Eggs are unlikely to be exposed to pile driving noise due to position in intertidal environment.</li> <li>Adults and juveniles: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Where possible, avoid stressor exposure during site-specific spawn timing, incubation, and larval dispersal. Require review of available data and/or site surveys to avoid exposure of spawners to stressor. If pile driving is necessary during spawning period, use double-confined bubble curtain to attenuate sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival and productivity during larval, juvenile, and adult life- history stages.

Maintenance Activit Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles; Adults	Larvae: Noise of sufficient magnitude may cause direct mortality of larvae, or permanent injury leading to decreased survival and fitness. Eggs are unlikely to be exposed to pile driving noise due to position in intertidal environment.	Ave imp NO hab driv Wh exp
						<ul> <li><u>Adults and juveniles</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and</li> </ul>	timi disp data exp pile spay bubl pres dew of v pilir

			Exp	osure	I	T			<b>Resulting Effects of the</b>
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable. Limit activities to system- specific in-water work windows where practicable to avoid effects on spawning adults.	May affect survival and productivity due to avoidance behavior, decrease foraging success, and increased predation risk.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: These life-history stages will be difficult to capture and relocate effectively. <u>Adults:</u> Capture, handling, and relocation is likely to cause mortality, or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Require review of available data and/or site surveys to reduce likelihood of stressor exposure.	Capture/removal of larvae and juveniles is impractical, meaning th these activities are likely to affect larval and juvenile survival. Captur and removal of adults is likely to af survival and spawning productivity
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: Pump entrainment is likely to cause mortality of drifting larvae. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. <u>Adults</u> : Impingement is likely to cause adult mortality.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Require review of available data and/or site surveys to reduce likelihood of stressor exposure.	May cause injury and mortality of larvae, juveniles, and adults. Effec are less likely to occur if activities conducted outside of spawning sea
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All life-history stages: See responses described under Hydraulic and Geomorphic Modification. Juveniles: Nearshore habitat use by smelt is currently a data gap, so the potential for exposure to this stressor is unknown.	To greatest extent practicable, limit alteration of current and circulation patterns to minimal area.	See effects for related stressors un Hydraulic and Geomorphic Modification. The potential for this mechanism t affect juvenile smelt is currently unknown because dependence on nearshore circulation patterns is a gap.
		Bottom disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae: Potential decreased larval foraging success due to turbidity exposure and substrate disturbance, leading to decreased growth and fitness. <u>Adults and juveniles</u> : Stress caused by avoidance behavior; decreased foraging success due to increased turbidity levels.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect larval productivity. Ma affect juvenile and adult survival a productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Surf smelt and sand lance dependence on benthic invertebrates for forage is likely limited but is currently a data gap. Therefore, the potential effects of stressor exposure are unknown.	Limit area of dewatering to the greatest extent practicable.	Potential effects resulting from this impact mechanism are unknown.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to system-specific in-water work windows.	See effects for related stressors une Water Quality Modification.
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors und Hydraulic and Geomorphic Modification.

Table A-16 (continued).         HPA HCP Shoreline Modification Exposure	e and Response Matrix for Surf Smelt and Sand l
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Sub-			Exp	osure		-			Resulting Effects of the
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Larvae; Juveniles; Adults	All life-history stages: Entrainment of smelt and sand lance during dredging is likely to cause mortality or injury, leading to decreased survival. See responses described for related stressors under Water Quality Modification.	Require review of available data and/or site surveys to reduce likelihood of larval and adult stressor exposure. Limit dredging-related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Unlikely to affect survival of larvae and adults if activities are conducted during in-water work windows. Likely to affect survival at any life-history stage if exposure occurs. See effects for related stressors under Water Quality Modification.
	Water Quality Modification	·		·			· ·		
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults and juveniles</u> : Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity at larval, juvenile, and adult life-history stages.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Juveniles and adults</u> : Avoidance behavior and increased stress, leading to reduced growth and fitness.	Avoid sediment pulses.	May affect eggs, larval, juvenile, and adult survival and productivity. Reduced adult fitness may affect spawning productivity.
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to	May affect survival and productivity of larvae, juveniles, and adults.

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ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Larvae; Juveniles	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
	Riparian Vegetation Modification								
	Altered shading, solar input, ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs	Eggs: Surf smelt and sand lance incubation success is demonstrably affected by microclimate conditions in the nearshore environment that are influenced by riparian vegetation. Alteration of riparian vegetation has been demonstrated to reduce egg survival and incubation success.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect egg survival, decreasing population productivity.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Juveniles; Adults	Eggs:Smothering of incubating eggs or alteration of substrate composition may decrease egg survival.Larvae and juveniles:See responses to increased turbidity exposure described under Water Quality Modification.Adults:Potential reduction of suitable spawning habitat, leading to decreased spawning productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect egg survival. May affect growth and fitness at larval and juvenile life-history stages. May affect adult spawning fitness and productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Leaf litter and other detritus may influence microclimate conditions in spawning substrates. Reduction in leaf litter may cause reduced incubation success. Larvae, juveniles, and adults: Dependence on allochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating egg Potential effects resulting from this impact mechanism on remaining life- history stages are unknown.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Juveniles; Adults	All life-history stages: Altered habitat complexity is likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure is currently a data gap for these species; the potential effects resulting from this impact mechanism are unknown.

	Mechanism of Impact		Ехро	osure				Resulting Effects of the	
		Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Groundwater inflow demonstrably affects substrate temperatures, creating favorable conditions for egg incubation. Larvae and juveniles: Dependence of larval and juvenile forage fish on surface water and groundwater exchange in nearshore habitats is currently a data gap; the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect egg survival and adult spawning productivity. Potential effects resulting from this impact mechanism on larvae and juveniles a unknown.
							<u>Adults</u> : Altered groundwater inflow may affect spawning habitat suitability, leading to decreased spawning success.		
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Alteration or reduction of submerged aquatic vegetation component of beach wrack may affect microclimate conditions in spawning substrates, decreasing egg survival (particularly during spring and summer spawning). <u>All life-history stages</u> : Altered autochthonous production and habitat complexity are likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect growth and fitness at egg, larval, juvenile, and adult life-history stages.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal				
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous				
	Hydraulic and Geomorphic Modification								
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring in spring and summer when larvae and juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	All life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Egg incubation success may be affected by alteration in wave energy patterns and groundwater inputs. Alteration of current velocities and circulation patterns may cause transportation of planktonic larvae to unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also have concomitant effects on food web relationships in the offshore environment. Therefore, alteration of these parameters may affect foraging opportunities for at larval and juvenile life- history stages, leading to decreased adult fitness, decreased survival, and decreased spawning productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at the egg, larval and juvenile life-history stages. May affect juvenile and adult growth and fitness. Decreased fitness may affect spawning productivity.
A	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

Sub- activity Type	Mechanism of Impact Altered groundwater- surface water exchange		Exp	osure				Resulting Effects of the	
		Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
			Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Bank barbs and groins in the marine environment can fragment nearshore rearing habitat, forcing larval and juvenile surf-smelt and sandlance to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion. These stressors may affect survival, growth, and fitness. <u>Adults</u> : The physical footprint of groins and bank barbs and their geomorphic effects on the upper intertidal zone may eliminate or decrease the suitability of spawning habitat, potentially limiting the spawning productivity of affected populations.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval and juvenile survival, growth, and fitness. May affect adult survival, fitness, and spawning productivity.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	Sensitivity to stressor exposure is currently a data gap for these species; the potential effects resulting from this impact mechanism are unknown.

Sub- activity			Exp	oosure	-				Resulting Effects of the
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Jetties									
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs; Larvae; Juveniles; Adults	<ul> <li>Eggs and larvae: Noise of sufficient magnitude may cause direct mortality of eggs and larvae, or permanent injury leading to decreased survival and fitness.</li> <li>Adults and juveniles: Stressor response, dependent on noise magnitude and project- specific environmental conditions; may range from: <ul> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> </ul> </li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Where possible, avoid stressor exposure during site-specific spawn timing, incubation, and larval dispersal. Require review of available data and/or site surveys to determine if spawning adults or rearing larvae are likely to be present, and time activities to avoid stressor exposure. If pile driving is necessary during spawning period, use double-confined bubble curtain to attenuate sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival during egg, larval, juvenile, and adult life-history stages.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable. Limit activities to in- water work windows where practicable.	May affect growth, fitness, and survival due to avoidance behavior, decreased foraging success, and increased predation risk.
	Work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles; Adults	Eggs:Extended dewatering may lead to egg desiccation or thermal exposure, causing mortality, or larval abnormalities limiting to survival.Larvae and juveniles:Dewatering is likely to lead to mortality, as larval and juvenile herring will be difficult to capture and relocate effectively.Adults:Capture, handling, and relocation are likely to cause mortality, or injury and stress, leading to mortality or decreased spawning fitness.	Limit activities to in-water work windows where practicable.	Dewatering and fish removal in marine habitats is an unlikely requirement for jetty development. However, in the event that such activities are required, adverse effects on exposed life-history stages should be expected. Capture and removal of larvae and juveniles is impractical, meaning that these activities are likely to affect larval and juvenile survival. Capture and removal of adults is likely to affect survival and spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: Pump entrainment is likely to cause mortality of drifting larvae. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. <u>Adults</u> : Impingement is likely to cause adult mortality.	Adhere to in-water work windows; avoid use during spawning, incubation, and larval dispersal.	May cause injury and mortality of larvae, juveniles, and adults. Effects are less likely to occur if activities are conducted outside of spawning season.

# Table A-17. HPA HCP Shoreline Modifications Exposure and Response Matrix for Pacific Herring.

Sub- activity	Mechanism of Impact		Exp	osure				Resulting Effects of the	
Туре		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae	Larvae: Alteration of nearshore current and circulation patterns may cause larvae to be transported offshore or into habitats with increased predation risk and reduced foraging opportunity, limiting survival, growth, and fitness.	To the greatest extent practicable, limit alteration of current and circulation patterns to minimal area.	May affect larval survival, growth, and fitness.
		Bottom disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles; Adults	Larvae:Potential decreased larval foraging success due to turbidity exposure and substrate disturbance, leading to decreased growth and fitness.Adults and juveniles:Stress caused by avoidance behavior; decreased foraging success due to increased turbidity levels.Adults:Decreased availability of spawning substrate due to sedimentation effects on submerged aquatic vegetation.All life-history stages:See responses to related stressors under Water Quality Modification.	Adhere to in-water work windows; avoid activity during spawning, incubation, and larval dispersal.	The likely stressor is increased suspended solids. May affect larval growth and survival. May affect juvenile and adult survival. May affect adult spawning productivity.
		Localized alteration in invertebrate abundance	NA	NA	NA	NA	NA	NA	NA
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to in-water work windows.	See effects for related stressors under Water Quality Modification.
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Entrainment of larval herring during dredging is likely to cause mortality or injury, leading to decreased survival. See responses described for related stressors under Water Quality Modification.	Require review of available data and/or site surveys to determine if spawning adults or rearing larvae are likely to be present, and time activities to avoid stressor exposure. Limit dredging- related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Increased suspended solids and resuspension of contaminated sediments would be the likely stressors. Unlikely to affect survival of larvae and adults if activities are conducted during in-water work windows. Likely to affect survival at any life-history stage if exposure occurs. See effects for related stressors under Water Quality Modification.

### Table A-17 (continued).

## HPA HCP Shoreline Modification Exposure and Response Matrix for Pacific Herring.

			Expo	osure					Resulting Effects of the
у	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs: Effects of suspended sediments on incubating herring eggs is currently a data gap. Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults and juveniles: Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bluff/bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity egg, larval, juvenile, and adult life- history stages.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Avoidance behavior and increased stress, leading to reduced growth and fitness.	Avoid sediment resuspension.	Decreased spawning habitat area. M affect egg, larval, juvenile, and adult survival and productivity. Reduced adult fitness may affect spawning productivity.
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Herring eggs are at an increased risk of exposure due to herring tendency to lay eggs directly on pilings and other vertical structures in the nearshore environment.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to	May affect survival and productivity eggs, larvae, juveniles, and adults.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Herring eggs are at an increased risk of exposure due to herring tendency to lay eggs directly on pilings and other vertical structures in the nearshore environment.	avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	

			Expo	osure					Resulting Effects of the
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Riparian Vegetation Modification	-		•				:	-
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Pronounced in summer during solar radiation and ambient temperature extremes	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs	Eggs: The influence of marine riparian shading on herring incubation is likely limited due to the typical elevation of herring spawn in the upper subtidal zone. However, the effects of this stressor are currently a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from this impact mechanism are unknown.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Juveniles; Adults	Eggs, larvae, and juveniles: See responses to increased turbidity exposure described under Water Quality Modification. <u>Adults</u> : Potential reduction of suitable spawning habitat, leading to decreased spawning productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect egg survival. May affect productivity at larval and juvenile life- history stages. May affect adult spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduced organic matter inputs.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Dependence on allochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from this impact mechanism on remaining life- history stages are unknown.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Altered habitat complexity is likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect larval, juvenile, and adult productivity. May affect adult spawning productivity.
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Eggs; Larvae; Adults	Eggs and larvae: Herring egg and larval development is demonstrably affected by surface water salinities beyond tolerance thresholds. Alteration of salinity characteristics may limit egg survival or cause larval abnormalities limiting to survival, growth, and fitness. <u>Adults</u> : The influence of surface water and groundwater exchange on spawning habitat suitability is currently a data gap. However, alteration of this habitat parameter that affect submerged aquatic vegetation may decrease availability and/or suitability of spawning habitat.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect egg and larval survival and productivity. May affect adult spawning productivity.

			Expo	osure		-			<b>Resulting Effects of the</b>
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Larvae; Juveniles; Adults	Eggs: Alteration or reduction of submerged aquatic vegetation may affect microclimate conditions in spawning substrates, decreasing egg survival. All life-history stages: Altered habitat	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. Construction: Avoid/minimize	May affect productivity at larval, juvenile, and adult life-history sta
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous		complexity is likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness. <u>Adults</u> : Reductions in available submerged aquatic vegetation or alteration of submerged aquatic vegetation community composition may limit spawning productivity.	disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	
(	Hydraulic and Geomorphic Modification								
I	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round(with stressor exposure occurring when larvae and juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Eggs; Larvae; Juveniles;	All exposed life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project	May affect egg and larval surviva larval fitness. Decreased larval f may affect survival and productiv during juvenile and adult life-his
	Altered current velocities		compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Alteration in the aerial extent and composition of the submerged aquatic vegetation	designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	phases in offshore and open ocean environments, and may affect spawning productivity. Loss or alteration of suitable spawning habi may affect spawning productivity.				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		community resulting from these mechanisms may reduce available spawning habitat, leading to reduced spawning productivity. Egg incubation success may be affected by alteration in wave energy patterns. Alteration		may arrect spawning productivity.
P	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		of current velocities and circulation patterns may cause transportation of planktonic larvae to unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also have concomitant		
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		effects on food web relationships in the offshore environment. Therefore, alteration of these parameters may affect foraging opportunities at the juvenile life-history stage, over time leading to decreased adult fitness, decreased survival, and decreased spawning productivity.		
	Altered groundwater surface water exchange		Year-round	Permanent	Continuous				

#### Table A-17 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Pacific Herring.

ub-			Exp	osure					<b>Resulting Effects of the</b>
ctivity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Ecosystem Fragmentation								
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Jetties fragment nearshore marine rearing habitat, potentially forcing planktonic herring away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion. <u>Adults</u> : The physical footprint of jetties and their geomorphic effects on the middle and	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval and juvenile surviva growth, and fitness. May affect adult survival, fitness, and spawning productivity.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	lower intertidal zone may eliminate or decrease the suitability of spawning habitat, potentially limiting the spawning productivity of affected populations. See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.
roak	waters	vegetation modification						where appropriate during maintenance.	
Car	Construction and								
	Maintenance Activities	1						1	1
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs; Larvae; Juveniles; Adults	<ul> <li>Eggs and larvae: Noise of sufficient magnitude may cause direct mortality of eggs and larvae, or permanent injury leading to decreased survival and fitness.</li> <li><u>Adults and juveniles</u>: Stressor response, dependent on noise magnitude and project- specific environmental conditions; may range from:</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Where possible, avoid stressor exposure during site-specific spawn timing, incubation, and larval dispersal. Require review of available data and/or site surveys to determine if spawning adults or rearing larvae are likely to be present, and time activities to avoid stressor exposure. If pile driving is necessary during spawning period, use double-confined bubble curtain to attenuate sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival during egg, larva juvenile, and adult life-history stages
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable. Limit activities to in- water work windows where practicable.	May affect growth, fitness, and survival due to avoidance behavior, decreased foraging success, and increased predation risk.

Sub-			Expo	osure					Resulting Effects of the
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
	Work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles; Adults	Eggs:Extended dewatering may lead to egg desiccation or thermal exposure, causing mortality, or larval abnormalities limiting to survival.Larvae and juveniles:Dewatering is likely to lead to mortality, as larval and juvenile herring will be difficult to capture and relocate effectively.Adults:Capture, handling, and relocation are likely to cause mortality, or injury and stress, leading to mortality or decreased spawning fitness.	Limit activities to in-water work windows where practicable.	Dewatering and fish removal in marine habitats is an unlikely requirement for breakwater development. However, in the event that such activities are required, adverse effects on exposed life-history stages should be expected. Capture and removal of larvae and juveniles is impractical, meaning that these activities are likely to affect larval and juvenile survival. Capture and removal of adults is likely to affect survival and spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: Pump entrainment is likely to cause mortality of drifting larvae. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. <u>Adults</u> : Impingement is likely to cause adult mortality.	Adhere to in-water work windows; avoid use during spawning, incubation, and larval dispersal.	May cause injury and mortality of larvae, juveniles, and adults. Effects are less likely to occur if activities are conducted outside of spawning season.
		Altered circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae	<u>Larvae</u> : Alteration of nearshore current and circulation patterns may cause larvae to be transported offshore or into habitats with increased predation risk and reduced foraging opportunity, limiting survival, growth, and fitness.	To the greatest extent practicable, limit alteration of current and circulation patterns to minimal area.	May affect larval survival, growth, and fitness.
		Bottom disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles; Adults	Larvae: Potential decreased larval foraging success due to turbidity exposure and substrate disturbance, leading to decreased growth and fitness. <u>Adults and juveniles</u> : Stress caused by avoidance behavior; decreased foraging success due to increased turbidity levels. <u>Adults</u> : Decreased availability of spawning substrate due to sedimentation effects on submerged aquatic vegetation. <u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Adhere to in-water work windows; avoid activity during spawning, incubation, and larval dispersal.	The likely stressor is increased suspended solids. May affect larval growth and survival. May affect juvenile and adult survival. May affect adult spawning productivity.
		Localized alteration in invertebrate abundance	NA	NA	NA	NA	NA	NA	NA
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to in-water work windows.	See effects for related stressors under Water Quality Modification.

Sub- activity			Exp	osure	-	-			Resulting Effects of the
аспуцу Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Larvae; Juveniles; Adults	All life-history stages: Entrainment of larval herring during dredging is likely to cause mortality or injury, leading to decreased survival. See responses described for related stressors under Water Quality Modification.	Require review of available data and/or site surveys to determine if spawning adults or rearing larvae are likely to be present, and time activities to avoid stressor exposure. Limit dredging- related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Increased suspended solids and resuspension of contaminated sediments would be the likely stressors. Unlikely to affect survival of larvae and adults if activities are conducted during in-water work windows. Likely to affect survival at any life-history stage if exposure occurs. See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs:Effects of suspended sediments on incubating herring eggs is currently a data gap.Larvae:Responses vary depending on stressor magnitude.Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes).Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness.Adults and juveniles:Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bluff/bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity at egg, larval, juvenile, and adult life- history stages.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	behavior. <u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Juveniles and adults</u> : Avoidance behavior and increased stress, leading to reduced growth and fitness.	Avoid sediment resuspension.	Decreased spawning habitat area. May affect egg, larval, juvenile, and adult survival and productivity. Reduced adult fitness may affect spawning productivity.

#### Table A-17 (continued).HPA HCP

		Expo	osure	1				<b>Resulting Effects of the</b>			
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism			
Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Herring eggs are at an increased risk of exposure due to herring tendency to lay eggs directly on pilings and other vertical structures in the nearshore environment.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to	May affect survival and productivit eggs, larvae, juveniles, and adults.			
Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Herring eggs are at an increased risk of exposure due to herring tendency to lay eggs directly on pilings and other vertical structures in the nearshore environment.	avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.				
Aquatic Vegetation Modification											
Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Alteration or reduction of submerged aquatic vegetation may affect microclimate conditions in spawning substrates, decreasing egg survival. All life-history stages: Altered habitat	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. Construction: Avoid/minimize	May affect productivity at egg, larv juvenile, and adult life-history stag			
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous		complexity is likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness. <u>Adults</u> : Reductions in available submerged aquatic vegetation or alteration of submerged aquatic vegetation community composition may limit spawning productivity.	disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.				

			Ехро	osure		-			Resulting Effects of the
Me	echanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Geo	draulic and omorphic dification						-		
Alte	ered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round(with stressor exposure occurring when larvae and juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Eggs; Larvae; Juveniles;	All exposed life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project	May affect egg and larval survival and larval fitness. Decreased larval fitness may affect survival and productivity during juvenile and adult life-history phases in offshore and open ocean environments, and may affect spawning productivity. Loss or alteration of suitable spawning habitat may affect spawning productivity.
	ered current ocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent	Adults	in one or more of these parameters can	designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	
	ered nearshore ulation patterns	у	Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
Alte	ered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	ered substrate position		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	ered groundwater ace water exchange		Year-round	Permanent	Continuous				
	system gmentation			·					
	eration of lator/prey dynamics	Increased predation exposure	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	<u>All exposed life history stages</u> : Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators. Juvenile and adult herring may be exposed to increased predation exposure. Larvae may experience similar exposure, but increased predation rates are most likely insignificant relative to natural mortality.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile and adult surviva May affect larval survival, but effects will be insignificant relative to natura mortality.
	s of LWD uitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles.	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.

#### Table A-17 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Pacific Herring.

ıb- tivity			Exp	osure	1				Resulting Effects of the
pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
roin	s and Bank Barbs								
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs; Larvae; Juveniles; Adults	<ul> <li>Eggs and larvae: Noise of sufficient magnitude may cause direct mortality of eggs and larvae, or permanent injury leading to decreased survival and fitness.</li> <li><u>Adults and juveniles</u>: Stressor response, dependent on noise magnitude and project- specific environmental conditions; may range from:         <ul> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul> </li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Where possible, avoid stressor exposure during site-specific spawn timing, incubation, and larval dispersal. Require review of available data and/or site surveys to determine if spawning adults or rearing larvae are likely to be present, and time activities to avoid stressor exposure. If pile driving is necessary during spawning period, use double-confined bubble curtain to attenuate sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	May affect survival during egg, larv juvenile, and adult life-history stage
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable. Limit activities to in- water work windows where practicable.	May affect growth, fitness, and survival due to avoidance behavior decreased foraging success, and increased predation risk.
	Work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles; Adults	Eggs:Extended dewatering may lead to egg desiccation or thermal exposure, causing mortality, or larval abnormalities limiting to survival.Larvae and juveniles:Dewatering is likely to lead to mortality, as larval and juvenile herring will be difficult to capture and relocate effectively.Adults:Capture, handling, and relocation are likely to cause mortality, or injury and stress, leading to mortality or decreased spawning fitness.	Limit activities to in-water work windows where practicable.	Dewatering and fish removal in ma habitats is an unlikely requirement groin and bank barb development. However, in the event that such activities are required, adverse effe on exposed life-history stages shou be expected. Capture and removal larvae and juveniles is impractical, meaning that these activities are lil to affect larval and juvenile surviv. Capture and removal of adults is li to affect survival and spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: Pump entrainment is likely to cause mortality of drifting larvae. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. <u>Adults</u> : Impingement is likely to cause adult mortality.	Adhere to in-water work windows; avoid use during spawning, incubation, and larval dispersal.	May cause injury and mortality o larvae, juveniles, and adults. Effe are less likely to occur if activitie conducted outside of spawning se

#### Table A-17 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Pacific Herring.

Sub- activity			Exp	osure		-			Resulting Effects of the
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Altered current and circulation conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae	Larvae: Alteration of nearshore current and circulation patterns may cause larvae to be transported offshore or into habitats with increased predation risk and reduced foraging opportunity, limiting survival, growth, and fitness.	To the greatest extent practicable, limit alteration of current and circulation patterns to minimal area.	May affect larval survival, growth, and fitness.
		Bottom disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles; Adults	Larvae:Potential decreased larval foraging success due to turbidity exposure and substrate disturbance, leading to decreased growth and fitness.Adults and juveniles:Stress caused by avoidance behavior; decreased foraging success due to increased turbidity levels.Adults:Decreased availability of spawning substrate due to sedimentation effects on submerged aquatic vegetation.All life-history stages:See responses to related stressors under Water Quality Modification.	Adhere to in-water work windows; avoid activity during spawning, incubation, and larval dispersal.	The likely stressor is increased suspended solids. May affect larval growth and survival. May affect juvenile and adult survival. May affect adult spawning productivity.
		Localized alteration in invertebrate abundance	NA	NA	NA	NA	NA	NA	NA
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering. Adhere to in-water work windows.	See effects for related stressors under Water Quality Modification.
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Entrainment of larval herring during dredging is likely to cause mortality or injury, leading to decreased survival. See responses described for related stressors under Water Quality Modification.	Require review of available data and/or site surveys to determine if spawning adults or rearing larvae are likely to be present, and time activities to avoid stressor exposure. Limit dredging- related turbidity to the greatest extent practicable. Adhere to system-specific in-water work windows.	Increased suspended solids and resuspension of contaminated sediments would be the likely stressors. Unlikely to affect survival of larvae and adults if activities are conducted during in-water work windows. Likely to affect survival at any life-history stage if exposure occurs. See effects for related stressors under Water Quality Modification.

			Exp	oosure	1	1	-		<b>Resulting Effects of the</b>
activity Type N	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
V N	Water Quality Modification			-					
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs: Effects of suspended sediments on incubating herring eggs is currently a data gap. Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults and juveniles: Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bluff/bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity at egg, larval, juvenile, and adult life- history stages.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Avoidance behavior and increased stress, leading to reduced growth and fitness.	Avoid sediment resuspension.	Decreased spawning habitat area. May affect egg, larval, juvenile, and adult survival and productivity. Reduced adult fitness may affect spawning productivity.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to pH levels outside of optimal thresholds, causing direct mortality or injury leading to reduced fitness. Juveniles and adults: Avoidance behavior and increased stress, leading to reduced growth and fitness.	Avoid curing of concrete or discharge of concrete leachate to surface waters.	May affect survival of eggs and larvae, juveniles, and adults.

		Expo	osure	T	T			Resulting Effects of the
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Herring eggs are at an increased risk of exposure due to herring tendency to lay eggs directly on pilings and other vertical structures in the nearshore environment.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to	May affect survival and productivi eggs, larvae, juveniles, and adults.
Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Herring eggs are at an increased risk of exposure due to herring tendency to lay eggs directly on pilings and other vertical structures in the nearshore environment.	avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
Riparian Vegetation Modification								
Altered shading, solar input and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures)	Pronounced in summer during solar radiation and ambient temperature extremes	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs	Eggs: The influence of marine riparian shading on herring incubation is likely limited due to the typical elevation of herring spawn in the upper subtidal zone. However, the effects of this stressor are currently a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from thi impact mechanism are unknown.
Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Juveniles; Adults	Eggs, larvae, and juveniles: See responses to increased turbidity exposure described under Water Quality Modification. <u>Adults</u> : Potential reduction of suitable spawning habitat, leading to decreased spawning productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect egg survival. May affe productivity at larval and juvenile history stages. May affect adult spawning productivity.
Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduced organic matter inputs.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Dependence on allochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from thi impact mechanism on remaining hi history stages are unknown.
Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Altered habitat complexity is likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect larval, juvenile, and add productivity. May affect adult spawning productivity.

ub- ctivity			Expo	sure					<b>Resulting Effects of the</b>
ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Eggs; Larvae; Adults	Eggs and larvae: Herring egg and larval development is demonstrably affected by surface water salinities beyond tolerance thresholds. Alteration of salinity characteristics may limit egg survival or cause larval abnormalities limiting to survival, growth, and fitness. <u>Adults</u> : The influence of surface water and groundwater exchange on spawning habitat suitability is currently a data gap. However, alteration of this habitat parameter that affect submerged aquatic vegetation may decrease availability and/or suitability of spawning habitat.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect egg and larval survival a productivity. May affect adult spawning productivity.
ľ	Modification								
	Altered autochthonous production	I autochthonous         Reduced food web productivity         Year-round (most pronounced         Permanent		Larvae; Juveniles;	Eggs: Alteration or reduction of submerged aquatic vegetation may affect microclimate conditions in spawning substrates, decreasing egg survival. All life-history stages: Altered habitat	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize	May affect productivity at egg, larva juvenile, and adult life-history stages		
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous		complexity is likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness. <u>Adults</u> : Reductions in available submerged	disturbance of aquatic vegetation during project construction.	
							aquatic vegetation or alteration of submerged aquatic vegetation community composition may limit spawning productivity.		

ub-			Expo	sure			
ctivity ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor
	Hydraulic and Geomorphic Modification			-		-	-
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round(with stressor exposure occurring when larvae and juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Eggs; Larvae; Juveniles;	<u>All exposed life-history stages</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent	Adults	compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Alteration in the aerial extent and composition of the submerged aquatic vegetation
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		community resulting from these mechanisms may reduce available spawning habitat, leading to reduced spawning productivity. Egg incubation success may be affected by
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		alteration in wave energy patterns. Alteration of current velocities and circulation patterns may cause transportation of planktonic larvae to unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also have concomitant effects on food web relationships in the offshore environment. Therefore, alteration of these parameters may affect foraging opportunities at the juvenile life-history stage,
	Altered groundwater surface water exchange		Year-round	Permanent	Continuous		over time leading to decreased adult fitness, decreased survival, and decreased spawning productivity.
	Ecosystem Fragmentation						
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Bank barbs and groins in the marine environment can fragment nearshore rearing habitat, potentially forcing planktonic herring away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion.
							<u>Adults</u> : The physical footprint of groins and bank barbs and their geomorphic effects on the middle and lower intertidal zone may eliminate or decrease the suitability of spawning habitat, potentially limiting the spawning productivity of affected populations.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.

Table A-17 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Pacific Herring.

Minimization M	leasures	Resulting Effects of the Submechanism
-		
Carefully evaluate proje design and consider the impact mechanisms prop project. Encourage sele designs that minimize et sediment supply, longsh patterns, and wave energy patterns.	magnitude of luced by the ction of project ffects on ore drift	May affect egg and larval survival and larval fitness. Decreased larval fitness may affect survival and productivity during juvenile and adult life-history phases in offshore and open ocean environments, and may affect spawning productivity. Loss or alteration of suitable spawning habitat may affect spawning productivity.
Require structures with footprint necessary to ac objectives. Avoid perm in areas where significan effects are already preva	chieve project itting projects nt cumulative	May affect larval and juvenile survival, growth, and fitness. May affect adult survival, fitness, and spawning productivity.
Recommend moving LV accumulations on the str adjacent beaches where otherwise be naturally d where appropriate durin	uctures to they would eposited,	May affect juvenile survival.

Sub-			Exposure	2					
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Jetties									
	Construction and Maintenance Activities	-						-	
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<ul> <li><u>Juveniles and adults</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality or otherwise affect survival, growth, and fitness at all life-history stages, depending on project-specific noise intensity and receptor exposure.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk. Actual effects are unknown as stressor sensitivity is currently a data gap.
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual- decadal	Juveniles; Adults	<u>Adults and juveniles</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual– decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described above under Riparian and Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual– decadal	Juveniles; Adults	<u>Juveniles</u> : Post-settlement, juveniles may suffer injury or mortality as they are insufficiently mobile to avoid entrainment. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness.	Avoid turbidity effects above background levels.	May cause direct mortality or injury to juveniles. May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.
							<u>All exposed life-history stages</u> : See responses described for related stressors under Water Quality Modification.		

# Table A-18. HPA HCP Shoreline Modification Exposure and Response Matrix for Lingcod.

Sub-			Exposu	re					Resulting Effects of the
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual– decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to increased suspended solids. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval, juvenile, and adult life-history stages.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality due to asphyxiation in acute low microlayer dissolved oxygen events. (Egg exposure may occur in rare circumstances if nests are located close to shore.) <u>Juveniles and adults</u> : Avoidance behavior or asphyxiation during acute events.	Avoid sediment pulses.	May affect survival of incubating eggs and larvae. May affect juvenile and adult survival. May cause temporary avoidance behavior, potentially leading to decreased growth and fitness.

Table A-18 (continued).

nued). HPA HCP Shoreline Modification Exposure and Response Matrix for Lingcod.

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7			Exposure						<b>Resulting Effects of the</b>
,	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and stronger currents or tidal exchange. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs: Larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Likelihood of egg exposure is limited but may occur if nesting takes place near treated wood structures.	Promote removal of creosote- treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable.	May affect survival, growth, and fitness of all exposed life-history stages. Reduced fitness may affect adult spawning productivity.
-	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality. Likelihood of egg exposure is limited but may occur if nesting takes place near treated wood structures.	Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
	Riparian Vegetation Modification								
-	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity. Currently a data gap.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. Currentl a data gap.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Lingcod dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, juveniles are known to use shallow vegetated habitats and pocket estuaries which contain food sources that depend on marine riparian allochthonous input. Decreased food web productivity may result in reduced foraging opportunities.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness

HPA HCP Shoreline Modification Exposure and Response Matrix for Lingcod.

Table A-18 (continued).

Sub-			Exposure	<u> </u>					<b>Resulting Effects of the</b>
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, growth, and fitness.
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Juvenile lingcod are known to selectively settle and rear in areas with reduced salinities; therefore, groundwater inflow may provide increased habitat suitability. Reduction in suitable habitat area may affect survival, growth, and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of juveniles.
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest	May affect juvenile growth and fitnes
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival. May affect adult growth and fitness.
							<u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	<u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	

HPA HCP Shoreline Modification Exposure and Response Matrix for Lingcod.



Table A-18 (continued).

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			Exposure				
Mechanism o	of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor
Hydraulic and Geomorphic Modification	d						
Altered wave e	energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the
Altered current	t velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent		nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval lingcod settlement in nearshore
Altered nearsho circulation patt			Year-round (with seasonally variable effects depending on site- specific geography and bathymetry, and project configuration)	Permanent	Seasonal		areas favorable for rearing, as well as the overall suitability of rearing habitat for juveniles. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns,
Altered sedime	ent supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging
Altered substra composition	ate		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.
Altered ground inputs	dwater		Year-round	Permanent	Continuous		
Ecosystem Fragmentation	'n						
Habitat loss and fragmentation		Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Jetties fragment nearshore marine rearing habitat, potentially affecting settlement of larval lingcod. May increase nearshore habitat suitability for juvenile lingcod by providing interstitial cover; however, the resulting potential effects on lingcod populations are a data gap. <u>Adults</u> : Jetties create three-dimensional habitat suitable for adult lingcod in the nearshore environment, encouraging occupation. The
							resulting potential effects on lingcod populations are a data gap.
Loss of LWD recruitment		Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.

Minimization Measures	Resulting Effects of the Submechanism
Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at larval and juvenile life- history stages.
Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival. Potential effects on juvenile and adult lingcod are a data gap.

Recommend moving LWD accumulations on the structures to

adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance. May affect juvenile survival.

Sub-			Exposure						Resulting Effects of the
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Breakwa	aters								
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<ul> <li>Juveniles and adults: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality or otherwise affect survival, growth, and fitness at all life-history stages, depending on project-specific noise intensity and receptor exposure.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk. Actual effects are unknown as stressor sensitivity is currently a data gap.
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual- decadal	Juveniles; Adults	<u>Adults and juveniles</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual- decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described above under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual– decadal	Juveniles; Adults	<u>Juveniles</u> : Post-settlement, juveniles may suffer injury or mortality as they are insufficiently mobile to avoid entrainment. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness. <u>All exposed life-history stages</u> : See responses	Avoid turbidity effects above background levels.	May cause direct mortality or injury to juveniles. May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.
			/				described for related stressors under Water Quality Modification.		

HPA HCP Shoreline Modification Exposure and Response Matrix for Lingcod.

Sub-			Exposu	re					Resulting Effects of the
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual– decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to increased suspended solids. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval, juvenile, and adult life-history stages.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality due to asphyxiation in acute low microlayer dissolved oxygen events. (Egg exposure may occur in rare circumstances if nests are located close to shore.) <u>Juveniles and adults</u> : Avoidance behavior or asphyxiation during acute events.	Avoid sediment pulses.	May affect survival of incubating eggs and larvae. May affect juvenile and adult survival. May cause temporary avoidance behavior, potentially leading to decreased growth and fitness.

Table A-18 (continued).

nued). HPA HCP Shoreline Modification Exposure and Response Matrix for Lingcod.

<b>x</b> 7	Mechanism of Impact		Exposure		·				<b>Resulting Effects of the</b>	
Activity Type		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism	
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and stronger currents or tidal exchange. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs: Larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Likelihood of egg exposure is limited but may occur if nesting takes place near treated wood structures.	Promote removal of creosote- treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary,	May affect survival, growth, and fitness of all exposed life-history stages. Reduced fitness may affe adult spawning productivity.	
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Juveniles; Adults		use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.		
								<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.		
	Aquatic Vegetation Modification									
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest	May affect juvenile growth and	
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival. M affect adult growth and fitness.	
							<u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	<u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.		

HPA HCP Shoreline Modification Exposure and Response Matrix for Lingcod.

Table A-18 (continued).

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Table A-18	(continued)
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HPA HCP Shoreline Modification Exposure and Response Matrix for Lingcod. ).

,			Exposure	•			Doculting Efforts of the		
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification	-		•			•		
Altered wave	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project.	May affect survival, growth, and fitness at larval and juvenile life- history stages.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent		nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval lingcod settlement in nearshore	Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and	
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site- specific geography and bathymetry, and project configuration)	Permanent	Seasonal		areas favorable for rearing, as well as the overall suitability of rearing habitat for juveniles. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging	current patterns.	
	Altered sediment supply	iment supply Year-round (linstallation ar	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		ha	opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.	
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Alteration of predator/prey dynamics	Increased availability of foraging and resting habitat	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : The increased hard surface area created by breakwaters may result in increased suitable habitat for juvenile lingcod.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid	May (beneficially) affect surviva growth, and fitness of juveniles adults.
							<u>Adults</u> : Lingcod are lie-in-wait predators which favor the types of habitats created by breakwaters. Altered predator/prey dynamics associated with these structures may result in increased foraging opportunities for this species.	permitting projects in areas where significant cumulative effects are already prevalent.	
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Aquatic Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.

Minimization Measures	Resulting Effects of the Submechanism
Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at larval and juvenile life- history stages.
Require structures with the	May (beneficially) affect survival,

Sub- Activity			Exposure						Resulting Effects of the
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Groins a	and Bank Barbs								
	Construction and Maintenance Activities	-	-	-		-	_		
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<ul> <li>Juveniles and adults: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality or otherwise affect survival, growth, and fitness at all life-history stages, depending on project-specific noise intensity and receptor exposure.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk. Actual effects are unknown as stressor sensitivity is currently a data gap.
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual- decadal	Juveniles; Adults	<u>Adults and juveniles</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual- decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described above under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual– decadal	Juveniles; Adults	<u>Juveniles</u> : Post-settlement, juveniles may suffer injury or mortality as they are insufficiently mobile to avoid entrainment. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness.	Avoid turbidity effects above background levels.	May cause direct mortality or injury to juveniles. May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.
							<u>All exposed life-history stages</u> : See responses described for related stressors under Water Quality Modification.		

HPA HCP Shoreline Modification Exposure and Response Matrix for Lingcod.

Sub-			Exposure					Γ
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Water Quality Modification					•		
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual– decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality due to asphyxiation in acute low microlayer dissolved oxygen events. (Egg exposure may occur in rare circumstances if nests are located close to shore.) Juveniles and adults: Avoidance behavior or asphyxiation during acute events.	
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual– decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness. Adult and juvenile avoidance behavior at subacute exposure levels.	

ued). HPA HCP Shoreline Modification Exposure and Response Matrix for Lingcod.

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Minimization Measures	Resulting Effects of the Submechanism
Ensure project design avoids and/or minimizes habitat alterations leading to increased suspended solids. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval, juvenile, and adult life-history stages.
Avoid sediment pulses.	May affect survival of incubating eggs and larvae. May affect juvenile and adult survival. May cause temporary avoidance behavior, potentially leading to decreased growth and fitness.
Prevent in-water curing of concrete and discharge of concrete leachate to surface waters.	Acute exposure may cause mortality at all exposed life-history stages. Juveniles and adults avoidance behavior at subacute exposure levels.

			Exposure						<b>Resulting Effects of the</b>
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and stronger currents or tidal exchange. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs: Larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Likelihood of egg exposure is limited but may occur if nesting takes place near treated wood structures.	Promote removal of creosote- treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary,	May affect survival, growth, and fitness of all exposed life-history stages. Reduced fitness may affect adult spawning productivity.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Juveniles; Adults		Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
	Riparian and Shoreline Vegetation Modification								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity. Currently a data gap.
-	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. Curren a data gap.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Lingcod dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, juveniles are known to use shallow vegetated habitats and pocket estuaries which contain food sources that depend on marine riparian allochthonous input. Decreased food web productivity may result in reduced foraging opportunities.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitne

. HPA HCP Shoreline Modification Exposure and Response Matrix for Lingcod.

#### Sub-Exposure Activity Mechanism of Impact **Response to Stressor** Life-history Form When Duration Frequency Туре Stressor Altered habitat Year-round (stressor exposure Continuous Juveniles Juveniles: Decreased refuge habitat availability Reduced recruitment of large Short-term to complexity woody debris, affecting habitat occurs during nearshore rearing permanent and foraging opportunities, leading to increased (dependent on nature structure, hydraulic and substrate competition and resulting effects on growth and period in spring and summer) complexity, and availability of of activity) fitness. organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover. Continuous Juveniles Juveniles: Juvenile lingcod are known to Altered groundwater-Reduced aquatic food web Year-round (stressor exposure Permanent surface water exchange productivity; secondary effects on occurs during nearshore rearing selectively settle and rear in areas with reduced habitat complexity (e.g., through period in spring and summer) salinities; therefore, groundwater inflow may alteration of aquatic vegetation) provide increased habitat suitability. Reduction in suitable habitat area may affect survival, growth, and fitness. **Aquatic Vegetation** Modification Altered autochthonous Reduced food web productivity Year-round (most pronounced in Permanent Continuous Juveniles Juveniles: Reduced foraging opportunities due to production spring and summer when vegetation decreased food web productivity; decreased growth and fitness. growth is most extensive) Altered habitat Reduced food web productivity, Short-term to Continuous Juveniles: Juveniles: Decreased refuge habitat availability Year-round complexity reduced foraging opportunity, permanent and foraging opportunities, leading to increased Adults reduction in available cover (dependent on nature competition and predation exposure, resulting in decreased survival, growth, and fitness. of activity) Adults: Decreased foraging opportunity due to decreased food web productivity. Decreased

Table A-18 (continued).

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HPA HCP Shoreline Modification Exposure and Response Matrix for Lingcod.

growth and reproductive fitness.



Minimization Measures	Resulting Effects of the Submechanism
Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, growth, and fitness.
Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of juveniles.
<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest	May affect juvenile growth and fitness.
extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival. May affect adult growth and fitness.

Table A-18	(continu	ed)
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HPA HCP Shoreline Modification Exposure and Response Matrix for Lingcod. **l).** 

		Exposure	2					Resulting Effects of the			
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism			
Hydraulic and Geomorphic Modification		•	•			•					
Altered wave energy	habitat suitability, reduced food web complexity, habitat availability and suitability     occ nea availability       red current velocities     Yea dep dyr       red nearshore llation patterns     Yea yea and yea spe and yea inst pro       red sediment supply     Yea yea and yea yea inst pro       red substrate position     Yea yea yea yea yea yea yea yea yea yea y	Year-round (with stressor exposure occurring when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project.	May affect survival, growth, and fitness at larval and juvenile life-history stages.			
Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent		nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval lingcod settlement in nearshore	Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and				
Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site- specific geography and bathymetry, and project configuration)	Permanent	Seasonal		areas favorable for rearing, as well as the overall suitability of rearing habitat for juveniles. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.	current patterns.				
Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous							
Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous							
Altered groundwater- surface water exchange		Year-round	Permanent	Continuous							
Ecosystem Fragmentation											
Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Bank barbs and groins in the marine environment can fragment nearshore rearing habitat, potentially affecting settlement of larval lingcod. May increase nearshore habitat suitability for juvenile lingcod by providing interstitial cover; however, the resulting potential effects on lingcod populations are a data gap. <u>Adults</u> : Groins and bank barbs in the marine	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival. Poter effects on juvenile and adult ling are a data gap.			
						environment may create three-dimensional habitat suitable for adult lingcod in the nearshore environment, encouraging occupation. The resulting potential effects on lingcod populations are a data gap.					
Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.			

Minimization Measures	Resulting Effects of the Submechanism
Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at larval and juvenile life- history stages.
Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival. Potential effects on juvenile and adult lingcod are a data gap.

Sub-			Exp	osure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
Jetties	5				-				
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles; Adults	<ul> <li><u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li><u>Barotraumas causing fatal injury or permanent auditory tissue damage in larvae, juveniles, and adults limiting to survival.</u></li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by these species. Limit pile driving to in-water work windows. Use double- confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality or otherwise affect survival, growth, and fitness and at all life-history stages, depending on project-specific noise intensity and receptor exposure.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	J <mark>uvenil</mark> es; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Larvae; Juveniles; Adults	All life-history stages: See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles;	<u>Juveniles</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Larvae; Juveniles	<u>Juveniles</u> : Post-settlement juveniles may suffer injury or mortality as they are insufficiently mobile to avoid entrainment. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness. <u>All exposed life-history stages</u> : See	Avoid turbidity effects above background levels.	May cause direct mortality of juveniles. May affect juvenile survival, growth, and fitness. See effects for related stressors under Water Quality Modification.
							responses described for related stressors under Water Quality Modification.		

Sub-			Exp	osure					
activity	Machaning Classes (	<u>S</u> 4waaaaa	When		Enormone-	Life History	Demonso de Stevenes	Minimization Management	
Туре	Mechanism of Impact Water Quality Modification	Stressor	wnen	Duration	Frequency	Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased larval survival. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to increased suspended solids. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval and juvenile life- history stages.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae and juveniles: Mortality due to asphyxiation in acute low microlayer dissolved oxygen events. Juveniles: Avoidance behavior or asphyxiation during acute events.	Avoid sediment pulses.	May cause direct mortality of larvae and juveniles. May affect juvenile survival, growth, and fitness.
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and stronger currents or tidal exchange. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Lingering physiological effects may limit adult fitness.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.	May affect survival, growth, and fitness and of larvae and juveniles. Reduced fitness may affect adult spawning productivity.
	Use of ACZA- and CCA type C-treated Wood	Leaching of metals (Cu, As, Cr, Zn),	Leaching begins upon installation with highest levels occurring within 7 months of initial immersion.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at sub-acute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality. Lingering physiological effects may limit adult fitness.	<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	

			Expo	osure					
r	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Riparian Vegetation Modification	-							-
i	Altered shading, solar nput and ambient air emperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity. Currently a data gap.
	Altered shoreline and oluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity.
	Altered allochthonous nputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Pacific cod, hake and walleye pollock dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, juvenile Pacific cod, hake, and walleye pollock are known to use shallow vegetated habitats that could have marine riparian allochthonous input. Decreased food web productivity may result in reduced foraging opportunities.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile, growth, and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, grow and fitness.
	Altered freshwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Pacific cod, hake, and walleye pollock dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Effects of action are unknown as receptor sensitivity to this stressor currently a data gap.

			Expe	osure						
Me	echanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action	
	atic Vegetation dification				-	2		÷	-	
	red autochthonous luction	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect juvenile growth and fitne	
	red habitat plexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	May affect juvenile growth and fitne	
Geo	lraulic and morphic dification									
Alte	red wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occuring when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project	May affect survival, growth, and fitness at larval and juvenile life-history stages.	
Alte	red current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the	Alteration in one or more of these sediment supply, longshore drift parameters can fundamentally alter marine	patterns, and wave energy and current	
	red nearshore ulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal areas favorable for rearing, as well as the overall suitability of juvenile rearing habitat. This may occur through a number of specific stressors, including increased exertion and stress due to change in current					
Alte	red sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foreging enportunity, and increased			
	pred substrate		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.			
Alte inpu	ered groundwater		Year-round	Permanent	Continuous					

b-			Exp	oosure				1				
vity be	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action			
	Ecosystem Fragmentation					<u>.</u>			-			
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Jetties fragment nearshore rearing habitat, potentially affecting settlement of larval cod, pollock, and hake. Physical footprint of structures may eliminate suitable rearing habitat or decrease habitat suitability, potentially affecting larval survival, growth, and fitness	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival, growth, as fitness.			
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.			
ak	waters											
	Construction and Maintenance Activities											
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles; Adults	<ul> <li><u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Barotraumas causing fatal injury or permanent auditory tissue damage in larvae, juveniles, and adults limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by these species. Limit pile driving to in-water work windows. Use double- confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality of otherwise affect survival, growth, an fitness and at all life-history stages, depending on project-specific noise intensity and receptor exposure.			
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.			
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.			
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles;	<u>Juveniles</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors unde Aquatic Vegetation Modification.			

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vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	<b>Response to Stressor</b>		
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Larvae; Juveniles	<u>Juveniles</u> : Post-settlement juveniles may suffer injury or mortality as they are insufficiently mobile to avoid entrainment. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness.	Avoid turbidity effects above background levels.	May cause direct mortality of juveniles. May affect juvenile survival, growth, and fitness. See effects for related stressors under Water Quality Modification.
							<u>All exposed life-history stages</u> : See responses described for related stressors under Water Quality Modification.		
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased larval survival. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to increased suspended solids. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval and juvenile life- history stages.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Larvae; Juveniles	<u>Larvae and juveniles</u> : Mortality due to asphyxiation in acute low microlayer dissolved oxygen events. <u>Juveniles</u> : Avoidance behavior or asphyxiation during acute events.	Avoid sediment pulses.	May cause direct mortality of larva and juveniles. May affect juvenile survival, growth, and fitness.

					osure	Exp			Sub-
Resulting Effects of the Action	Minimization Measures	Response to Stressor	Life History Form	Frequency	Duration	When	Stressor	Mechanism of Impact	activity Type
	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.	All life-history stages: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Lingering physiological effects may limit adult fitness.	Larvae; Juveniles; Adults	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Long-term (with decreasing concentration intensity over time)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and stronger currents or tidal exchange. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Use of creosote-treated wood	
	<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	All life-history stages: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at sub-acute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality. Lingering physiological effects may limit adult fitness.	Larvae; Juveniles: Adults	Continuous with seasonal pulses (dependent on current velocity)	Intermediate-term	Leaching begins upon installation with highest levels occurring within 7 months of initial immersion.	Leaching of metals (Cu, As, Cr, Zn)	Use of ACZA- and CCA type C-treated Wood	
								Aquatic Vegetation Modification	
May affect juvenile growth and fitne	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Juveniles	Continuous	Permanent	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Reduced food web productivity	Altered autochthonous production	
May affect juvenile growth and fitne	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	Juveniles	Continuous	Short-term to permanent (dependent on nature of activity)	Year-round	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Altered habitat complexity	
	footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble	due to decreased food web productivity;         decreased growth and fitness.         Juveniles:       Decreased refuge habitat         availability and foraging opportunities,         leading to increased competition and         predation exposure, resulting in decreased			Short-term to permanent (dependent on nature	in spring and summer when vegetation growth is most extensive)	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning	Altered autochthonous production Altered habitat	

ıb-			Exp	osure					
tivity ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Hydraulic and Geomorphic Modification				-				<u>.</u>
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at larval and juvenile life- history stages.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Alteration of predator/prey dynamics	Increased availability of foraging and resting habitat	Year-round	Permanent	Continuous	Larvae; Juveniles;	All exposed life history stages: Breakwaters provide three dimensional structure potentially attractive to lie-in-wait predators. Juvenile cod, pollock, and hake may be exposed to increased predation exposure. Larvae may experience similar exposure, but increased predation rates are most likely insignificant relative to natural mortality.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival, growth, and fitness of juveniles. Affects on larva likely insignificant relative to natural mortality.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.

Sub-			Expo	osure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Action
	s and Bank Barbs	8							
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles; Adults	<ul> <li><u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Barotraumas causing fatal injury or permanent auditory tissue damage in larvae, juveniles, and adults limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by these species. Limit pile driving to in-water work windows. Use double- confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality or otherwise affect survival, growth, and fitness and at all life-history stages, depending on project-specific noise intensity and receptor exposure.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual–decadal	Juveniles;	<u>Juveniles</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Larvae; Juveniles	<u>Juveniles</u> : Post-settlement juveniles may suffer injury or mortality as they are insufficiently mobile to avoid entrainment. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness. <u>All exposed life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May cause direct mortality of juveniles. May affect juvenile survival, growth, and fitness. See effects for related stressors under Water Quality Modification.

## Table A-19 (continued). HPA HCP Shoreline Modifications Exposure and Response Matrix for Pacific cod, hake, and Walleye Pollock.

Type         Medianium di mupati         Stressor         When         Duration         Fequency         Form         Response to Stressor         Minimization Masaures         Resulting Effects of the Action           Mediane di mupati         Stressor         Jaccas         Internativation	Sub-			Exp	osure					
Modification         Dependent on contributing mechanism of impact         International decide on international decidea on international decide on internation decide on internation	activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
Image: Instrument in the second sec		Water Quality Modification				-	-			
Altered pH levels       Dependent on contributing mechanism of impact       term (e.g., contributing mechanism of impact)       term (e.g., contributing mechanism of impact)       term (e.g., contributing mechanism of impact)       asphysication in acute low microlayer dissolved oxygoin acute ovents.       asphysication in acute low microlayer dissolved oxygoin acute ovents.       and juveniles. May affect juvenile survival, growth, and fitness.         Altered pH levels       Dependent on contributing mechanism of impact       Temporary to short time ranual-decadal (dependent on contributing mechanism of inpact)       Temporary to short time ranual-decadal (dependent on contributing mechanism of inpact)       Larvae: Larvae: Larvae and juveniles. Physiological thresholds, causing mortality or njury leading to reduced fitness.       Prevent in-water curing of concrete leachate to surface all all exposed life-history stages. Juvenile and adult avoidance behavior as the short or contributing mechanism of impact			Increased suspended solids	Dependent on contributing mechanism of impact	term (dependent on contributing mechanism of	interannual-decadal (dependent on contributing mechanism of	,	microlayer habitat may lead to direct mortality and decreased larval survival. <u>Juveniles</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement	minimizes habitat alterations leading to increased suspended solids. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and	fitness at larval and juvenile life-
mechanism of impact term (depending on contributing mechanism of impact term (dependent on contributing mechanism of impact) term (dependent on contributing mechanism of impact) term (dependent on contributing mechanism of contributing mechanism of impact) term (dependent on contributing mechanism of contributing mechanism of impact) term (dependent on contributing mechanism of contributing mechanism of impact) term (dependent on contributing mechanism of contributing mechanism of impact) term (dependent on contributing mechanism of contributing mechanism of impact) term (dependent on contributing mechanism of contributing mechanism of impact) term (dependent on contributing mechanism of contributing mechanism of impact) term (dependent on contributing mechanism of contributing mechanism of impact) term (dependent on contributing mechanism of contributing mechanism of impact) term (dependent on contributing mechanism of contributing mechanism of impact) term (dependent on contributing mechanism of contributing mechanism of impact) term (dependent on contributing mechanism of contributing mechanism of impact) term (dependent on contributing mechanism of contributing mechanism of impact) term (dependent on contributing mechanism of c			Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) dependent on contributing	permanent (dependent on contributing mechanism of	,	asphyxiation in acute low microlayer dissolved oxygen events. <u>Juveniles</u> : Avoidance behavior or	Avoid sediment pulses.	and juveniles. May affect juvenile
impact)			Altered pH levels		term (depending on contributing mechanism of	interannual-decadal (dependent on contributing mechanism of	*	responses to pH levels outside of optimal thresholds, causing mortality or injury	discharge of concrete leachate to surface	Juvenile and adult avoidance behavior

## Table A-19 (continued). HPA HCP Shoreline Modifications Exposure and Response Matrix for Pacific cod, hake, and Walleye Pollock.

# Table A-19 (continued). HPA HCP Shoreline Modifications Exposure and Response Matrix for Pacific cod, hake, and Walleye Pollock.

		Exp	osure					
Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Actio
Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and stronger currents or tidal exchange. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Larvae; Juveniles; Adults	Larvae and juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Lingering physiological effects may limit adult fitness.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.	May affect survival, growth, and fitness and of larvae and juveniles Reduced fitness may affect adult spawning productivity.
Use of ACZA- and CCA type C-treated Wood	Leaching of metals (Cu, As, Cr, Zn),	Leaching begins upon installation with highest levels occurring within 7 months of initial immersion.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Larvae; Juveniles; Adults	Larvae and juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at sub-acute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality. Lingering physiological effects may limit adult fitness.	<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
Riparian Vegetation Modification								
Altered shading, solar input and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity. Currently a data ga
Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity.
Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Pacific cod, hake and walleye pollock dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, juvenile Pacific cod, hake, and walleye pollock are known to use shallow vegetated habitats that could have marine riparian allochthonous input. Decreased food web productivity may result in reduced foraging opportunities.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile, growth, and fitness.

# Table A-19 (continued). HPA HCP Shoreline Modifications Exposure and Response Matrix for Pacific cod, hake, and Walleye Pollock.

			Expo	osure					
rity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, growth, and fitness.
	Altered groundwater- surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Pacific cod, hake, and walleye pollock dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Effects of action are unknown as receptor sensitivity to this stressor is currently a data gap.
	Aquatic Vegetation Modification								
-	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect juvenile growth and fitness
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction. Operation: Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	May affect juvenile growth and fitness



# Table A-19 (continued). HPA HCP Shoreline Modifications Exposure and Response Matrix for Pacific cod, hake, and Walleye Pollock.

			Exp	osure					
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Hydraulic and Geomorphic Modification								-
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics	substratedesign and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		Alteration in one or more of these parameters can fundamentally alter marine	designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous	0			
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Bank barbs and groins in the marine environment can fragment nearshore rearing habitat, potentially affecting settlement of larval cod, pollock, and hake. Physical footprint of structures may eliminate suitable rearing habitat or decrease habitat suitability, potentially affecting larval survival, growth, and fitness	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival, growth, a fitness.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles.	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.

Sub-				Exposure		-			
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	<b>Resulting Effects of the Action</b>
Jetties									
	Construction and Maintenance Activities		-			_			
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<ul> <li>Juveniles and adults: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by these species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality or injury affecting juvenile and adult survival, depending on project- specific noise intensity and receptor exposure.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Juveniles and adults: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey. However, rockfish sensitivity to this stressor is currently a data gap.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect juvenile and adult survival due to avoidance behavior, decreased foraging success, and increased predation risk. Actual effects are unknown as stressor sensitivity is a data gap.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Riparian and Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	<u>Juveniles</u> : Direct mortality or injury from entrainment. Decreased foraging opportunity due to short- term reduction in prey availability. Decreased growth and fitness. <u>Adults</u> : See responses described	Avoid turbidity effects background levels.	May cause direct mortality or injury to juveniles. May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.
							for related stressors under Water Quality Modification.		

Sub-				Exposure					
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual– decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of larvae. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to increased suspended solids. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval and juvenile life- history stages.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short-term (e.g., contaminant spill or discharge)	Intermittent to permanent (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae and juveniles: Mortality due to asphyxiation in acute low microlayer dissolved oxygen events. Juveniles: Avoidance behavior or asphyxiation during acute events.	Avoid sediment pulses.	May affect larval survival. May affect juvenile survival. May cause temporary avoidance behavior.
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Larvae; Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.	May affect growth, fitness, and survival of larvae, juveniles, and adults.
	Use of ACZA- and CCA type C-treated Wood	Leaching of metals (Cu, As, Cr, Zn),	Leaching begins upon installation with highest levels occurring within 7 months of initial immersion.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Larvae; Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at sub-acute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	

Table A-20 (continued).	HPA HCP Shoreline Modification Exposure and Response Matrix for Group 20 Rockfish Sp	Df
	In A not onotonic mouncation Exposure and Response matrix for oroup 20 Rockinsh 5	Р

,			1	Exposure		1			
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Action
	Riparian Vegetation Modification			•	•		•	•	•
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. Currently a data gap.
1	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long- term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. Currently a data gap.
	Altered allochthonous nputs	Reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Rockfish dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, juvenile rockfish are known to use shallow vegetated habitats and pocket estuaries which contain food sources that depend on marine riparian allochthonous input. Decreased food web productivity may result in reduced foraging opportunities.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
1	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, growth, and fitness.
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Rockfish dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Effects of the action resulting from this impact mechanism are unknown.

# pecies.

Sub-				Exposure			-		
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	<b>Resulting Effects of the Action</b>
	Aquatic Vegetation Modification	•		•	•		•	•	•
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.Operation: Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased refuge habitat availability. Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		May affect juvenile survival. May affect adult growth and fitness.

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Table A-20 (continued).	HPA HCP Shoreline Modification	Exposure and Response	Matrix for Group	20 Rockfish Spe
Table A-20 (continueu).		Exposure and Response	Mailly for Group	20 Rockiish Spe

Sub-				Exposure						
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Action	
	Hydraulic and Geomorphic Modification	-					•	-	-	
	Marine	T	1	T		1		1		
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that	May affect survival, growth, and fitness at larval and juvenile life-history stages.	
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral	minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.		
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		habitats, potentially decreasing the likelihood of larval rockfish settlement in nearshore areas favorable for rearing, as well as the overall suitability of rearing habitat. This may occur through a number of			
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in			
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.		n	
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous					
	<b>Ecosystem Fragmentation</b>		·							
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Jetties fragment nearshore rearing habitat, potentially affecting settlement of larval rockfish. May increase nearshore habitat suitability for juvenile rockfish, however the resulting potential effects on rockfish populations are a data gap. <u>Adults</u> : Jetties are three dimensional habitat potentially	f objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival. Potentia effects on juvenile and adult rockfish are a data gap.	
							suitable for adult rockfish in the nearshore environment, encouraging occupation. The resulting potential effects on rockfish populations are a data gap.			

# pecies.

Sub-				Exposure						
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	<b>Response to Stressor</b>	Minimization Measures	<b>Resulting Effects of the Action</b>	
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.	
Breaky	waters									
	Construction and Maintenance Activities									
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<ul> <li>Juveniles and adults: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by these species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality or injury affecting juvenile and adult survival, depending on project- specific noise intensity and receptor exposure.	
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Juveniles and adults: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey. However, rockfish sensitivity to this stressor is currently a data gap.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect juvenile and adult survival due to avoidance behavior, decreased foraging success, and increased predation risk. Actual effects are unknown as stressor sensitivity is a data gap.	
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.	
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.	

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Sub-				Exposure		1			
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Action
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Direct mortality or injury from entrainment. Decreased foraging opportunity due to short- term reduction in prey availability. Decreased growth and fitness.	Avoid turbidity effects background levels.	May cause direct mortality or injury to juveniles. May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.
							<u>Adults</u> : See responses described for related stressors under Water Quality Modification.		
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual– decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of larvae. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to increased suspended solids. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval and juvenile life- history stages.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short-term (e.g., contaminant spill or discharge)	Intermittent to permanent (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae and juveniles: Mortality due to asphyxiation in acute low microlayer dissolved oxygen events. Juveniles: Avoidance behavior or asphyxiation during acute events.	Avoid sediment pulses.	May affect larval survival. May affect juvenile survival. May cause temporary avoidance behavior.

## HPA HCP Shoreline Modification Exposure and Response Matrix for Group 20 Rockfish Species. Table A-20 (continued).

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# HPA HCP Shoreline Modification Exposure and Response Matrix for Group 20 Rockfish Species.

ıb-			-	Exposure		-			
ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Larvae; Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood	May affect growth, fitness, and survival of larvae, juveniles, and adults.
	Use of ACZA- and CCA type C-treated Wood	Leaching of metals (Cu, As, Cr, Zn),	Leaching begins upon installation with highest levels occurring within 7 months of initial immersion.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Larvae; Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at sub-acute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design:Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.Construction:Avoid/minimize disturbance of aquatic vegetation during project construction.Operation:Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased refuge habitat availability. Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		May affect juvenile survival. May affect adult growth and fitness.

			1	Exposure		1	4		
Mechanism of	of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Actio
Hydraulic and Geomorphic Mo	odification								
Altered wave ene	ergy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that	May affect survival, growth, and fitness at larval and juvenile life history stages.
Altered current ve	velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral	f	
Altered nearshore circulation pattern			Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		habitats, potentially decreasing the likelihood of larval rockfish settlement in nearshore areas favorable for rearing, as well as the overall suitability of rearing habitat. This may occur through a number of		
Altered sediment	t supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in		
Altered substrate composition	3		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.		
Altered groundwa surface water exc			Year-round	Permanent	Continuous				
Ecosystem Frag	gmentation								
Alteration of pred dynamics	edator/prey	Increased availability of foraging and resting habitat	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : The increased hard surface area created by breakwaters may result in increased suitable habitat for juvenile rockfish. <u>Adults</u> : Rockfish are lie-in-wait	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May (beneficially) affect survir growth, and fitness of juveniles adults.
							predators which favor the types of habitats created by breakwaters. Altered predator/prey dynamics associated with these structures may result in increased foraging opportunities for this species.		
Loss of LWD rec	cruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Aquatic Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival.

Sub-				Exposure					
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
Groins	and Bank Barbs								
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<ul> <li>Juveniles and adults: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from:</li> <li>Fatal injury or permanent auditory tissue damage limiting to survival.</li> <li>Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey.</li> <li>Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.</li> </ul>	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by these species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality or injury affecting juvenile and adult survival, depending on project- specific noise intensity and receptor exposure.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Juveniles and adults: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey. However, rockfish sensitivity to this stressor is currently a data gap.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect juvenile and adult survival due to avoidance behavior, decreased foraging success, and increased predation risk. Actual effects are unknown as stressor sensitivity is a data gap.
	Construction/maintenance dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Riparian and Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	<u>Juveniles</u> : Direct mortality or injury from entrainment. Decreased foraging opportunity due to short- term reduction in prey availability. Decreased growth and fitness. <u>Adults</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects background levels.	May cause direct mortality or injury to juveniles. May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.

Sub-				Exposure					
ctivity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Water Quality Modification	•		•	•		•	•	•
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual– decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of larvae. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to increased suspended solids. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval and juvenile life- history stages.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short-term (e.g., contaminant spill or discharge)	Intermittent to permanent (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae and juveniles: Mortality due to asphyxiation in acute low microlayer dissolved oxygen events. Juveniles: Avoidance behavior or asphyxiation during acute events.	Avoid sediment pulses.	May affect larval survival. May affect juvenile survival. May cau temporary avoidance behavior.
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Larvae; Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.	May affect growth, fitness, and survival of larvae, juveniles, and adults.
	Use of ACZA- and CCA type C-treated Wood	Leaching of metals (Cu, As, Cr, Zn),	Leaching begins upon installation with highest levels occurring within 7 months of initial immersion.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Larvae; Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at sub-acute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	

Table A-20 (continued).	HPA HCP Shoreline Modification Exposure and Response Matrix for Group 20 Rockfish Sp	Df
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,				Exposure		-	_		
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Action
	Riparian Vegetation Modification			•	•		•	•	•
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. Currently a data gap.
1	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long- term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. Currently a data gap.
	Altered allochthonous inputs	Reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Rockfish dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, juvenile rockfish are known to use shallow vegetated habitats and pocket estuaries which contain food sources that depend on marine riparian allochthonous input. Decreased food web productivity may result in reduced foraging opportunities.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
1	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, growth, and fitness.
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Rockfish dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Effects of the action resulting from this impact mechanism are unknown.

# pecies.

		1	Exposure					
Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
Aquatic Vegetation Modification								
Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased refuge habitat availability. Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		May affect juvenile survival. Ma affect adult growth and fitness.
Hydraulic and Geomorphic Modification								
Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with stressor exposure occurring when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that	May affect survival, growth, and fitness at larval and juvenile life history stages.
Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral	minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	
Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		habitats, potentially decreasing the likelihood of larval rockfish settlement in nearshore areas favorable for rearing, as well as the overall suitability of rearing habitat. This may occur through a number of		
Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation		
Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.	n	
Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				

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Sub-				Exposure					
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	<b>Resulting Effects of the Action</b>
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Bank barbs and groins in the marine environment can fragment nearshore rearing habitat, potentially affecting settlement of larval rockfish. May increase nearshore habitat suitability for juvenile rockfish, however the resulting potential effects on rockfish populations are a data gap. <u>Adults</u> : Groins and bank barbs in the marine environment may create three dimensional habitat suitable for adult rockfish in the nearshore environment, encouraging occupation. The resulting potential effects on rockfish populations are a data gap.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival. Potential effects on juvenile and adult rockfish are a data gap.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival, growth, and fitness.

# Table A-20 (continued). HPA HCP Shoreline

# HPA HCP Shoreline Modification Exposure and Response Matrix for Group 20 Rockfish Species.

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Sub- activity			Exp	oosure	1	1			Resulting Effects of the
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Jetties									
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary	Interannual-decadal	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Effect of piling driving sound is a data gap.	Effect of increased underwater noise level on Olympic oyster is a data gap.	Effect of increased underwater noise level on Olympic oyster is a data gap.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary	Interannual-decadal	Veliger larvae; Juveniles, Adults	<u>All life-history stages</u> : Effect of anthropogenic sound is a data gap.	Effect of increased ambient noise level on Olympic oyster is a data gap.	Effect of increased ambient noise level on Olympic oyster is a data gap.
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Veliger larvae Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Veliger larvae; Juveniles; Adults	All life-history stages: See responses described under Riparian and Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Veliger larvae; Juveniles; Adults;	<u>All life-history stages</u> : Mortality from entrainment. Decreased growth and fitness. See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect veliger larvae productivity and fitness. See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating larvae and juveniles. May affect juvenile and adult productivity.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Olympia oyster dissolved oxygen effect thresholds are currently a data gap. Sensitivity to dissolved oxygen levels appears to be low, however.	Avoid sediment pulses.	May affect survival of incubating larvae, juveniles, and adults. May affect juvenile and adult survival, growth, and fitness, including adult spawning success. Actual effects are unknown, as sensitivity to this stressor and effects thresholds are currently data gaps.

y			Ехро	osure					<b>Resulting Effects of the</b>			
Y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism			
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Veliger larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to	May affect survival, growth, and fitness of larvae, juveniles, and adult			
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Veliger larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.				
	Riparian Vegetation Modification											
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	J <mark>uvenile</mark> s; Adults	Juveniles and adults: Although, riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors, Olympia oysters along the intertidal zone can gain benefits from extreme cold or heat that are known to cause mortality in other species.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of juvenile and adult oysters (effects may be beneficial).			
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	Juveniles and adults: Burial can smother Olympia oysters. Siltation is a known limiting factor causing injury or mortality. See turbidity effects described in Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult surviv			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Olympia oyster dependence on allochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Effects of this impact mechanism and related stressors are currently a data gap.			
	Altered habitat complexity	Reduced food web productivity, reduced feeding opportunity	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles and adults:</u> Decreased food resources, leading to adverse effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, adult spawning success, and overall population productivity.			
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round	Permanent	Continuous	Veliger larvae; Juveniles: Adults	<u>All life history stages</u> : Olympia oyster are known to prefer areas where freshwater seepage into the intertidal zone likely limits extremes in temperature.	Avoid disturbance of riparian vegetation.	Effects from this impact mechanism may also include protection from predators unable to tolerate low salinity habitats.			

			Expo	osure			_		Resulting Effects of the		
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	<b>Minimization Measures</b>	Submechanism		
	Aquatic Vegetation Modification										
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Reduced feeding opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect juvenile and adult growth fitness, and survival.		
	Altered habitat complexity	Reduced food web productivity, reduced feeding opportunity	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased habitat availability and feeding opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	May affect juvenile survival. May affect adult growth and spawning productivity.		
	Hydraulic and Geomorphic Modification										
	Altered wave energy	Change in habitat structure and	Year-round	Permanent	Continuous	Veliger larvae;	velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that	Carefully evaluate project siting and	May affect survival, growth, and		
	Altered current velocities	habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent	Juveniles; Adults		design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	fitness at all life-history stages.		
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal						
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous						
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		veliger larvae. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine movement, and direct mortality.				
			Year-round	Permanent	Continuous						
	Ecosystem Fragmentation										
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Velliger larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : The structural footprint of jetties may limit the area suitable for larval settlement, decreasing overall juvenile and adult abundance.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival, in turn affecting juvenile and adult populatio abundance.		

Sub- activity			Exp	osure	-				Resulting Effects of the
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival. May affect adult growth and spawning productivity.
Break	waters								
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary	Interannual–decadal	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Effect of piling driving sound is a data gap.	Effect of increased underwater noise level on Olympic oyster is a data gap.	Effect of increased underwater noise level on Olympic oyster is a data gap.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary	Interannual-decadal	Veliger larvae; Juveniles, Adults	All life-history stages: Effect of anthropogenic sound is a data gap.	Effect of increased ambient noise level on Olympic oyster is a data gap.	Effect of increased ambient noise level on Olympic oyster is a data gap.
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Veliger larvae Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Veliger larvae; Juveniles; Adults;	<u>All life-history stages</u> : Mortality from entrainment. Decreased growth and fitness. See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect veliger larvae productivity and fitness. See effects for related stressors under Water Quality Modification.
	Water Quality Modification					· · · · · · · · · · · · · · · · · · ·			
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating larvae and juveniles. May affect juvenile and adult productivity.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Olympia oyster dissolved oxygen effect thresholds are currently a data gap. Sensitivity to dissolved oxygen levels appears to be low, however.	Avoid sediment pulses.	May affect survival of incubating larvae, juveniles, and adults. May affect juvenile and adult survival, growth, and fitness, including adult spawning success. Actual effects are unknown, as sensitivity to this stressor and effects thresholds are currently data gaps.

Minimization Measures
ommend moving LWD
imulations on the structures to
cent beaches where they would
erwise be naturally deposited,
ere appropriate during maintenance.

y			Expo	osure	1			<b>Resulting Effects of the</b>			
ý	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism		
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Veliger larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to	May affect survival, growth, and fitness of larvae, juveniles, and adul		
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Veliger larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.			
	Aquatic Vegetation Modification										
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	J <mark>uvenile</mark> s; Adults	<u>Juveniles and adults</u> : Reduced feeding opportunities due to decreased food web productivity; decreased growth and fitness.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect juvenile and adult grown fitness, and survival.		
	Altered habitat complexity	Reduced food web productivity, reduced feeding opportunity	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles</u> : Decreased habitat availability and feeding opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction. <u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	May affect juvenile survival. May affect adult growth and spawning productivity.		

Sub- activity			Expo	osure	-	1		
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Hydraulic and Geomorphic Modification		-					
	Altered wave energy	Change in habitat structure and	Year-round	Permanent	Continuous	Veliger larvae;	All life-history stages: Wave energy, current	Care
	Altered current velocities	habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent	Juveniles; Adults	velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can	desig impa proje desig sedin
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		fundamentally alter marine littoral habitats, potentially decreasing the suitability of settling and rearing habitat for Olympia oyster. This may occur through a number of specific stressors, including food web	patte patte
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		alterations and decreased prey resources, introduced non-native species, and increased competition for suitable habitats. Alteration of circulation patterns may also affect spawn timing and the transport and settlement of	
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])		Continuous		veliger larvae. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine movement, and direct mortality.	
	Altered groundwater inputs		Year-round	Permanent	Continuous			
	Ecosystem Fragmentation	I					I	
	Alteration of predator/prey dynamics	Increased predation exposure	NA	NA	NA	NA	Alteration of predator/prey dynamics will not significantly affect Olympia oyster, which are not subject to predation by lie in wait predators. Indirect effects on species which feed on veliger larvae (e.g., through increased predation on forage fish) are possible, but these effects will be insignificant relative to natural mortality rates.	Requ footp object in an effect
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Decreased food resources, leading to adverse effects on growth and fitness.	Reco accu adjao other when

Minimization Measures	Resulting Effects of the Submechanism
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on liment supply, longshore drift terns, and wave energy and current terns.	May affect survival, growth, and fitness at all life-history stages.
quire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative jects are already prevalent.	The effects of this stressor on Olympia oyster are considered insignificant.
commend moving LWD cumulations on the structures to acent beaches where they would erwise be naturally deposited, ere appropriate during maintenance.	May affect juvenile survival, adult spawning success, and overall population productivity.

7			Exp	oosure					Resulting Effects of the			
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism			
ns a	and Bank Barbs											
	Construction and Maintenance Activities											
I	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary	Interannual-decadal	Veliger larvae; Juveniles; Adults	All life-history stages: Effect of piling driving sound is a data gap.	Effect of increased underwater noise level on Olympic oyster is a data gap.	Effect of increased underwater nois level on Olympic oyster is a data g			
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary	Interannual-decadal	Veliger larvae; Juveniles, Adults	<u>All life-history stages</u> : Effect of anthropogenic sound is a data gap.	Effect of increased ambient noise level on Olympic oyster is a data gap.	Effect of increased ambient noise on Olympic oyster is a data gap.			
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Veliger larvae Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors un Hydraulic and Geomorphic Modification.			
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Riparian and Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors un Riparian and Aquatic Vegetation Modification.			
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Veliger larvae; Juveniles; Adults;	All life-history stages: Mortality from entrainment. Decreased growth and fitness. See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect veliger larvae production and fitness. See effects for related stressors under Water Quality Modification.			
	Water Quality Modification											
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating larvae and juveniles. May affect juvenile and adult productivity.			
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Olympia oyster dissolved oxygen effect thresholds are currently a data gap. Sensitivity to dissolved oxygen levels appears to be low, however.	Avoid sediment pulses.	May affect survival of incubating larvae, juveniles, and adults. May affect juvenile and adult survival, growth, and fitness, including adu spawning success. Actual effects unknown, as sensitivity to this stre and effects thresholds are currently data gaps.			

ty			Expo	osure	1	T			Resulting Effects of the				
Ŷ	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism				
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Veliger larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to	May affect survival, growth, and fitness of larvae, juveniles, and adu				
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.					
	Riparian Vegetation Modification	Modification											
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	J <mark>uvenile</mark> s; Adults	<u>Juveniles and adults</u> : Although, riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors, Olympia oysters along the intertidal zone can gain benefits from extreme cold or heat that are known to cause mortality in other species.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of juvenile and adult oysters (effects may be beneficial).				
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	Juveniles and adults: Burial can smother Olympia oysters. Siltation is a known limiting factor causing injury or mortality. See turbidity effects described in Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult surv				
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Olympia oyster dependence on allochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Effects of this impact mechanism a related stressors are currently a dat gap.				
	Altered habitat complexity	Reduced food web productivity, reduced feeding opportunity	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles and adults:</u> Decreased food resources, leading to adverse effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, adult spawning success, and overall population productivity.				
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round	Permanent	Continuous	Veliger larvae; Juveniles: Adults	<u>All life history stages</u> : Olympia oyster are known to prefer areas where freshwater seepage into the intertidal zone likely limits extremes in temperature.	Avoid disturbance of riparian vegetation.	Effects from this impact mechanism may also include protection from predators unable to tolerate low salinity habitats.				

y			Expe	osure				<b>Resulting Effects of the</b>	
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Aquatic Vegetation Modification	-		•	•	•	÷	-	
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Reduced feeding opportunities due to decreased food web productivity; decreased growth and fitness.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	May affect juvenile and adult growth fitness, and survival.
	Altered habitat complexity	Reduced food web productivity, reduced feeding opportunity	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased habitat availability and feeding opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival. May affect adult growth and spawning productivity.
							<u>Adults</u> : Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		
	Hydraulic and Geomorphic Modification								
[	Altered wave energy	Change in habitat structure and	Year-round	Permanent	Continuous	Veliger larvae;	All life-history stages: Wave energy, current	Carefully evaluate project siting and	May affect survival, growth, and
	Altered current velocities	habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent	Juveniles; Adults	composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of settling and rearing habitat for Olympia oyster. This may occur through a number of specific stressors, including food web alterations and decreased prey resources, introduced non-native species, and increased competition for suitable habitats. Alteration of circulation patterns may also affect spawn timing and the transport and settlement of veliger larvae. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine	design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	fitness at all life-history stages.
-	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition	undwater- er exchange	Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous		movement, and direct mortality.		
	Ecosystem Fragmentation								
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Velliger larvae; Juveniles; Adults	All exposed life-history stages: The structural footprint of bank barbs and groins may limit the area suitable for larval settlement, decreasing overall juvenile and adult abundance.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival, in turn affecting juvenile and adult popular abundance.
-	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	PermVnent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival, adult spawning success, and overall population productivity.

			Exp	osure					
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
es									
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Effect of piling driving sound on northern abalone is a data gap.	Effect of pile driving sound pressure on northern abalone is a data gap. Therefore appropriate minimization measures are unclear.	Effect of pile driving sound pressu on northern abalone is a data gap.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Juveniles and adults</u> : Effect of anthropogenic sound on northern abalone is a data gap.	Effect of anthropogenic sound pressure on northern abalone is a data gap. Therefore appropriate minimization measures are unclear.	Effect of anthropogenic sound on northern abalone is a data gap.
	Construction/maintenan ce dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors un Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Eggs; Larvae; Juveniles; Adults	<u>All/life-history stages</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors un Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Decreased foraging opportunity due to short-term reduction in prey availability. Decreased growth and fitness. Mortality due to entrainment. See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile productivity a fitness. See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality or hinder feeding.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productiv of all life-history stages.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Juveniles and adults</u> : Increased stress, leading to reduced growth and fitness.	Avoid sediment pulses.	May affect survival of all life-histo stages.

# Table A-22. HPA HCP Shoreline Modification Exposure and Response Matrix for Northern Abalone.

ıb-			Ехро	osure	1	I	4		
ity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs; Larvae; Juveniles	All exposed life history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of	May affect survival and productivity of eggs, larvae, and juveniles.
	Use of ACZA- and CCA type C-treated Wood	Leaching of metals (Cu, As, Cr, Zn),	Leaching begins upon installation with highest levels occurring within 7 months of initial immersion.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Juveniles; Adults	Juveniles and Adults: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at sub-acute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	
	Riparian Vegetation Modification						·		
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	NA	NA	NA	NA	NA	NA	NA
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	<u>Juveniles and adults:</u> Burial can smother northern abalones if large pulses of landslide debris were to enter Puget Sound waters. Siltation is a known limiting factor causing injury or mortality. See turbidity effects described under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult surviva
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduced organic matter inputs.	NA	NA	NA	NA	NA	NA	NA
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover.	NA	NA	NA	NA	NA	NA	NA
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	NA	NA	NA	NA	NA	NA	NA

Ą	NA
void/minimize disturbance of parian vegetation. Maintain system- propriate riparian buffer widths to e greatest extent possible.	May affect juvenile and adult survival.
A	NA
A	NA
A	NA

HPA HCP Shoreline Modification Exposure and Response Matrix for Northern Abalone.

Sub-			Exposure						
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification	-							-
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Northern abalone dependence on allochthonous and autochthonous inputs from marine aquatic vegetation is a data gap. Northern abalone are known to use intertidal and subtidal vegetation and phytoplankton that could be a product of aquatic vegetation autochthonous input.	footprint to minimize shading of aquatic vegetation to the greatest extent practicable.	Effect from this impact mechanism is currently a data gap.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles</u> : Decreased refuge and rearing habitat availability and food resource availability, leading to increased competition and predation exposure and resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	<u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	May affect juvenile growth, fitness, and survival. May affect adult growth and spawning productivity.

Table A-22 (continued).	HPA HCP Sh

		Exp	osure	-				
Mechanism of Imp	act Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Hydraulic and Geomorphic Modification								
Altered wave energy	Change in habitat structure and	Year-round	Permanent	Continuous	Eggs;	All life-history stages: Wave energy, current	Carefully evaluate project siting and	May affect survival at all life-his
Altered current velocities	habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent	Larvae; Juveniles; Adults	velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can	design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	stages.
Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		fundamentally alter marine littoral habitats,		
Altered sediment sup	ply	Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous	0			
Altered groundwater inputs		Year-round	Permanent	Continuous				
Altered current velocities		Year-round	Permanent	Common				
Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
Altered groundwater inputs		Year-round	Permanent	Continuous				
Altered sediment sup	ply	Year-round	Permanent	Continuous				
Altered substrate composition		Year-round	Permanent	Continuous				
Ecosystem Fragmentation								
Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	All exposed life-history stages: The structural footprint of jetties may eliminate suitable habitat for larval settlement and juvenile and adult foraging. Over time, increased hard surface area associated with structures may increase the amount of surface area available for abalone foraging, but these beneficial effects may be offset by stressors related to hydraulic and geomorphic modification.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival, growth, an fitness at all life-history stages.

## Table A-22 (continued). HPA HCP Shoreline Modification Exposure and Response Matrix for Northern Abalone.

ub-			Exp	posure					
tivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	NA	NA	NA	NA	NA	NA	NA
eak	waters								
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Effect of piling driving sound on northern abalone is a data gap.	Effect of pile driving sound pressure on northern abalone is a data gap. Therefore appropriate minimization measures are unclear.	Effect of pile driving sound pressure on northern abalone is a data gap.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Juveniles and adults</u> : Effect of anthropogenic sound on northern abalone is a data gap.	Effect of anthropogenic sound pressure on northern abalone is a data gap. Therefore appropriate minimization measures are unclear.	Effect of anthropogenic sound on northern abalone is a data gap.
	Construction/maintenan ce dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Decreased foraging opportunity due to short-term reduction in prey availability. Decreased growth and fitness. Mortality due to entrainment. See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile productivity and fitness. See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality or hinder feeding.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity of all life-history stages.

		Expo	osure	Γ	4					
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism		
	Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Juveniles and adults</u> : Increased stress, leading to reduced growth and fitness.	Avoid sediment pulses.	May affect survival of all life-histor stages.		
Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs; Larvae; Juveniles; Adults	All exposed life history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates. <u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	May affect survival and productivity of eggs, larvae, juveniles, and adults		
Use of ACZA- and CCA type C-treated Wood	Leaching of metals (Cu, As, Cr, Zn),	Leaching begins upon installation with highest levels occurring within 7 months of initial immersion.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at sub-acute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.				
Aquatic Vegetation Modification	Aquatic Vegetation									
Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Northern abalone dependence on allochthonous and autochthonous inputs from marine aquatic vegetation is a data gap. Northern abalone are known to use intertidal and subtidal vegetation and phytoplankton that could be a product of aquatic vegetation autochthonous input.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	Effect from this impact mechanism currently a data gap.		
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge and rearing habitat availability and food resource availability, leading to increased competition and predation exposure and resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	<u>Operation</u> : Enforce vessel operation rules to limit submerged aquatic vegetation damage from prop wash, grounding, and anchoring, as well as reduced ambient light from fine bubble profusion.	May affect juvenile growth, fitness, and survival. May affect adult grow and spawning productivity.		

			Expo	osure	Exposure							
у	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor					
	Altered wave energy	Change in habitat structure and	Year-round	Permanent	Continuous	Eggs;	<u>All life-history stages</u> : Wave energy, current	Care				
	Altered current velocities	habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent	Larvae; Juveniles; Adults	velocity, sediment supply, substrate composition, and groundwater inputs are con ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can	desig impa proje desig sedin				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		fundamentally alter marine littoral habitats, potentially decreasing the suitability of settling and rearing habitat for northern abalone. This may occur through a number of specific stressors, including food web	patte patte				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		alterations and decreased prey resources, introduced non-native species, and increased competition for suitable habitats. Loss of marine macroalgae may increase the visibilit of the northern abalone to predators. The					
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine movement, and direct mortality.					
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous							
	Ecosystem Fragmentation											
	Alteration of predator/prey dynamics	Increased predation exposure	NA	NA	NA	NA	Alteration of predator/prey dynamics will not significantly affect northern abalone, which are not subject to predation by lie in wait predators. Indirect effects on species which feed on larvae (e.g., through increased predation on forage fish) are possible, but these effects will be insignificant relative to natural mortality rates.	Requ footp objec in are effec				
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	NA	NA	NA	NA	NA	NA				

Construction and Maintenance Activities							
Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Effect of piling driving sound on northern abalone is a data gap.	Effec on no There meas
Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Juveniles and adults: Effect of anthropogenic sound on northern abalone is a data gap.	Effec on no There meas

Minimization Measures	Resulting Effects of the Submechanism
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on liment supply, longshore drift iterns, and wave energy and current iterns.	May affect survival at all life-history stages.
quire structures with the minimal opprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative jects are already prevalent.	The effects of this stressor on northern abalone are considered insignificant.
Α	NA
fect of pile driving sound pressure northern abalone is a data gap. erefore appropriate minimization asures are unclear.	Effect of pile driving sound pressure on northern abalone is a data gap.
fect of anthropogenic sound pressure northern abalone is a data gap. erefore appropriate minimization asures are unclear.	Effect of anthropogenic sound on northern abalone is a data gap.

Sub-		Exposure							
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction/maintenan ce dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Decreased foraging opportunity due to short-term reduction in prey availability. Decreased growth and fitness. Mortality due to entrainment. See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile productivity and fitness. See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality or hinder feeding.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity of all life-history stages.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Juveniles and adults</u> : Increased stress, leading to reduced growth and fitness.	Avoid sediment pulses.	May affect survival of all life-history stages.
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Eggs; Larvae; Juveniles; Adults	<u>All exposed life history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of	May affect survival and productivity of eggs, larvae, juveniles, and adults.

#### Table A-22 (continued).

# HPA HCP Shoreline Modification Exposure and Response Matrix for Northern Abalone.

Sub-			Ехро	osure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Use of ACZA- and CCA type C-treated Wood	Leaching of metals (Cu, As, Cr, Zn),	Leaching begins upon installation with highest levels occurring within 7 months of initial immersion.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Juveniles; Adults	Juveniles and adults: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at sub-acute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	treat Rem woo with Men plac surfa Con disp
	Riparian Vegetation Modification							
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	NA	NA	NA	NA	NA	NA
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	<u>Juveniles and adults:</u> Burial can smother northern abalones if large pulses of landslide debris were to enter Puget Sound waters. Siltation is a known limiting factor causing injury or mortality. See turbidity effects described under Water Quality Modification.	Avoi ripar appro the g
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduced organic matter inputs.	NA	NA	NA	NA	NA	NA
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover.	NA	NA	NA	NA	NA	NA
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	NA	NA	NA	NA	NA	NA
	Aquatic Vegetation Modification							
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Northern abalone dependence on allochthonous and autochthonous inputs from marine aquatic vegetation is a data gap. Northern abalone are known to use intertidal and subtidal vegetation and phytoplankton that could be a product of aquatic vegetation autochthonous input.	Desi footj aqua exter <u>Cons</u> distu

Minimization Measures	Resulting Effects of the Submechanism
eated wood particulates.	
emoval: Completely remove treated bod where practicable, consistent ith WDNR Standard Practice emorandum. When piles are left in ace, cut off at least 2 ft below rface and cap with clean sediment. ontain and capture sawdust for sposal at approved facility.	

Ą	NA
woid/minimize disturbance of parian vegetation. Maintain system- propriate riparian buffer widths to e greatest extent possible.	May affect juvenile and adult survival.
Ą	NA
A	NA
Ą	NA
esign: Limit project structural otprint to minimize shading of uatic vegetation to the greatest tent practicable. <u>onstruction</u> : Avoid/minimize sturbance of aquatic vegetation	Effect from this impact mechanism is currently a data gap.

			Expo						
у	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge and rearing habitat availability and food resource availability, leading to increased competition and predation exposure and resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased feeding opportunity due to	during project construction.	May affect juvenile growth, fitness, and survival. May affect adult grow and spawning productivity.
							decreased food web productivity. Decreased growth and reproductive fitness.		
	Hydraulic and Geomorphic Modification								
	Altered wave energy	Change in habitat structure and	Year-round	Permanent	Continuous	Eggs;	All life-history stages: Wave energy, current	Carefully evaluate project siting and	May affect survival at all life-histor
	Altered current velocities	habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent	Larvae; Juveniles; Adults	composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can	design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	ct
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		fundamentally alter marine littoral habitats, potentially decreasing the suitability of settling and rearing habitat for northern abalone. This may occur through a number of specific stressors, including food web		
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	U	alterations and decreased prey resources, introduced non-native species, and increased competition for suitable habitats. Loss of marine macroalgae may increase the visibility of the northern abalone to predators. The		
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell-hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		of the northern abalone to predators. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine movement, and direct mortality.		
	Altered groundwater inputs Ecosystem		Year-round	Permanent	Continuous				
	Fragmentation								
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	All exposed life-history stages: The structural footprint of groins and bank barbs may eliminate suitable habitat for larval settlement and juvenile and adult foraging. Over time, increased hard surface area associated with structures may increase the amount of surface area available for abalone foraging, but these beneficial effects may be offset by stressors related to hydraulic and geomorphic modification.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival, growth, and fitness at all life-history stages.

## Table A-22 (continued).

# HPA HCP Shoreline Modification Exposure and Response Matrix for Northern Abalone.

# Table A-22 (continued).HPA HCP Shoreline Modification Exposure and Response Matrix for Northern Abalone.

Sub-			Exposure						
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification		NA	NA	NA	NA	NA	NA

NA Not applicable. Species is not exposed to stressors caused by this impact mechanism.



Sub-			Exp	oosure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
letties									
	Construction and Maintenance Activities								-
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	NA	Habitats used by this species are restricted to a narrow band of littorine and riparian terrestrial vegetation; therefore, it is not exposed to aquatic impacts from jetty construction.	NA	NA
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	NA		NA	NA
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	NA		NA	NA
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	NA		NA	NA
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	NA		NA	NA

		Ехро	xposure					Dogulting Effects of the
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Water Quality Modification								
	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	NA	Habitats used by this species are restricted to a narrow band littorine and riparian terrestrial vegetation and is therefore not exposed to aquatic impacts from jetties.	NA	NA
	Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	NA		NA	NA
Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	NA		NA	NA
Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	NA			

			Expo	osure	1	1		
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Riparian Vegetation Modification							
i	Altered shading, solar input and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Newcomb's littorine snail it is an intertidal mollusk species that lives under and on the stems of glasswort ( <i>Salicornia virginica</i> ), which occurs in narrow bands on the fringes	Ave mar appr the
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)		of salt marshes. Little is known of the life- history of this species, although its limited distribution and dependence on specific vegetation types increases sensitivity to specific types of riparian impacts. <i>Salicorna</i> fringe habitats are typically less influenced by	Avc mar syst wid
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous		riparian shade, but the actual shade requirements and life-history specific temperature requirements of this species are unknown. While tolerant of both salt and	Avo ripa appr the
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous		fresh water, it avoids immersion for long periods and will drown if trapped. Actual dependence on freshwater inflow is a data gap. However, salt marsh habitats in general are shaped by combined surface and ground water flows; therefore, alteration of freshwater	Enc perr habi salt <i>Sali</i>
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous		inflow may lead to reduction in suitable habitat area.	Ave vege seep
	Aquatic Vegetation Modification							
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	NA	NA	NA
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (fresh water)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous			

#### **Minimization Measures**

#### Resulting Effects of the Submechanism

void/minimize disturbance of salt arsh vegetation. Maintain system- propriate riparian buffer widths to a greatest extent possible. void/minimize disturbance of salt arsh riparian vegetation. Maintain stem-appropriate riparian buffer dths to the greatest extent possible. void/minimize disturbance of parian vegetation. Maintain system- propriate riparian buffer widths to a greatest extent possible.	Riparian vegetation modification leading to the alteration of <i>Salicorna</i> habitat in salt marsh environments where this species occurs is likely to lead to reduced survival, growth, and fitness at one or more life-history stages. Effects resulting from exposure to specific impact mechanisms are unknown, however, as sensitivity to stressor exposure and life-history requirements are a data gap.
courage project designs that limit rmanent alteration of high-quality bitat features. Avoid disturbance of t marsh vegetation, particularly the <i>licorna</i> fringe.	
void alteration of nearshore getation in and around freshwater eps.	
A	NA

b-			Exp	osure	-			
ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Hydraulic and Geomorphic Modification							
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, sediment supply, substrate composition, and groundwater inputs are core ecosystem	Car desi
	Altered current velocities	and suitability	Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent	NA	processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially	imp proj desi sedi patte
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal	NA	altering the extent and composition of <i>Salicorna</i> habitat for Newcomb's littorine snail. In particular, alteration of littoral wave energy and sediment characteristics could lead to reductions in the amount of <i>Salicorna</i> habitat, or more frequent inundation leading to	patte
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles; Adults	reduced habitat suitability. These alterations could lead to reduced survival, growth, and fitness; however, life-history specific sensitivity to these stressors is currently a data	
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time as caused by altered longshore drift patterns )	Permanent	Continuous	Juveniles; Adults	gap. As Newcomb's littorine snail is not a truly aquatic species and spends little time below the water surface, it is not affected by changes in current and circulation patterns.	
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous	Juveniles; Adults		
	Ecosystem Fragmentation	I		1			l	
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : The onshore component of the structural footprint of jetties may eliminate suitable habitat for this species, affecting survival and overall population abundance.	Req foot obje in at effe
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under <i>Riparian Vegetation Modification</i>	Year-round	Permanent	Continuous	Juveniles; Adults	The importance of LWD recruitment to Newcomb's littorine snail is currently a data gap, therefore the effects of stressor exposure are unknown. However, except for the potential effects of this impact mechanism on the quantity and quality of available <i>Salicorna</i> habitat, the effects of this stressor are likely limited.	Rec accu adja othe whe

Minimization Measures	Resulting Effects of the Submechanism
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on diment supply, longshore drift tterns, and wave energy and current tterns.	May affect survival, growth, and fitness at all life-history stages. However, actual effects are uncertain as life-history specific sensitivity to these impact mechanisms and related stressors is currently a data gap.
quire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative fects are already prevalent.	May affect survival and overall population abundance.
commend moving LWD cumulations on the structures to jacent beaches where they would herwise be naturally deposited, here appropriate during maintenance.	The effects of exposure to this stressor are unknown, but are likely to be insignificant.

)-			Exp	osure		1	_		Demilting Effects of the
r <b>ity</b> e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
eakv	waters								
	Construction and Maintenance Activities			_				_	
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	NA	Habitats used by this species are restricted to a narrow band of littorine and riparian terrestrial vegetation; therefore, it is not exposed to aquatic impacts from breakwater construction.	NA	NA
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	NA		NA	NA
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	NA		NA	NA
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	NA		NA	NA
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	NA		NA	NA
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	NA	Habitats used by this species are restricted to a narrow band littorine and riparian terrestrial vegetation and is therefore not exposed to aquatic impacts from breakwater construction.	NA	NA
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	NA		NA	NA

etivity									
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Resulting Effects of the Submechanism
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	NA		NA	NA
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	NA			
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	NA	NA	NA	NA
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (fresh water)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous				

Sub- activity			Expe	osure	<u> </u>		4			
ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>			
	Hydraulic and Geomorphic Modification									
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, sediment supply, substrate composition, and groundwater inputs are core ecosystem	Caref design impac		
	Altered current velocities	and suitability	Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent	NA	processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially	projec design sedim patter		
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal	NA	altering the extent and composition of Salicorna habitat for Newcomb's littorine snail. In particular, alteration of littoral wave energy and sediment characteristics could lead to reductions in the amount of Salicorna habitat, or more frequent inundation leading to	patter		
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles; Adults	reduced habitat suitability. These alterations could lead to reduced survival, growth, and fitness; however, life-history specific sensitivity to these stressors is currently a data			
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time as caused by altered longshore drift patterns )	Permanent	Continuous	Juveniles; Adults	gap. As Newcomb's littorine snail is not a truly aquatic species and spends little time below the water surface, it is not affected by changes in current and circulation patterns.			
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous	Juveniles; Adults				
	Ecosystem Fragmentation									
	Alteration of predator/prey dynamics	Increased predation exposure	NA	NA	NA	NA	NA	NA		
Loss of LWD recruitment Reduced availability drift. See altered all inputs and altered ha complexity stressors		Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under <i>Riparian Vegetation Modification</i>	Year-round	Permanent	Continuous	Juveniles; Adults	The importance of LWD recruitment to Newcomb's littorine snail is currently a data gap, therefore the effects of stressor exposure are unknown. However, except for the potential effects of this impact mechanism on the quantity and quality of available <i>Salicorna</i> habitat, the effects of this stressor are likely limited.	Recor accum adjace otherv where		
oins	s and Bank Barbs	;								
	Construction and Maintenance Activities									
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	NA	Habitats used by this species are restricted to a narrow band of littorine and riparian terrestrial vegetation; therefore, it is not exposed to aquatic impacts from groin and bank barb construction.	NA		
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	NA		NA		

Minimization Measures	Resulting Effects of the Submechanism
arefully evaluate project siting and esign and consider the magnitude of npact mechanisms produced by the roject. Encourage selection of project esigns that minimize effects on ediment supply, longshore drift atterns, and wave energy and current atterns.	May affect survival, growth, and fitness at all life-history stages. However, actual effects are uncertain as life-history specific sensitivity to these impact mechanisms and related stressors is currently a data gap.
IA	NA
ecommend moving LWD ccumulations on the structures to djacent beaches where they would therwise be naturally deposited, where appropriate during maintenance.	The effects of exposure to this stressor are unknown, but are likely to be insignificant.
ΙΑ	NA
IA	NA

)-			Expo	osure					Resulting Effects of the
vity De	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Construction/maintenanc e dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	NA		NA	NA
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	NA		NA	NA
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	NA		NA	NA
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	NA	Habitats used by this species are restricted to a narrow band littorine and riparian terrestrial vegetation and is therefore not exposed to aquatic impacts from groins and bank barbs.	NA	NA
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns) depending on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	NA		NA	NA
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration will occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	NA		NA	NA
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	NA			

Sub-			Expo	osure							
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor				
	Riparian Vegetation Modification										
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Newcomb's littorine snail it is an intertidal mollusk species that lives under and on the stems of glasswort ( <i>Salicornia virginica</i> ), which occurs in narrow bands on the fringes	Avoi mars appro			
	Altered shoreline stability	1 ,		Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)		of salt marshes. Little is known of the life- history of this species, although its limited distribution and dependence on specific vegetation types increases sensitivity to specific types of riparian impacts. <i>Salicorna</i> fringe habitats are typically less influenced by	Avoi mars syste widtl			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous		riparian shade, but the actual shade requirements and life-history specific temperature requirements of this species are unknown. While tolerant of both salt and	Avoi ripar appro the g			
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous		fresh water, it avoids immersion for long periods and will drown if trapped. Actual dependence on freshwater inflow is a data gap. However, salt marsh habitats in general are shaped by combined surface and ground water flows; therefore, alteration of freshwater	Enco perm habit salt 1 <i>Salic</i>			
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous		inflow may lead to reduction in suitable habitat area.	Avoi vege seeps			
	Aquatic Vegetation Modification										
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	NA	NA	NA			
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (fresh water)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous						

#### **Minimization Measures**

#### Resulting Effects of the Submechanism

void/minimize disturbance of salt arsh vegetation. Maintain system- propriate riparian buffer widths to a greatest extent possible. void/minimize disturbance of salt arsh riparian vegetation. Maintain stem-appropriate riparian buffer dths to the greatest extent possible. void/minimize disturbance of parian vegetation. Maintain system- propriate riparian buffer widths to a greatest extent possible.	Riparian vegetation modification leading to the alteration of <i>Salicorna</i> habitat in salt marsh environments where this species occurs is likely to lead to reduced survival, growth, and fitness at one or more life-history stages. Effects resulting from exposure to specific impact mechanisms are unknown, however, as sensitivity to stressor exposure and life-history requirements are a data gap.
courage project designs that limit rmanent alteration of high-quality bitat features. Avoid disturbance of t marsh vegetation, particularly the <i>licorna</i> fringe.	
void alteration of nearshore getation in and around freshwater eps.	
A	NA

Sub-			Ехр	osure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Hydraulic and Geomorphic Modification							
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, sediment supply, substrate composition, and groundwater inputs are core ecosystem	Care desi imp
	Altered current velocities	and suitability	Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent	NA	processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially	proj desi sedi
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	Juveniles; Adults	altering the extent and composition of <i>Salicorna</i> habitat for Newcomb's littorine snail. In particular, alteration of littoral wave energy and sediment characteristics could lead to reductions in the amount of <i>Salicorna</i>	patte
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time as caused by altered longshore drift patterns )	Permanent	Continuous	Juveniles; Adults	habitat, or more frequent inundation leading to reduced habitat suitability. These alterations could lead to reduced survival, growth, and fitness; however, life-history specific sensitivity to these stressors is currently a data	
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous	Juveniles; Adults	gap. As Newcomb's littorine snail is not a truly aquatic species and spends little time below the water surface, it is not affected by changes in current and circulation patterns.	
	Ecosystem Fragmentation							
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: The onshore component of the structural footprint of groins and bank barbs may eliminate suitable habitat for this species, affecting survival and overall population abundance.	Req foot obje in a effe
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under <i>Riparian Vegetation Modification</i>	Year-round	Permanent	Continuous	Juveniles; Adults	The importance of LWD recruitment to Newcomb's littorine snail is currently a data gap, therefore the effects of stressor exposure are unknown. However, except for the potential effects of this impact mechanism on the quantity and quality of available <i>Salicorna</i> habitat, the effects of this stressor are likely limited.	Reco accu adja othe whe

? Unknown. Life-history characteristics and habitat requirements of this species are poorly understood, therefore the exposed life history stages are unknown.

Minimization Measures	Resulting Effects of the Submechanism
arefully evaluate project siting and esign and consider the magnitude of npact mechanisms produced by the roject. Encourage selection of project esigns that minimize effects on ediment supply, longshore drift atterns, and wave energy and current atterns.	May affect survival, growth, and fitness at all life-history stages. However, actual effects are uncertain as life-history specific sensitivity to these impact mechanisms and related stressors is currently a data gap.
equire structures with the minimal otprint necessary to achieve project ojectives. Avoid permitting projects areas where significant cumulative fects are already prevalent.	May affect survival and overall population abundance.
ecommend moving LWD ccumulations on the structures to djacent beaches where they would therwise be naturally deposited, here appropriate during maintenance.	The effects of exposure to this stressor are unknown, but are likely to be insignificant.

Sub- ctivity			Exp	osure					Resulting Effects of the
vity /pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
oins a	and Bank Barbs*	<							
	Construction and Maintenance Activities								
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>All life-history stages</u> : The effects of pile- driving sounds and other anthropogenic sounds to Columbia River limpet and Columbia River spire snail are a data gap.	Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	The effects of pile-driving sounds ar other anthropogenic sounds to Columbia River limpet and Columbi River spire snail are a data gap.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles, Adults	All life-history stages: The effects of pile- driving sounds and other anthropogenic sounds to Columbia River limpet and Columbia River spire snail are a data gap.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	The effects of pile-driving sounds an other anthropogenic sounds to Columbia River limpet and Columbi River spire snail are a data gap.
	Channel/work area dewatering	Species removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages</u> : Mortality from dewatering.	Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	Mortality and reduced survival and productivity at affected life-history stages.
		Entrainment in pumps or impingement on pump screens	These species' potential for entrainment in pumps or impingement on pump screens is a data gap.	These species' potential for entrainment in pumps or impingement on pump screens is a data gap.	These species' potential for entrainment in pumps or impingement on pump screens is a data gap.	Juveniles; Adults	These species' potential for entrainment in pumps or impingement on pump screens is a data gap.	Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	These species' potential for entrainment in pumps or impingeme on pump screens is a data gap.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages:</u> Potential downstream sedimentation resulting in decreased downstream habitat suitability; decreased dissolved oxygen levels, reduced prey resource availability, and reduced suitable settling habitat; decreased fitness, growth, and productivity.	Limit alteration of flow conditions to minimal area.	May affect survival and productivity during all affected life-history stages
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages:</u> Decreased prey resource availability, decreased dissolved oxygen, decreased suitable settling habitat; resulting in decreased fitness, growth, and survival.	Adhere to system-specific in-water work windows.	May affect growth and productivity a all life-history stages.
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages:</u> Decreased growth and fitness due to a loss of food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable.	May affect growth and productivity a juvenile and adult life-history stages.
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
	Construction/maintenan ce dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modification

# Table A-24. HPA HCP Shoreline Modification Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

# Table A-24 (continued).HPA HCP Shoreline Modification Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-	Mechanism of Impact		Exp	osure				Resulting Effects of the	
Activity Type		Stressor	When	Duration	Frequency	Life-history Form	<b>Response to Stressor</b>	Minimization Measures	Submechanism
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : Decreased prey resource availability; decreased fitness, growth, and productivity of adults and juveniles. See responses described above under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Juveniles; Adults	<u>All life-history stages:</u> Mortality from entrainment and decreased prey availability resulting in decreased growth and fitness. See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect all life-history stages; decreased fitness, growth and survival of affected stages. See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	All life-history stages: Turbidity sufficient to cause fine sediment embededdness may lead to direct mortality and burial. Responses vary depending on stressor magnitude. Reduction in suitable settling habitat (due to substrate embededdness) and reduced dissolved oxygen could limit growth and survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May decrease survival and productivity.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>All life-history stages:</u> Requires high dissolved oxygen content. Mortality, decreased fitness, growth, and survival.	Avoid sediment pulses.	May affect productivity and survival of all life-history stages.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and productivity of all life stages.

# Table A-24 (continued).HPA HCP Shoreline Modification Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-			Ехр	osure						
Activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor			
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Juveniles; Adults	Juveniles and adults: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Pror woo accc Avo proc alter galv recy whe is ne to li cuff frag woo <u>Rem</u>		
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation with highest levels occurring within 7 months of initial immersion.	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	Juveniles and adults: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at sub-acute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	woo WD Mer plac and and appi		
	Riparian Vegetation Modification									
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	<u>All life-history stages:</u> Prefers cool water and temperature regulation form shading. Altered growth and productivity caused by temperatures outside optimal growth range and alteration of food web patterns. Wide tolerance range but prefers cooler waters. Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avo vege appi grea		
	Altered stream bank and shoreline stability	Increased suspended solids; decreased dissolved oxygen; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	<u>All life-history stages:</u> Decreased prey resource availability, decreased dissolved oxygen, decreased suitable settling habitat; resulting in decreased fitness, growth, and survival.	Avo vege appi grea		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults:</u> Reduced prey resource availability due to decreased food web productivity; decreased growth and fitness.	Avo vege appi grea		
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles and adults:</u> Decreased prey resource availability, leading to increased competition and resulting effects on growth and fitness.	Ence perri habi		
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	NA	NA	NA	NA	NA	NA		

Minimization Measures	Resulting Effects of the Submechanism
romote removal of creosote-treated ood and prevent new uses in cordance with pertinent regulations. void use of other treated wood oducts where practicable. Use ternative materials such as concrete, alvanized steel, plastic lumber, cycled plastics, and plastic coatings here practicable. Where treated wood necessary, use dense-grained material limit leaching. Use plastic or metal ffs at abrasion points to avoid agmentation and release of treated ood particulates. emoval: Completely remove treated ood where practicable, consistent with	May affect survival and productivity of juveniles and adults.
<sup>1</sup> /DNR Standard Practice lemorandum. When piles are left in ace, cut off at least 2 ft below surface ad cap with clean sediment. Contain ad capture sawdust for disposal at opproved facility.	
void/minimize disturbance of riparian egetation. Maintain system- opropriate riparian buffer widths to the reatest extent possible.	May affect survival and productivity.
void/minimize disturbance of riparian egetation. Maintain system- opropriate riparian buffer widths to the reatest extent possible.	May affect survival and productivity.
void/minimize disturbance of riparian egetation. Maintain system- opropriate riparian buffer widths to the eatest extent possible.	May affect juvenile and adult life- history stages.
ncourage project designs that limit ermanent alteration of high-quality abitat features.	May affect juvenile and adult survival and productivity.
A	NA.

#### Table A-24 (continued).HPA HCP Shoreline Modification Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub- Activity			Ex	posure	1			
Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Aquatic Vegetation Modification	·			- 			
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Juvenile and adults</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Desi offsi wasi foot
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Alteration.	aqua prac struc acco limi
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles and adults:</u> Decreased prey resource availability leading to increased competition, and resulting effects on growth and fitness.	Con distu duri: <u>Ope</u> rules vege grou
	Hydraulic and Geomorphic Modification				·			
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, reduced habitat	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All life-history stages</u> : Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Care designing
	Altered flow velocity	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		and stability, leading to decreased survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and	proje proje char subs exch
	Altered substrate composition (including placement of non- erodable substrate)		Year-round	Permanent	Continuous		changes in food web complexity. This may limit prey resource availability and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	pract
	Altered groundwater inputs		Year-round	Permanent	Continuous		<u>Adults</u> : Changes in channel morphology may lead to habitat alteration, leading to increased stress and predation rate. Changes in substrate	
	Addition of impervious surface		Year-round	Permanent	Continuous		composition and stability resulting from altered channel geometry and flow velocity.	

\* The Giant Columbia River Limpet and Great Columbia River Spire Snail are only found in flowing freshwater. As such, they will not be impacted by breakwaters and jetties, since these subactivities only occur in still-water environments.

Minimization Measures	Resulting Effects of the Submechanism
esign: Site majority of facility fshore to limit grounding and prop ash effects. Limit project structural otprint to minimize shading of	May affect juvenile and adult productivity and survival.
uatic vegetation to the greatest extent acticable. Design overwater ructures and mooring buoys in cordance with USACE guidance to nit shading and anchor scour effects.	See effects for related stressors under Water Quality Modification.
onstruction: Avoid/minimize sturbance of aquatic vegetation rring project construction.	May affect juvenile and adult survival and productivity.
peration: Enforce vessel operation les to limit submerged aquatic getation damage from prop wash, ounding, and anchoring.	
arefully evaluate project siting and esign and consider the magnitude of npact mechanisms produced by the oject. Encourage selections of oject designs that minimize effects on nannel geometry, flow velocity, bstrate composition, and groundwater techange to the greatest extent acticable.	May affect all life-history stages; decreased growth, survival, and productivity.

Sub-Activity			Exp	osure					
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
Jetties									
	Construction and Maint	enance Activities							
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : The effect of pile- driving sound pressure on California floater and western ridged mussels at any life-history stage is a data gap. Any potential impact would likely occur on the host fish species for the glochidia larvae (California floater = native minnows; western ridge = coldwater stream fish such as trout and salmon).	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	This is a data gap for these species. However, effects on host fish species for glochidia larvae will affect population productivity of this species This indirect effect applies to all stressors.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles, Adults	<u>All life-history stages</u> : The effect of pile- driving sound pressure on California floater and western ridged mussels is a data gap.	Although little is known on the effects of anthropogenic sounds on California floater and western ridged mussels, it is prudent to avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	Very little is known of the effects of pile-driving sounds on California floater and western ridged mussels at any life-history stage.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles and adults</u> : Mortality from dewatering.	River beds containing live freshwater mussels should not be disturbed. If live mussels are encountered during excavation of the bed, operations should immediately cease and should be relocated a minimum of 200 ft away from the mussels.	May affect survival at juvenile and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae	<u>Glochidia larvae</u> : Any potential impact would only occur if the glochidia fish host is entrained or impinged.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when glochidia fish host are present.	Any potential impact would only occu if the glochidia fish host is entrained o impinged.
		Localized alteration in periphyton abundance	NA	NA	NA	NA	NA	NA	NA
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
	Construction/maintenan ce dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats. Substrates containing live freshwater mussels should not be disturbed. If live mussels are encountered during excavation of the bed, operations should immediately cease and should be relocated a minimum of 200 ft away from the mussels.	See effects for related stressors under Hydraulic and Geomorphic Modification.
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.

ivity			Expe	osure	-				
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Actio
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Glochidia larvae; Juveniles; Adults;	<u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect growth and fitness. Se effects for related stressors under Water Quality Modification.
	Water Quality Modification								
-		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults:</u> Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult sur
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation. Effects to host-fish could be stressor to these mussels.	Avoid sediment pulses.	May affect survival of larvae. Ma affect juvenile survival and adult survival, productivity, and spawn success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury and leading to reduced fitness of host fish.	Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival of juveniles a adults.
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Juveniles; Adults	Juveniles and adults: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.	May affect survival of juveniles a adults.
-	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	

Sub-Activity			Exp	osure					
Гуре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Altered riparian shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Glochidia larvae; Juveniles; Adults	<u>Glochidia larvae:</u> Host-fish of the California floater and Western ridged mussel may be affected by increased temperatures, which may lead to mortality or increased thermal stress and decreased fitness of host fish.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of all life-history stages.
							<u>Juveniles and adults</u> : Mortality due to increased temperatures.		
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	<u>Juveniles and adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness for mussel host-fish.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs.	Year-round	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	<u>All life-history stages:</u> Mussel dependence on allochthonous inputs from shoreline riparian vegetation is a data gap. This could be a stressor to host fish.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult growth, fitness, and productivity.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Glochidia larvae; Juveniles; Adult	<u>All life-history stages:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival and productivity, as well as spawning success and overall population productivity.
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Mussel dependence on groundwater inflow is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown.
	Aquatic Vegetation Modification								
	Lacustrine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : Reduced prey availability due to decreased food web productivity, decreased growth and fitness of host fish. Although effects specific to altered autochthonous inputs for the California floater and Western ridged mussels are a data gap, alterations could be expected to affect prey resource availability.	Design:Limit project structural footprintto minimize shading of aquaticvegetation to the greatest extentpracticable.Construction:Avoid/minimizedisturbance of aquatic vegetation duringproject construction.Operation:Enforce vessel operationrules to limit submerged aquatic	May affect all life-history stages.
		Altered dissolved oxygen levels due to reduced photosynthesis.	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : Require high levels of dissolved oxygen. See related stressor responses under Water Quality Alteration. Effects include effects to host fish.	vegetation damage from prop wash, grounding, and anchoring.	See effects for related stressors under Water Quality Modification.

<u>n</u> : Limit project structural footprint imize shading of aquatic ation to the greatest extent cable.	May affect all life-history stages.
ruction: Avoid/minimize bance of aquatic vegetation during t construction.	
tion: Enforce vessel operation o limit submerged aquatic ation damage from prop wash, ding, and anchoring.	See effects for related stressors under Water Quality Modification.

Sub-Activity			Exp	osure				
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : Reduced prey resources due to decreased food web productivity, decreased growth and fitness of the California floater and Western ridged mussel prey and host fish. Altered autochthonous production could be expected to affect foraging success for this filter feeding species.	
	Hydraulic and Geomorphic Modification							
	Lacustrine							
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with predominant effects from fall through spring, when wind driven waves are most pronounced)	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	All life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and	Carefull design a impact r project.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral	designs t sediment and way
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		habitats, potentially decreasing the suitability of rearing habitat for juvenile and adult mussels. This may occur	
	Altered groundwater inputs		Year-round	Permanent	Continuous		through increased predation exposure, food web alterations and decreased foraging opportunity. Effects to host fish	
	Altered sediment supply		Year-round	Permanent	Continuous		affect these mussels.	
	Altered substrate composition		Year-round	Permanent	Continuous			
	Ecosystem Fragmentation							
-	Lacustrine							
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Glochiddia larvae; Juveniles; Adults	<u>Glochidia larvae</u> : Changes in habitat availability may indirectly affect survival through effects on host fish. <u>Juveniles and adults</u> : The structural footprint of jetties may permanently modify habitat suitable for juveniles and adults, affecting survival and overall population abundance.	Require footprint objective areas wh effects a
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Glochiddia larvae; Juveniles; Adults	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recomm accumul adjacent otherwis appropri
Breakwat	ters							
	Construction and Maint	enance Activities						

Minimization Measures	Resulting Effects of the Action
	May affect all life stages.
ally evaluate project siting and a and consider the magnitude of t mechanisms produced by the t. Encourage selections of project is that minimize effects on ent supply, longshore drift patterns, ave energy and current patterns.	May affect survival at all life-history stages. Decreased fitness may lead to reduced spawning productivity.
re structures with the minimal int necessary to achieve project ives. Avoid permitting projects in where significant cumulative s are already prevalent.	May affect survival at all life-history stages and affect life-history stages and productivity of host-fish.
nmend moving LWD ulations on the structures to ont beaches where they would vise be naturally deposited, where oriate during maintenance.	See effects for related stressors under altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.

Sub-Activity Type			Ехро	osure					
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : The effect of pile- driving sound pressure on California floater and western ridged mussels at any life-history stage is a data gap. Any potential impact would likely occur on the host fish species for the glochidia larvae (California floater = native minnows; western ridge = coldwater stream fish such as trout and salmon).	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	This is a data gap for these species. However, effects on host fish species for glochidia larvae will affect population productivity of this species. This indirect effect applies to all stressors.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles, Adults	All life-history stages: The effect of pile- driving sound pressure on California floater and western ridged mussels is a data gap.	Although little is known on the effects of anthropogenic sounds on California floater and western ridged mussels, it is prudent to avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	Very little is known of the effects of pile-driving sounds on California floater and western ridged mussels at any life-history stage.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from dewatering.	River beds containing live freshwater mussels should not be disturbed. If live mussels are encountered during excavation of the bed, operations should immediately cease and should be relocated a minimum of 200 ft away from the mussels.	May affect survival at juvenile and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae	<u>Glochidia larvae</u> : Any potential impact would only occur if the glochidia fish host is entrained or impinged.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when glochidia fish host are present.	Any potential impact would only occur if the glochidia fish host is entrained or impinged.
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : Potential downstream sedimentation, resulting in decreased downstream habitat suitability, decreased dissolved oxygen levels, reduced food resource availability, and reduced suitable habitat; decreased fitness, growth, and productivity.	Limit alteration of flow conditions to minimal area.	May affect survival in all life stages.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from increased sedimentation.	Adhere to system-specific in-water work windows.	May affect survival at juvenile and adult life-history stages.
		Localized alteration in periphyton abundance	NA	NA	NA	NA	NA	NA	NA
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.
	Construction/maintenan ce dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats. Substrates containing live freshwater mussels should not be disturbed. If live mussels are encountered during excavation of the bed, operations should immediately cease and should be relocated a minimum of 200 ft away from the mussels.	See effects for related stressors under Hydraulic and Geomorphic Modification.

Sub-Activity			Expo	osure					
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Glochidia larvae; Juveniles; Adults;	All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults:</u> Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival.
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Glochidia larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Effects to host-fish could be stressor to these mussels.	Avoid sediment pulses.	May affect survival of larvae. May affect juvenile survival and adult survival, productivity, and spawning success.
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury and leading to reduced fitness of host fish.	Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival of juveniles and adults
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense-grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.	May affect survival of juveniles and adults.
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.	

ivity			Exp	osure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Aquatic Vegetation Modification	-							
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Glochidia larvae; Juveniles; Adult	All life-history stages: Reduced prey availability due to decreased food web productivity, decreased growth and fitness of host fish. Although effects specific to altered autochthonous inputs for the California floater and Western ridged mussels are a data gap, alterations could be expected to affect prey resource availability.	Design:Limit project structural footprintto minimize shading of aquaticvegetation to the greatest extentpracticable.Construction:Avoid/minimizedisturbance of aquatic vegetation duringproject construction.Operation:Enforce vessel operationrules to limit submerged aquatic	May affect all life-history stages.
		Altered dissolved oxygen levels due to reduced photosynthesis.	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : Require high levels of dissolved oxygen. See related stressor responses under Water Quality Alteration. Effects include effects to shot fish.	vegetation damage from prop wash, grounding, and anchoring.	See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : Reduced prey resources due to decreased food web productivity, decreased growth and fitness of the California floater and Western ridged mussel prey and host fish. Altered autochthonous production could be expected to affect foraging success for this filter feeding species.		May affect all life stages.
	Hydraulic and Geomorphic Modification Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, reduced habitat	Year-round	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	<u>Glochidia larvae</u> : Changes in channel morphology, flow velocity, and substrate composition can affect host fish.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at all life-histor stages and affect life-history stages productivity of host-fish.
	Altered flow velocity	availability and suitability	Year-round (with stressor exposures occurring during high-flow events, fall through spring)	Permanent	Seasonal		<u>Juveniles and adults</u> : As filter feeders, constant water flow is required. Altered channel geometry, flow velocity, and substrate composition can result in	d project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	Altered substrate composition (including placement of non- erodable substrate)		Year-round	Permanent	Continuous		decrease habitat suitability and changes in food web complexity. This may limit prey resource availability and foraging opportunities and increase competition for suitable habitats, leading to decreased		
			Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		growth, fitness, and survival.		

ivity			Exp	osure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Addition of impervious surface	Alteration in the magnitude, volume, and timing of peak flows	During storm events (predominantly from fall through spring)	Permanent	Common	Glochidia larvae; Juveniles Adults	<u>All life-history stages</u> : Because the amount of impervious surface associated with marinas is a relatively inconsequential component of the overall drainage area of the larger river systems that would support this type of development, the magnitude of the hydrologic modification stressor is expected to be negligible. As such, this stressor is not expected to significantly affect the riverine environment, and there will be no response to the stressor.	Encourage facilities to employ modern low-impact development and stormwater treatment technology.	Impervious surface at anticipated scal is not likely to produce stressors of sufficient magnitude to adversely affect mussels at any life-history stag
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with predominant effects from fall through spring, when wind driven waves are most pronounced)	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	All life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project	May affect survival at all life-history stages. Decreased fitness may lead t reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral	designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		habitats, potentially decreasing the suitability of rearing habitat for juvenile and adult mussels. This may occur		
	Altered groundwater inputs		Year-round	Permanent	Continuous		through increased predation exposure, food web alterations and decreased foraging opportunity. Effects to host fish		
	Altered sediment supply		Year-round	Permanent	Continuous		affect these mussels.		
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
ľ	Riverine								
	Alteration of predator/prey dynamics	Increased availability of foraging and resting habitat	Year-round	Permanent	Continuous	Glochiddia larva;	<u>Larvae</u> : Floater mussels are not directly sensitive to changes in predator prey dynamics, however the effects of this stressor on host fish in all environment types may indirectly affect the survival and dispersal of larvae, affecting overall population abundance and distribution.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	No direct effects. Indirect effects on host fish may affect larval survival ar dispersal, potentially limiting population abundance and distributio
-	Loss of LWD recruitment	Sequestration of LWD preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Glochiddia larva; Juveniles; Adults	<u>All life-history stages:</u> Decreased habitat availability and food availability, leading to increased competition and resulting effects on growth and fitness, including health of host fish.	No specific recommendations.	May affect juvenile survival and productivity, as well as spawning success and overall population productivity.

Sub-Activity		Exposure									
pe	Mechanism of Impact	Stressor	When	Duration	Duration Frequency		Response to Stressor	Minimization Measures	Resulting Effects of the Action		
	Lacustrine										
	Alteration of predator/prey dynamics	Increased availability of foraging and resting habitat	Year-round	Permanent	Continuous	Glochiddia larva;	<u>Larvae</u> : Floater mussels are not directly sensitive to changes in predator prey dynamics, however the effects of this stressor on host fish in all environment types may indirectly affect the survival and dispersal of larvae, affecting overall population abundance and distribution.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	No direct effects. Indirect effects on host fish may affect larval survival ar dispersal, potentially limiting population abundance and distributio		
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Glochidia larvae; Juveniles; Adult	<u>All life-history stages:</u> Decreased habitat availability and food availability, leading to increased competition and resulting effects on growth and fitness, including health of host fish.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	May affect juvenile survival and productivity, as well as spawning success and overall population productivity.		
oins a	nd Bank Barbs										
	Construction and Maintenance Activities										
	Pile driving	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : The effect of pile- driving sound pressure on California floater and western ridged mussels at any life-history stage is a data gap. Any potential impact would likely occur on the host fish species for the glochidia larvae (California floater= native minnows; western ridge = coldwater stream fish such as trout and salmon).	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	This is a data gap for these species. However, effects on host fish species for glochidia larvae will affect population productivity of this specie This indirect effect applies to all stressors.		
	Construction vessel operation	Increased or altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles, Adults	<u>All life-history stages</u> : The effect of pile- driving sound pressure on California floater and western ridged mussels is a data gap.	Although little is known on the effects of anthropogenic sounds on California floater and western ridged mussels, it is prudent to avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable.	Very little is known of the effects of pile-driving sounds on California floater and western ridged mussels a any life-history stage.		
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)		Juveniles and adults: Mortality from dewatering.	River beds containing live freshwater mussels should not be disturbed. If live mussels are encountered during excavation of the bed, operations should immediately cease and should be relocated a minimum of 200 ft away from the mussels.	May affect survival at juvenile and adult life-history stages.		
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae	<u>Glochidia larvae</u> : Any potential impact would only occur if the glochidia fish host is entrained or impinged.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when glochidia fish host are present.	Any potential impact would only occur if the glochidia fish host is entrained or impinged.		

ub-Activity			Expo	osure								
уре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	<b>Resulting Effects of the Action</b>			
		Altered flow conditions (riverine)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : Potential downstream sedimentation, resulting in decreased downstream habitat suitability, decreased dissolved oxygen levels, reduced food resource availability, and reduced suitable habitat; decreased fitness, growth, and productivity.	Limit alteration of flow conditions to minimal area.	May affect survival in all life stages.			
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles and adults</u> : Mortality from increased sedimentation.	Adhere to system-specific in-water work windows.	May affect survival at juvenile and adult life-history stages.			
		Localized alteration in periphyton abundance	NA	NA	NA	NA	NA	NA	NA			
		Increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages:</u> See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modification.			
	Construction/maintenan ce dredging	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described under Hydraulic and Geomorphic Modification.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats. Substrates containing live freshwater mussels should not be disturbed. If live mussels are encountered during excavation of the bed, operations should immediately cease and should be relocated a minimum of 200 ft away from the mussels.	See effects for related stressors under Hydraulic and Geomorphic Modification.			
		Aquatic vegetation removal and delayed recovery	During project construction and maintenance activities	Intermediate-term	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Aquatic Vegetation Modification.	Limit dredging-related disturbance of submerged aquatic vegetation to the greatest extent practicable through project siting.	See effects for related stressors under Riparian and Aquatic Vegetation Modification.			
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Glochidia larvae; Juveniles; Adults;	<u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.			
	Water Quality Modification											
		Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults:</u> Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short- term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult surviva			
		Altered dissolved oxygen levels	Dependent on contributing mechanism of impact	Temporary to short- term (e.g., contaminant spill or discharge) to seasonal (e.g., reduced submerged aquatic vegetation productivity due to changes in ambient light patterns), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : Mortality in acute low dissolved oxygen events due to asphyxiation. Effects to host-fish could be stressor to these mussels.	Avoid sediment pulses.	May affect survival of larvae. May affect juvenile survival and adult survival, productivity, and spawning success.			

rity		Exposure										
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	<b>Resulting Effects of the Action</b>			
		Altered pH levels	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury and leading to reduced fitness of host fish.	Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival of juveniles and adults			
	Use of creosote-treated wood	Leaching of polycyclic aromatic hydrocarbons (PAHs)	Leaching begins upon installation, with highest levels after initial immersion, followed by peaks during periods of increased temperatures and higher flows. Leaching more pronounced when used in fresh water. Spikes in concentration occur during removal due to leaching from freshly cut surfaces and dispersal of sawdust fragments with high surface area.	Long-term (with decreasing concentration intensity over time)	Continuous with seasonal pulses (associated with high water temperature and current velocity)	Juveniles; Adults	Juveniles and adults: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Promote removal of creosote-treated wood and prevent new uses in accordance with pertinent regulations. Avoid use of other treated wood products where practicable. Use alternative materials such as concrete, galvanized steel, plastic lumber, recycled plastics, and plastic coatings where practicable. Where treated wood is necessary, use dense- grained material to limit leaching. Use plastic or metal cuffs at abrasion points to avoid fragmentation and release of treated wood particulates.	May affect survival of juveniles and adults.			
	Use of ACZA- and CCA type C-treated wood	Leaching of metals (Cu, As, Cr, Zn)	Leaching begins upon installation, with highest levels occurring within 7 months of initial immersion	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	<u>Removal</u> : Completely remove treated wood where practicable, consistent with WDNR Standard Practice Memorandum. When piles are left in place, cut off at least 2 ft below surface and cap with clean sediment. Contain and capture sawdust for disposal at approved facility.				
	Riparian Vegetation Modification											
_	Riverine					_						
	Altered shading, solar input and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Glochidia larvae; Juveniles; Adults	All life-history stages: Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns (including food web supporting host fish). <u>Adults and juveniles</u> : Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival and productivit during incubation, rearing, and spawning.			
	Altered shoreline stability	Increased suspended solids and burial of benthic organisms attached to coarse substrate	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Glochidia larvae; Juveniles; Adults	All life-history stages: Decreased food resource availability, leading to increased competition and resulting effects on growth and fitness for mussels and host fish. Decreased suitable habitat, injury, or mortality caused by excessive turbidity or resulting smothering by burial.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult fitnes and survival of mussels and host fis			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Glochidia larvae	Mussel dependence upon allochthonous input is a data gap. However, could affect host fish.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect productivity.			

Sub-Activity Type		Exposure									
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action		
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced feeding opportunity, reduction in available cover, reduction in available habitat.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Glochidia larvae; Juveniles; Adults	<u>All life-history stages:</u> Decreased habitat availability and food availability, leading to increased competition and resulting effects on growth and fitness, including health of host fish.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect survival, spawning success, and overall population productivity.		
	Altered groundwater- surface water exchange	The effect of groundwater exchange to California floater and Western ridged mussels is a data gap	Year-round	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	Mussel responses to groundwater exchange are a data gap.	Avoid disturbance of vegetation along stream.	Effect of groundwater exchange to mussel health and fitness is a data gap		
	Lacustrine										
	Altered shading, solar input and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Host-fish of the California floater and Western ridged mussel may be affected by increased temperatures, which may lead to mortality or increased thermal stress and decreased fitness of host fish. Juveniles and adults: Mortality due to increased temperatures.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of all life-history stages.		
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness for mussel host-fish.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of all life-history stages.		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs.	Year-round	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : Mussel dependence on allochthonous inputs from shoreline riparian vegetation is a data gap. This could be a stressor to host fish.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult growth fitness, and productivity.		
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Glochidia larvae; Juveniles; Adult	<u>All life-history stages:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival and productivity, as well as spawning success and overall population productivity.		
	Altered groundwater– surface water exchange	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Mussel dependence on groundwater inflow is currently a data gap.	Avoid disturbance of vegetation along shoreline	Effects of the action resulting from this impact mechanism are unknown.		

Sub-Activity			Exp	osure							
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor				
	Aquatic Vegetation Modification	-									
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced prey availability due to decreased food web productivity, decreased growth and fitness of host fish. Although effects specific to altered autochthonous inputs for the California floater and Western ridged mussels are a data gap, alterations could be expected to affect prey resource availability.	Design: to minin to the gr <u>Construe</u> disturba project c			
		Altered dissolved oxygen levels due to reduced photosynthesis.	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Glochidia larvae; Juveniles; Adult	<u>All life-history stages:</u> Require high levels of dissolved oxygen. See related stressor responses under Water Quality Alteration. Effects include effects to host fish.				
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Glochidia larvae; Juveniles; Adult	<u>All life-history stages:</u> Reduced prey resources due to decreased food web productivity, decreased growth and fitness of the California floater and Western ridged mussel prey and host fish, Altered autochthonous production could be expected to affect foraging success in this filter feeding species.	_			
	Hydraulic and Geomorphic Modification			·							
	Riverine										
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, reduced habitat	Year-round	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	<u>Glochidia larvae</u> : Changes in channel morphology, flow velocity, and substrate composition can affect host fish.	Carefull design a impact r			
	Altered flow velocity	availability and suitability	Year-round (with stressor exposures occurring during high-flow events, fall through spring)	Permanent	Seasonal		<u>Juveniles and adults</u> : As filter feeders, constant water flow is required. Altered channel geometry, flow velocity, and substrate composition can result in	project. designs geometr composi to the gr			
	Altered substrate composition (including placement of non- erodable substrate)		Year-round	Permanent	Continuous		decrease habitat suitability and changes in food web complexity. This may limit prey resource availability and foraging opportunities and increase competition for suitable habitats, leading to decreased				
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		growth, fitness, and survival.				
	Addition of impervious surface		Year-round	Permanent	Continuous						

Minimization Measures	Resulting Effects of the Action
<u>n</u> : Limit project structural footprint nimize shading of aquatic vegetation greatest extent practicable. <u>ruction</u> : Avoid/minimize bance of aquatic vegetation during et construction.	May affect all life-history stages.
	See effects for related stressors under Water Quality Modification.
	May affect all life stages.
ully evaluate project siting and a and consider the magnitude of t mechanisms produced by the tt. Encourage selection of project as that minimize effects on channel etry, flow velocity, substrate position, and groundwater exchange greatest extent practicable.	May affect survival at all life-history stages and affect life-history stages and productivity of host-fish.

b-Activity pe	Mechanism of Impact		Exp	oosure					
		Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Minimization Measures	Resulting Effects of the Action
	Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability, reduced food web complexity, habitat availability and suitability	Year-round (with predominant effects from fall through spring, when wind driven waves are most pronounced)	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project	May affect survival at all life-history stages. Decreased fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral	designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous		habitats, potentially decreasing the suitability of rearing habitat for juvenile and adult mussels. This may occur through increased predation exposure, food web alterations and decreased foraging opportunity. Effects to host fish affect these mussels.		
	Altered sediment supply		Year-round	Permanent	Continuous	_			
	Altered substrate composition		Year-round	Permanent	Continuous	-			
	Ecosystem Fragmentation			-					
	Riverine								
	Habitat loss and fragmentation	Fragmentation of side channel and floodplain habitat, change in habitat structure, availability, and suitability, reduced food web complexity	Year-round	Permanent	Continuous	Glochiddia larvae; Juveniles; Adults	<u>Glochidia larvae</u> : Changes in habitat availability may indirectly affect survival through effects on host fish. <u>Juveniles and adults</u> : The structural footprint of groins and bank barbs may permanently modify habitat suitable for juveniles and adults, affecting survival and overall population abundance.	Require assessment of the hydraulic effects of the project before permitting and avoid permitting designs that lead to disconnection of floodplain habitat.	
	Loss of LWD recruitment	Sequestration of LWD preventing downstream recruitment. See altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Glochiddia larvae; Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	No specific recommendations.	May affect growth and survival, as well as spawning success and overal population productivity.
	Lacustrine								
	Habitat loss and fragmentation	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Glochiddia larvae; Juveniles; Adults	Glochidia larvae: Changes in habitat availability may indirectly affect survival through effects on host fish. <u>Juveniles and adults</u> : The structural footprint of groins and bank barbs may permanently modify habitat suitable for juveniles and adults, affecting survival and overall population abundance.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at all life-history stages and affect life-history stages a productivity of host-fish.
	Loss of LWD recruitment	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Glochiddia larvae; Juveniles; Adults	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Recommend moving LWD accumulations on the structures to adjacent beaches where they would otherwise be naturally deposited, where appropriate during maintenance.	See effects for related stressors under altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.