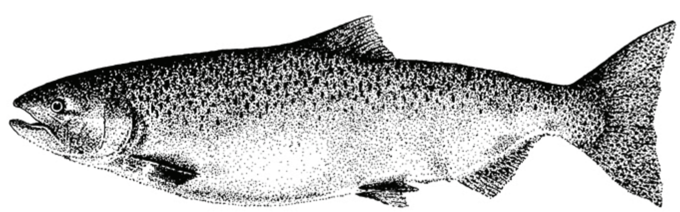
STATE OF WASHINGTON June 2010

# Cowlitz River Evaluation Program Annual Report for 2009



by Julie A. Henning

Washington Department of FISH AND WILDLIFE
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# Cowlitz River Evaluation Program Annual Report for 2009

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Washington Department of Fish and Wildlife

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# Acknowledgements

Mike Blankenship, Chris Gleizes, and Teresa Fryer assisted in the data collection for 2009. Gary Gilhuly, Scott Gibson, and Jamie Murphy supervised the collection of adults and data entry at the Cowlitz Salmon Hatchery separator. Mark LaRiviere and Wolf Dammers provided comments on earlier drafts of this report. Activities were funded by Tacoma Power.

# Introduction

This report documents the 2009 Cowlitz River Evaluation activities completed by Washington Department of Fish and Wildlife and funded by Tacoma Power. The report documents the activities in the Tilton Basin as well as the activities in the lower Cowlitz River (below the Barrier Dam). Most of the activities are associated with Tacoma Power's Federal Energy Regulatory Commission (FERC) license in accordance with the Fisheries and Hatcheries Management Plan (FHMP).

This report covers the following programs associated with fisheries monitoring in the Cowlitz Basin:

1) Upstream Anadromous Fish Program (Tilton only)
2) Lower Cowlitz River Evaluation
3) Resident Fish Program
4) Coho Sport Harvest in the Upper Cowlitz Basin

An additional report is presented in Appendix 2 that uses a genetic analysis to differentiate juvenile Chinook stocks collected at Mayfield Dam. The report is a summary of 4 years of data.

# Upstream Anadromous Fish Program

The Cowlitz River Basin reintroduction strategy for salmonids into the Tilton and upper Cowlitz River basins included the transportation and release of adult salmonids from the lower river around the dams to various upper basin locations. Juvenile salmonids produced in the Tilton River Basin migrate downstream through Mayfield Reservoir and enter the Mayfield Dam Collection Facility where they are identified to species, enumerated, and wire tagged. As those adult fish return to the Cowlitz Salmon Hatchery separator, they are handled and transported by truck upstream and released near spawning habitat (Figure 1).

In 2009, fish management goals for fall Chinook in the Tilton Basin included transportation of all unmarked, unmarked wired tagged and ad-clipped fish above hatchery broodstock needs. For coho management in the Tilton River, the goal was to transport all unmarked wire tagged fish for stock recovery, and transport 3,000 ad-clipped adults for harvest opportunities.

A total of 10,291 adult fall Chinook arrived at the separator and 7,491 were transported and released in the Tilton Basin (Table 1). In 2009/2010, approximately 85,000 adult coho salmon arrived at the separator. A total of 7,491 coho salmon were transported and released into the Tilton Basin (Table 2). The remainder of the coho that arrived at the separator were transported to the Upper Cowlitz Basin, sent to the food bank/buyer, used for hatchery broodstock, and nutrient enhancement. Other species transported and released into the Tilton Basin include: 170 winter steelhead, and 130 cutthroat trout (Tables 3 and 4). Numbers of fish transported to the Upper Cowlitz and Cispus Rivers will not be included in this report but can be found in the Cowlitz Falls Anadromous Fish Reintroduction Project Report by J. Serl.

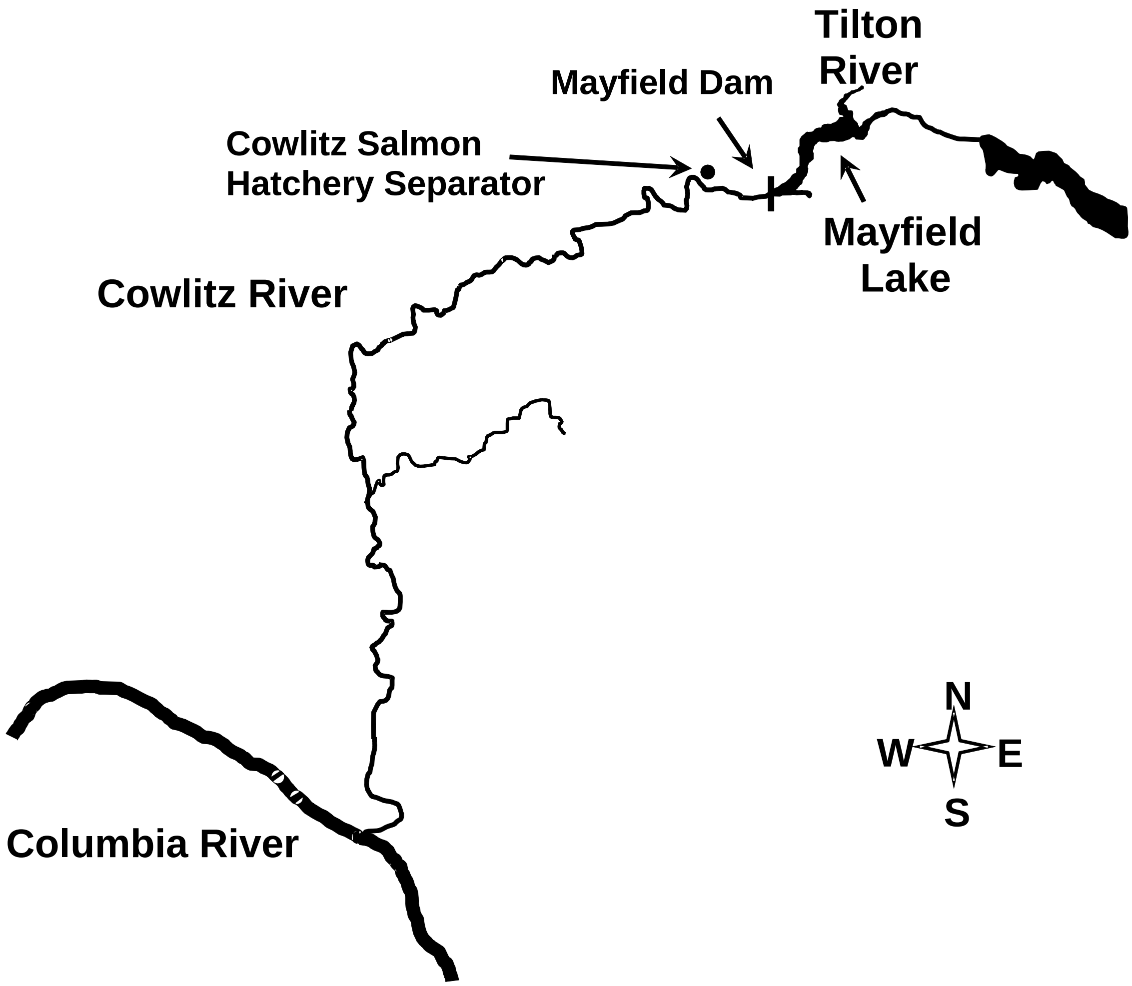


Figure 1. **A map of the Cowlitz River and other locations where fish are handled and transported.**

Tables 1 – 4 lists the numbers of adults and jacks transported to the Tilton Basin from the Salmon Hatchery separator. Each table lists the number of fish with each tag type.

**Table 1. Fall Chinook transported and released in the Tilton basin in 2009.**

**Mayfield Lake Park and Ike Kinswa State Park --: August 2009 – January 2010.**

| | **Female** | **Male** | **Jack** | **Total** |
|---|---|---|---|---|
| Unmarked | 1,619 | 1,546 | 246 | 3,411 |
| Unmarked + blank wire tagged | 208 | 254 | 39 | 501 |
| AD-clipped only | 805 | 1,843 | 1,473 | 4,121 |
| Ad-clipped CWT | 0 | 0 | 0 | 0 |
| **Total** | **2,632** | **3,643** | **1,758** | **8,033** |

**Gust Backstrom Park (Tilton River) --: August 2009 – January 2010.**

| | **Female** | **Male** | **Jack** | **Total** |
|---|---|---|---|---|
| Unmarked | 447 | 281 | 35 | 763 |
| Unmarked + blank wire tagged | 16 | 16 | 3 | 35 |
| Ad-clipped only | 199 | 257 | 194 | 650 |
| Ad-clipped CWT | 0 | 0 | 0 | 0 |
| **Total** | **662** | **554** | **232** | **1,448** |

Note: A total of 7,491 adults (3,294 females) and 1,990 jacks were planted in Tilton Basin in 2008.

**Table 2. Coho salmon transported and released in the Tilton Basin in 2009.**

**Mayfield Lake Park and Ike Kinswa State Park -- Coho: August 2009 – March 2010.**

| | **Female** | **Male** | **Jack** | **Total** |
|---|---|---|---|---|
| Unmarked | 3 | 2 | 0 | 5 |
| Unmarked + blank wire tagged | 140 | 253 | 10 | 403 |
| AD-clipped only | 3 | 8 | 1 | 12 |
| Total | 146 | 263 | 11 | **420** |

**Gust Backstrom Park -- Coho: August 2009 – March 2010.**

| | **Female** | **Male** | **Jack** | **Total** |
|---|---|---|---|---|
| Unmarked | 0 | 0 | 0 | 0 |
| Unmarked + blank wire tagged | 423 | 484 | 32 | 939 |
| AD-clipped only | 1,602 | 1,464 | 220 | 3,286 |
| Total | 2,025 | 1,948 | 252 | **4,225** |

Note: A total of 4,383 adult coho salmon were transported to the Tilton Basin in 2009/2010.

**Table 3. Winter steelhead trout transported to the Tilton Basin in 2009/2010 (November 1, 2009 – June 1, 2010).**

| | Unmarked+BWT | | | Unmarked | | |
|---|---|---|---|---|---|---|
| | Male | Female | Jack | Male | Female | Jack |
| November | 1 | 2 | 0 | 0 | 0 | 0 |
| December | 1 | 7 | 0 | 0 | 0 | 0 |
| January | 9 | 8 | 0 | 0 | 1 | 0 |
| February | 14 | 18 | 0 | 2 | 0 | 0 |
| March | 41 | 31 | 0 | 0 | 0 | 0 |
| April | 11 | 20 | 1 | 0 | 0 | 0 |
| May | 3 | 0 | 0 | 0 | 0 | 0 |
| **TOTAL** | **80** | **86** | **1** | **2** | **1** | **0** |

**Table 4. Cutthroat trout transported and released in the Tilton Basin in 2009.**

**Mayfield Lake Park and Ike Kinswa State Park --Cutthroat trout: June – December 2009**

| | unknown sex |
|---|---|
| Unmarked | 0 |
| Unmarked + blank wire tagged | 0 |
| Total | **0** |

**Tilton River -- Cutthroat trout: June – December 2009**

| | unknown sex |
|---|---|
| Unmarked | 81 |
| Unmarked + blank wire tagged | 49 |
| Total | **130** |

# Migrant Trap Operation and Fish Tagging

The downstream migrant trap at Mayfield Dam collects downstream migrants originating from the Tilton River, Mayfield reservoir, other Mayfield reservoir drainages, and some migrants from the Upper Cowlitz River Basin. Fish enter the louver bays of the dam, swim through the outfall and into a pipe that runs through Mayfield Dam to the counting house facility (migrant trap). Fish are sorted through a series of bar racks and into raceways. They are held in the raceways until they are examined by biologists.

In 2009, the migrant trap operated April 1- December 31. The louver pumps were shut off from January through the end of March, which affected the attraction flow to the trap and bypass flume. While the pumps were off, the trap was run occasionally to test whether fish were migrating into the facility without pumps on. During these occasional tests, few salmonids were captured.

While pumps were on, the trap was run continuously and checked approximately 3 times per week. Fish in the trap were examined by lowering the water in the migrant trap raceways, which facilitates fish exiting from the raceways and into a cofferdam. Once the fish were in the cofferdam, they were hand netted into a sluice box and flumed into the counting house holding troughs. Fish were netted from a trough into tubs containing tricaine methanesulfonate (MS-222). After being anesthetized, fish were identified and enumerated. Wild (no adipose clip) coho parr and smolts were tagged with a unique coded wire tag in the snout using a Northwest Marine Technology Inc. Mark IV (Shaw Island, WA) tagging machine. Juvenile Chinook, steelhead and cutthroat were tagged with a blank wire tag using the Mark IV tagging machine. All smolts in distress or poor health were not tagged and released downstream. Juvenile salmonids were wire-tagged so that survival and fishery contributions can be determined (in non-selective fisheries), and adults returning to Cowlitz Salmon separator could be identified as Tilton River origin fish and transported accordingly.

This year the Mayfield facility was rebuilt as part of the requirements of Tacoma Power relicensing agreements. Construction began in April and continued through the end of the year. A new counting house facility was built with the intent to decrease fish handling stress. The trap ran during the construction with some difficulties. This year staff hauled most of the fish in 5- gallon buckets to the fish flume for transport downstream. This was because the hoist was not functional most of the season.

A total of 85,795 live fish were counted at the trap and coho salmon were the dominant species captured. Juvenile Chinook numbers were extremely low compared to the last few years. For example, this year 30,360 less fish were handled than in 2008. This year Tacoma Power did not spill water at Mayfield or Mossyrock Dams while the counting house facility was in operation. While spilling of water at the Dams can affect fish numbers at Mayfield, winter flows were high and likely contributed to redd scour and overall juvenile survival in the Tilton Basin.

**Table 5. Monthly totals of fry, parr, and smolts coded wire tagged and untagged at the Mayfield Migrant Trap in 2009.**

| | Chinook '0' | | Chinook '1' | | Coho | | Cutthroat | | Steelhead | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Tag '0' | Untag '0' | Tag '1' | Untag '1' | Tag | Untag | Tag | Untag | Tag | Untag |
| January | | | | | | | | | | |
| February | | | | | | | | | | |
| March | | | | | | | | | | |
| April | 110 | 14 | 3 | 0 | 862 | 6 | 107 | 12 | 251 | 81 |
| May | 65 | 29 | 19 | 0 | 2456 | 225 | 654 | 10 | 3190 | 326 |
| June | 154 | 41 | 400 | 0 | 18528 | 357 | 264 | 3 | 868 | 68 |
| July | 684 | 0 | 213 | 0 | 5751 | 15 | 8 | 0 | 3 | 1 |
| August | 389 | 0 | 137 | 0 | 263 | 1 | 2 | 0 | 1 | 0 |
| September | 44 | 1 | 129 | 0 | 74 | 1 | 2 | 0 | 0 | 0 |
| October | 71 | 0 | 1121 | 2 | 59 | 0 | 5 | 0 | 5 | 1 |
| November | 110 | 0 | 298 | 0 | 999 | 1 | 36 | 0 | 27 | 0 |
| December | 41 | 0 | 20 | 0 | 120 | 0 | 8 | 0 | 13 | 1 |
| Total | 1668 | 85 | 2340 | 2 | 29112 | 606 | 1086 | 25 | 4358 | 478 |

Tag ‘0’ = tagged 0-age or <1 years old, differentiated by <160mm
Tag ‘1’ = tagged greater to or equal to a 1 year old, >160mm
Tag = tagged fish
Untag = Untagged fish

In 2009, the juvenile Chinook genetics study continued for the 4th consecutive year. Fin tissue was collected from Chinook to differentiate spring and fall Chinook stocks (Henning and Blankenship 2009). Samples were collected randomly from juvenile Chinook captured at the trap. Both the Mixed Stock Analysis and individual assignment genetics methods estimated similar stock proportions for the juvenile samples. Approximately 95% of the samples were fall Chinook and 5% of the samples were spring Chinook. These results were consistent with what was found in 2007 and 2008 (Blankenship and Henning 2010; Appendix 2).

The overall fish mortality rate at the Mayfield counting house in 2009 was 2.2% (not including hatchery rainbow trout) (Table 6). This compares to 2.1% in 2006, 1.1 % in 2007 and 1.7% in 2008. Of the total catch for the downstream juvenile migrants, the mortality rate was about 1.8% (a total of 728) in 2009. This is the same percentage as in 2008.

**Table 6. Total fish mortality at Mayfield in 2009.**

| Species | Total |
|---|---|
| Chinook wild juvenile fry | 9 |
| Chinook wild juvenile 0+ | 14 |
| Chinook wild juvenile 1+ | 182 |
| Chinook hatchery jacks | 30 |
| Chinook adults | 125 |
| Coho wild juvenile fry | 1 |
| Coho wild juvenile parr | 10 |
| Coho wild juvenile smolt | 501 |
| Coho wild adults | 8 |
| Coho hatchery adults | 5 |
| Cutthroat (wild) | 1 |
| Rainbow trout | 46 |
| Steelhead wild juvenile | 1 |
| Steelhead wild adult | 9 |
| Steelhead hatchery adult | 37 |
| Bluegill | 1 |
| Shiner | 2 |
| Sucker | 12 |
| Yellow perch | 2 |
| Tiger Musky | 1 |
| Sculpin | 4 |
| **Total Fish mortality** | **1,001** |

Note: Fish with zero mortality are not listed.

Chinook descaling information was obtained when fish were processed at the counting house. Fish were randomly selected each month to evaluate the percent descaled (Table 7).

**Table 7. Juvenile Chinook descaling information from Mayfield counting house in 2009.**

| Month | Total tagged | # sampled | <5% | 5-20% | 21-40% | >40% |
|---|---|---|---|---|---|---|
| September | 174 | 37 | 24 | 12 | 1 | 0 |
| October | 1192 | 107 | 55 | 39 | 5 | 8 |
| November | 408 | 79 | 43 | 28 | 3 | 5 |
| December | 61 | 16 | 8 | 7 | 1 | 0 |

## Adult Salmonids at Mayfield

Adult salmon arrive at the Cowlitz Salmon Hatchery separator throughout the year and the appropriate fish are transported to the Tilton Basin. A portion of those fish are captured at the Mayfield facility and identified as fall-backs (Table 9). This year we handled high numbers of adults at the Mayfield facility (1,233 fish) however, fallback rates were similar to previous years. The highest fallback rate was on fall Chinook. This was because high numbers of fall Chinook were released into the Mayfield reservoir. Steelhead had the highest fallback rate of all the species, but many of these fish were kelts.

**Table 8. Adult salmonids captured at Mayfield in 2009.**

| Species | Origin | Total live adults at Mayfield | Mortality | Percent fall-back (or kelt) | Total adults transported to Tilton Basin* |
|---|---|---|---|---|---|
| coho | hatchery | 97 | 5 | 3.31% | 3,078 |
| coho | unmarked (UM) | 10 | 8 | 1.46% | 1,233 |
| fall Chinook** | hatchery/UM | 774 | 125 | 12.0% | 7,491 |
| steelhead | Unmarked | 32 | 9 | 30.8% | 133 |
| steelhead | hatchery | 436 | 37 | 38.7% | 1,221 |

*Total adults transported to the Tilton Basin were from August 1, 2009 – December 31, 2009 for coho and Chinook and November 1, 2008 – April 30, 2009 for steelhead.

**Fall Chinook hatchery and unmarked were combined because they cannot be differentiated at the trap.

## Injuries of Adult Fish Collected at Mayfield

Adult fish caught in the trap were inspected for injuries. Once an injury was discovered, that injury was described. Fish species inspected for injuries were fall Chinook, coho, winter-run steelhead, and tiger musky. Fresh abrasions on fish were likely trap related. This year external injuries were observed on tiger musky. All tiger muskies showed some type of injury such as scrapes, bruises, descaling, and torn or missing fins. There was one tiger musky mortality that occurred between the louvers and the trap entrance. No fresh injuries/abrasions were observed on adult steelhead or salmon.

## Adult Recoveries at the Salmon Separator

Tagged adult fish were recovered at the Cowlitz Salmon Hatchery separator by examining each fish for an adipose fin and a wire tag. If the adult fish had an adipose fin and a wire tag it was presumed that the fish was from the Tilton basin. Recoveries of tagged adult fish that originated in the Tilton Basin (tagged at Mayfield Dam) are reported in Table 9. The smolt to adult return rates for fall and spring Chinook are undetermined because of the difficulty in deciphering between juvenile spring and fall Chinook that arrive at the Mayfield counting house.

**Table 9. Number of smolts tagged at Mayfield trap and adults recovered at Cowlitz Salmon Hatchery separator.**

| Tag | Species | Tag location | Calendar year tagged | Number tagged | Return Jacks | Return Adults | % Return |
|---|---|---|---|---|---|---|---|
| BWT | Coho | snout | 2001 | 78,158 | 37 | 480 | 0.66 |
| BWT | Coho | snout | 2002 | 11,376 | 80 | 704 | 6.89 |
| BWT | Coho | snout | 2003 | 38,127 | 63 | 1078 | 2.99 |
| BWT | Coho | snout | 2004 | 36,299 | 79 | 725 | 2.21 |
| BWT | Coho | snout | 2005 | 40,174 | 70 | 822 | 2.22 |
| CWT | Coho | snout | 2006 | 24,153 | 36 | 919 | 3.95 |
| CWT | Coho | snout | 2007 | 25,578 | 119 | 1,301 | 5.50 |
| CWT | Coho | snout | 2008 | 27,132 | 42 | | |
| CWT | Coho | snout | 2009 | 42,722 | | | |
| | | | | | | | |
| BWT | Cutthroat | snout | 2001 | 462 | | 9 | 1.95 |
| BWT | Cutthroat | snout | 2002 | 181 | | 9 | 4.97 |
| BWT | Cutthroat | snout | 2003 | 414 | | 10 | 2.42 |
| BWT | Cutthroat | snout | 2004 | 677 | | 36 | 5.32 |
| BWT | Cutthroat | snout | 2005 | 526 | | 20 | 3.80 |
| BWT | Cutthroat | snout | 2006 | 225 | | 10 | 2.25 |
| BWT | Cutthroat | snout | 2007 | 647 | | 22 | 3.4 |
| BWT | Cutthroat | snout | 2008 | 560 | | 72 | 12.85 |
| BWT | Cutthroat | snout | 2009 | 1,086 | | 53 | 4.88 |
| | | | | | | | |
| BWT | Steelhead | snout | 1999 | 2,834 | | 55 | 1.94 |
| BWT | Steelhead | snout | 2000 | 2,761 | | 125 | 4.53 |
| BWT | Steelhead | snout | 2001 | 7,134 | | 99 | 1.39 |
| BWT | Steelhead | snout | 2002 | 2,046 | 1 | 22 | 1.12 |
| BWT | Steelhead | snout | 2003 | 4,779 | 0 | 51 | 1.07 |
| BWT | Steelhead | snout | 2004 | 6,210 | 0 | 79 | 1.27 |
| BWT | Steelhead | snout | 2005 | 8,134 | 0 | 40 | 0.49 |
| BWT | Steelhead | snout | 2006 | 4,825 | 0 | 52 | 1.08 |
| BWT | Steelhead | snout | 2007 | 5,992 | 0 | 166 | 2.78 |
| BWT | Steelhead | snout | 2008 | 3,879 | 1 | | |
| BWT | Steelhead | snout | 2009 | 4,358 | | | |

The number of adult coho females that were released in the Tilton River basin was compared to the number of smolts collected at the Mayfield migrant trap two years later. This data was used to determine the number of juveniles produced per adult female. Results indicate that on average about 13 smolts could be expected per adult female coho released in the Tilton River (Table 10).

**Table 10. Adult female coho released in the Tilton River and number of smolts trapped at Mayfield Dam two years later.**

| Year | Adult females Released[1] | Smolts trapped 2 yrs later | Smolts per female released |
|---|---|---|---|
| 1996 | 663 | 16,805 | 25.3 |
| 1997 | 867 | 9,951 | 11.5 |
| 1998 | 1,438 | 23,526 | 16.4 |
| 1999 | 3,059 | 82,156 | 26.9 |
| 2000 | 5,092 | 11,869 | 2.3 |
| 2001 | 12,477 | 32,811 | 2.6 |
| 2002 | 8,273 | 34,458 | 4.7 |
| 2003 | 3,718 | 38,379 | 7.8 |
| 2004 | 6,053 | 24,153[2] | 4.0 |
| 2005 | 3,807 | 25,578[2] | 6.7 |
| 2006 | 1,905[3] | 27,132[2] | 14.2 |
| 2007 | 1,250 | 42,722[2] | 34.2 |
| 2008 | 1,393 | | |
| 2009 | 2,171 | | |

[1] Does not take into account fall-backs captured at Mayfield.
[2] Changed the smolt numbers to reflect juveniles from the same brood year (smolts two years later and parr one year later) from adult females released.
[3] In 2006, some adult coho were released into Riffe Reservoir.

# Natural Origin Fish in Hatchery Broodstock and Surplus

The Cowlitz Evaluation staff wanded all fall Chinook broodstock and natural origin coho broodstock for coded wire tags. Unlike last year, surplused fish were not wanded for coded wire tags. The adult handling protocol states that no coded wire tagged adipose intact fish should go into broodstock, but rather be transported and released into the Tilton River Basin. The coded wire tagged adipose intact fish are ESA listed and are from the Tilton River. There were UM+CWT fall Chinook and coho found in the hatchery broodstock in 2009 (Table 11). For the Fall Chinook, there were 2,481 fall Chinook wanded and of those, 11 had a wire tag. Of the total Tilton River wire tagged (UM+CWT) population that returned to the separator, 2.05% were put into the broodstock. This was less than 2007 and 2008 when 5.3% and 5.2% of the population were sorted into the hatchery broodstock.

For the NOR coho broodstock, 785 fish were wanded and of those, 17 fish had a coded wire tag. A total of 1.3% of the adult coho (UM+CWT) that returned for the year were put into the hatchery broodstock. Releasing wire tagged fish with an adipose fin into the broodstock or surplusing these fish is against the current management protocols. Further measures need to be taken at the separator so natural origin fish can be returned to their stream origin.

**Table 11. A summary of UM+CWT (Tilton origin) fish than were handled at the separator and released into hatchery broodstock in 2009.**

| Species | Origin | Number | Release location |
|---|---|---|---|
| fall Chinook | UM-CWT | 11 | broodstock |
| spring Chinook | UM | 1 | broodstock |
| coho | UM-CWT | 17 | broodstock |

## Spring and Fall Chinook Salmon Escapement

### Chinook Spawning Surveys

Aerial surveys by helicopter are conducted on the Cowlitz River to monitor natural spawning populations and specifically to estimate spring and fall Chinook salmon spawning abundance, distribution, and run timing. Beginning September 15, aerial spawning surveys were conducted about every two weeks (Table 12). Number of redds observed was noted for each of the ten river sections. This year the Kelso to Castle Rock section was never completed because of low water visibility. A total of 2,757 Chinook redds were counted this season. The peak count occurred on October 27th and 988 redds were observed. The Chinook spawner abundance was stronger than last year estimating over 40% more redds.

**Table 12. 2009 Aerial spawning surveys for Chinook salmon.**

| Section: | 15-Sep | 02-Oct | 13-Oct | 27-Oct | 11-Nov | Total |
|---|---|---|---|---|---|---|
| River Flow (cfs) | 4,680 | 4,430 | 4,420 | 4,870 | 6,710 | |
| Kelso to Castle Rock Bridge | | | | | | 0 |
| Castle Rock Bridge to Toutle River Bridge | | 16 | 15 | 0 | 2 | 33 |
| Toutle River Bridge to I-5 Bridge | 3 | 37 | 50 | 70 | 56 | 216 |
| I-5 Bridge to Toledo Bridge | 1 | 27 | 36 | 36 | 36 | 136 |
| Toledo Bridge to Skook Creek | 1 | 28 | 65 | 121 | 78 | 293 |
| Skook Creek to Blue Creek Boat Ramp | 1 | 36 | 109 | 137 | 128 | 411 |
| Blue Creek Boat Ramp to Baker rock | 5 | 72 | 213 | 349 | 231 | 870 |
| SideChannel | 2 | 30 | 65 | 83 | 90 | 270 |
| Baker Rock to Mill Creek | 7 | 46 | 98 | 163 | 106 | 420 |
| Mill Creek to Barrier Dam | 13 | 14 | 21 | 22 | 11 | 81 |
| Barrier Dam to Mayfield powerhouse | | | 8 | 7 | 12 | 27 |
| Total | 33 | 306 | 680 | 988 | 750 | 2757 |

In 2008 and 2009, a digital audio recorder and a global positioning system (GPS) track log were used to map the locations of each redd or cluster of redds during aerial spawning surveys (Figure 2). This information was then transferred into a geographic information system (GIS) database (ArcMap 9.3, Environmental Systems Research Institute, Inc. [ESRI], Redlands, California). Collecting GPS locations for redds during aerial surveys is cost-effective and allows for much greater flexibility for analysis of redd distributions across scales. Total counts within large sections of the river provide limited information about gaps and clusters of redds. By collecting spatial data on redds each year we can have a better understanding about spawning trends on a spatial and temporal scale. We did observe a longitudinal trend with more redds closer to the dam (Murray 2010). This would be expected because of the location of the hatchery and the imprinting that occurs there.

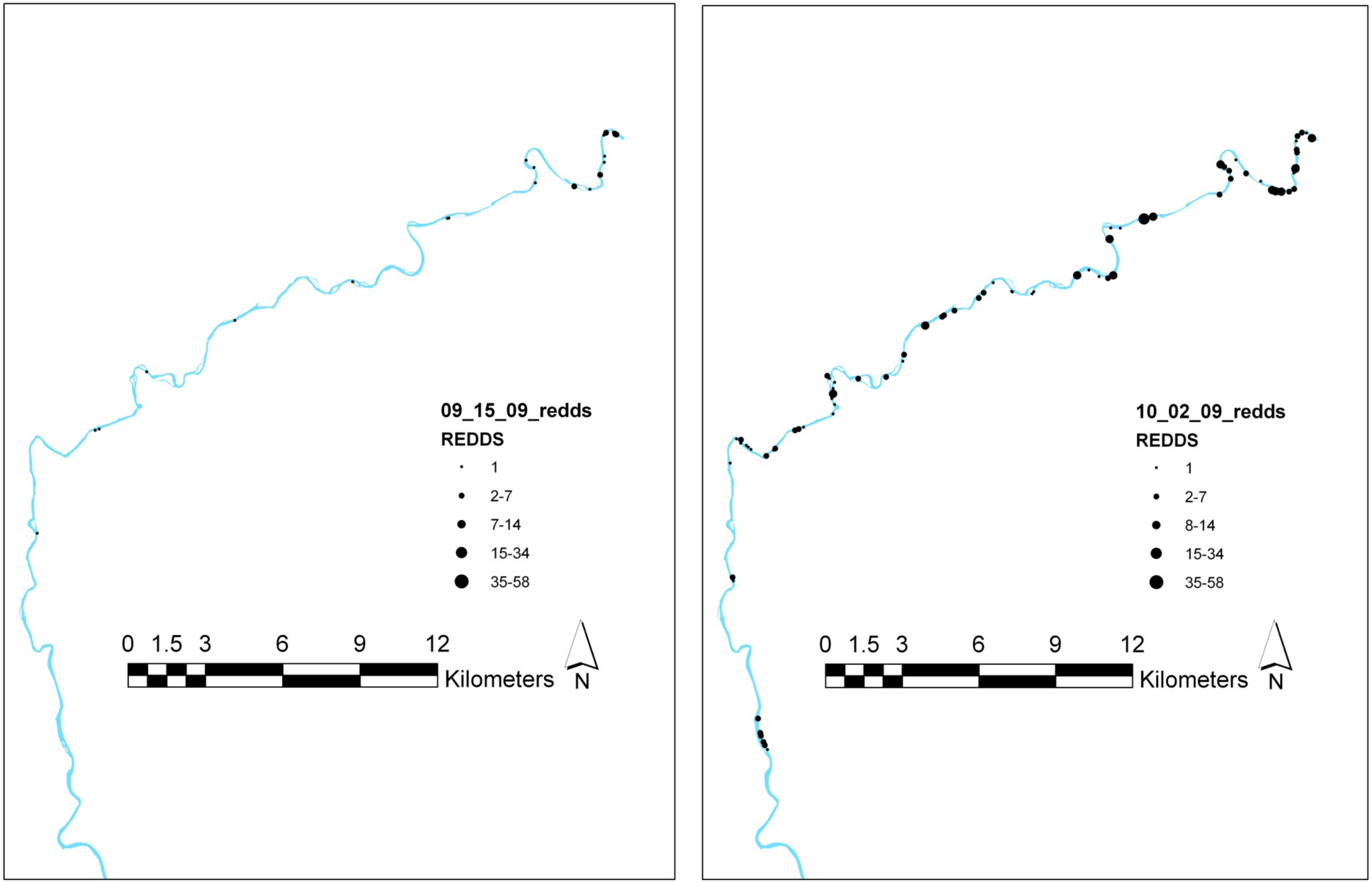


**Figure 2. The spatial distribution of Chinook redds in the lower 83 km of the Cowlitz River (from the Barrier Dam to Kelso). Each map represents an aerial spawning survey and the black dots represent a redd or cluster of redds. (Courtesy of Katherine Murray)**

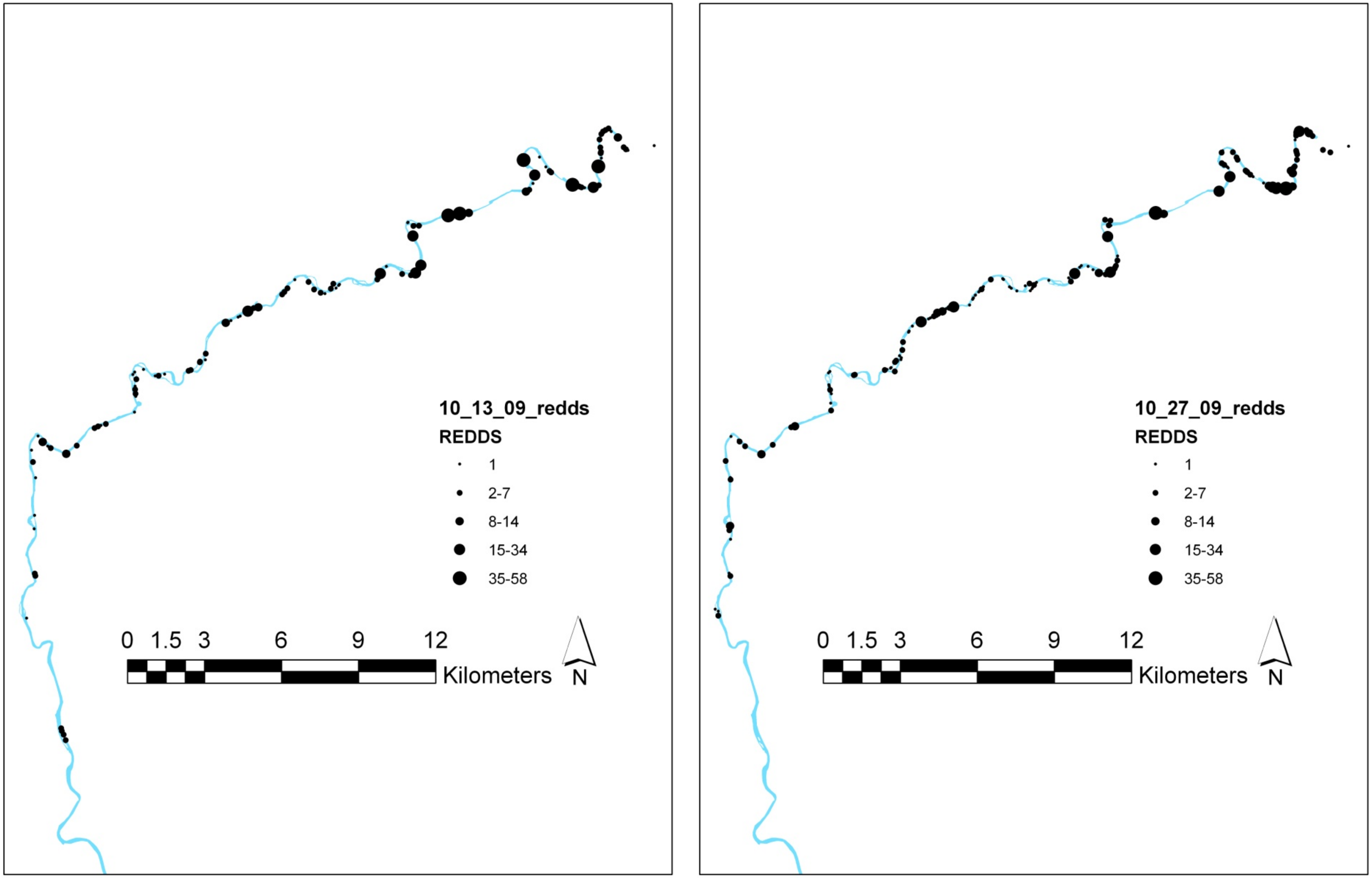


**Figure 2. (continued) The spatial distribution of Chinook redds in the lower 83 km of the Cowlitz River (from the Barrier Dam to Kelso). Each map represents an aerial spawning survey and the black dots represent a redd or cluster of redds. (Courtesy of Katherine Murray)**

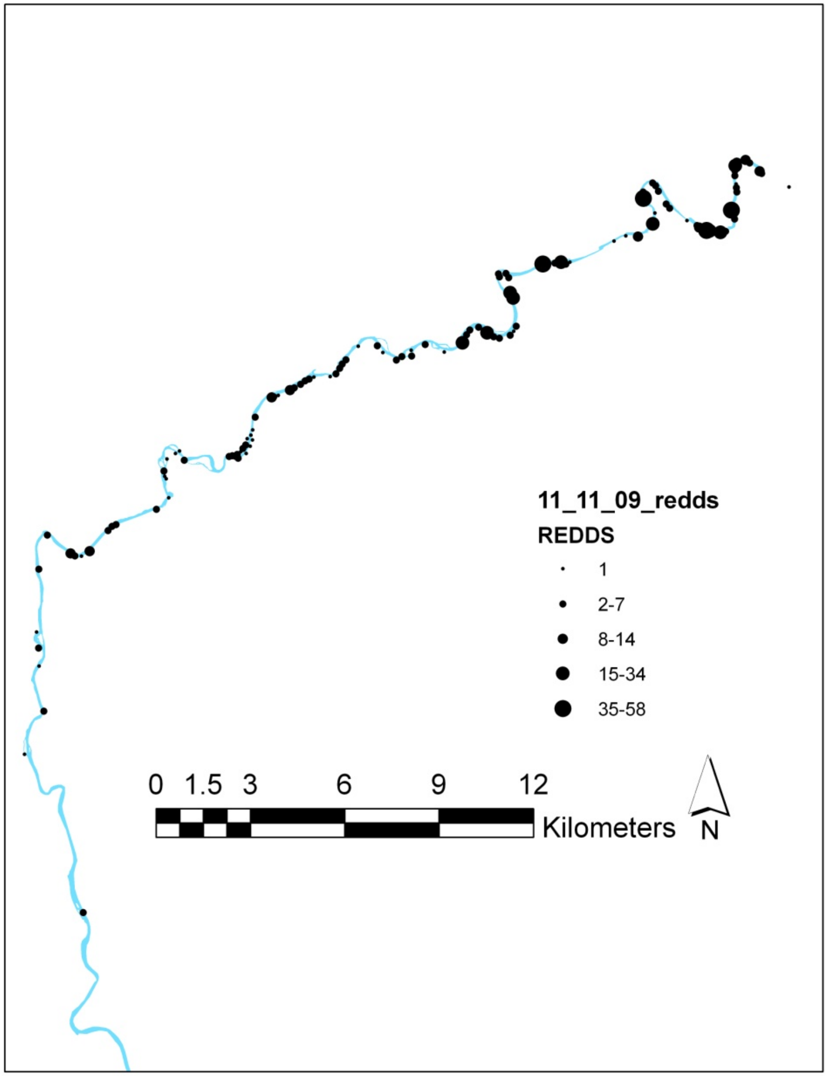


**Figure 2. (continued) The spatial distribution of Chinook redds in the lower 83 km of the Cowlitz River (from the Barrier Dam to Kelso). Each map represents an aerial spawning survey and the black dots represent a redd or cluster of redds. (Courtesy of Katherine Murray)**

In addition to the aerial spawning surveys, boat surveys were completed simultaneously to evaluate the feasibility and accuracy of completing boat surveys instead of aerial surveys (Table 13). The boat surveys were completed on October 13th and October 27th. The surveys were broken out into three sections: Blue Creek to Baker Rock, a side-channel, and Baker Rock to Mill Creek. The side-channel was just downstream of Baker Rock. Comparison of the survey methods showed that aerial counts were higher than boat counts in the Blue Creek to the Baker Rock section and the Baker to Mill Creek section. Boat counts were higher than aerial counts in the side-channel on both survey days. This result was expected because of the overhanging trees and shaded areas that affected visibility from the air.

**Table 13. Comparison of Chinook spawning surveys completed by boat and air simultaneously, 2009.**

| **Location** | **10/13/09** | | **10/27/09** | |
|---|---|---|---|---|
| | aerial count | boat count | aerial count | boat count |
| Blue Creek Boat Ramp to Baker Rock | 213 | 120 | 349 | 137 |
| The Side Channel | 65 | 136 | 83 | 112 |
| Baker Rock to Mill Creek | 98 | 66 | 163 | 80 |
| **Total** | **376** | **322** | **595** | **329** |

## Spring and Fall Chinook Carcass Surveys

Starting September 10, the Cowlitz River was surveyed using a jet sled for spring and fall Chinook salmon carcasses (Table 14). Carcasses were sampled for stock (spring verses fall), sex, length, presence of an adipose fin clip and possible coded-wire tag. Also, scale samples were obtained for age analysis. The collected snouts with coded wire were sent to Olympia for decoding, scales were read by a WDFW scale reader, and Vancouver staff completed a run reconstruction analysis, which summarizes stock and age composition on the spawning grounds (Table 15). This analysis also provides an estimate of spawning by HOR and NOR fish.

Natural spawning Chinook were sampled at a rate of 1:4 ratio for fall Chinook and 1:1 ratio for spring Chinook. Sample rates were kept separate for UM and ad-clipped fall Chinook so the populations could have equal representation in the sample. This year we had two and three year old hatchery fish returning from the newly implemented fall Chinook mass marking program. All adipose clipped fish were wanded and snouts were collected on all wand positive fish. This year surveys occurred 2 to 3 days per week from I-5 bridge to Mill Creek. We sampled 1,405 carcasses from September 10th to December 3rd.

**Table 14. Number of Chinook carcasses by Chinook stock and separated by adipose clipped or non-clip (UM) fish recovered in the Cowlitz River in 2009.**

| Area* | Date | Chinook Stock | # ad clip (H) | # non-clip (UM) |
|---|---|---|---|---|
| BC-MC | 10-Sep | spring | 3 | 0 |
| BC-MC | 14-Sep | spring | 12 | 0 |
| BC-MC | 17-Sep | spring | 5 | 0 |
| BC-MC | 22-Sep | spring | 9 | 0 |
| BC-Mission | 24-Sep | spring | 2 | 0 |
| BC-MC | 28-Sep | spring | 11 | 0 |
| BC-Toledo | 30-Sep | spring | 4 | 0 |
| BC-MC | 5-Oct | spring | 1 | 0 |
| **TOTAL** | | **spring** | **47** | **0** |
| BC-MC | 14-Sep | fall | 1 | 1 |
| BC-MC | 22-Sep | fall | 1 | 0 |
| BC-Mission | 24-Sep | fall | 0 | 1 |
| BC-MC | 28-Sep | fall | 1 | 6 |
| BC-Toledo | 30-Sep | fall | 3 | 10 |
| BC-MC | 5-Oct | fall | 22 | 28 |
| Sal-BC | 7-Oct | fall | 15 | 26 |
| BC-MC | 12-Oct | fall | 27 | 71 |
| I-5-BC | 15-Oct | fall | 17 | 54 |
| BC-MC | 20-Oct | fall | 25 | 98 |
| I-5-BC | 22-Oct | fall | 21 | 120 |
| BC-MC | 27-Oct | fall | 25 | 123 |
| I-5-BC | 29-Oct | fall | 4 | 27 |
| BC-Baker | 3-Nov | fall | 14 | 198 |
| I-5-BC | 4-Nov | fall | 5 | 58 |
| Baker-MC | 5-Nov | fall | 9 | 62 |
| BC-MC | 10-Nov | fall | 3 | 134 |
| BC-MC | 25-Nov | fall | 2 | 24 |
| BC-MC | 3-Dec | fall | 2 | 13 |
| I-5-BC | 1-Dec | fall | 0 | 13 |
| **TOTAL** | | **fall** | **291** | **1067** |

*BC-MC – Blue Creek to Mill Creek, MC-Toledo- is Mill Creek to the Toledo Bridge, I-5-BC is I-5 bridge to Blue Creek, BC-Baker is Blue Creek to Baker Rock, Sal-BC is Salmon Creek to Blue Creek.

## Natural Spawn Escapement Sampling

**Table 15. Results of lower river carcass surveys for natural spawning fall Chinook. Information includes age and stock composition on the spawning grounds for 2009.**

| | Age Composition | | | | | |
|---|---|---|---|---|---|---|
| Origin | 2's | 3's | 4's | 5's | 6's | **Total** |
| Kalama H Esc. | 0 | 0 | 434 | 0 | 0 | **434** |
| Cowlitz H Esc. | 0 | 0 | 135 | 0 | 0 | **135** |
| Unknown LRH Esc. | 132 | 369 | 737 | 59 | 0 | **1297** |
| Unknown LRW Esc. | 66 | 185 | 653 | 30 | 0 | **934** |
| **Total** | **198** | **554** | **1959** | **89** | **0** | **2800** |

Note: Does not include fish released above the Barrier Dam.
LRH = Lower River Hatchery, LRW = Lower River Wild

## Hatchery Broodstock Sampling

Data collected from the hatchery broodstock sampling, CWT fish that were surplused, and tallies of adult and jacks that arrive at the separator, the age composition is produced (Table 16).

**Table 16. Cowlitz River fall Chinook hatchery broodstock by age and stock composition, 2009.**

| | Age Composition | | | | | **Total** |
|---|---|---|---|---|---|---|
| Origin | 2's | 3's | 4's | 5's | 6's | |
| Toutle H Esc. | 111 | 0 | 0 | 0 | 0 | **111** |
| Kalama H Esc. | 14 | 0 | 132 | 0 | 0 | **146** |
| Cowlitz H Esc. | 1,978 | 5,303 | 4,676 | 177 | 0 | **12,134** |
| **Total** | **2,103** | **5,303** | **4,808** | **177** | **0** | **12,391** |

Note: Includes fish released above the Mayfield Dam.

## Chum Salmon Spawning Surveys

Spawning surveys were completed to locate chum salmon spawning in the lower Cowlitz River. Surveys were conducted starting in early September however due to low water is September few surveys were actually completed. Streams were checked in the following areas; Mill Creek from the mouth to the PUD dam, in Blue Creek from the mouth to the trout hatchery, in Lacamas Creek from the mouth to Coon Creek, and in Ostrander from the upper Ostrander Road bridge to I5 (one-mile long). No chum redds or chum salmon were observed during these surveys (Table 17). Surveys were not completed if flows were low and streams were impassible due to beaver dams.

**Table 17. Chum spawning surveys completed on Mill Creek, Blue Creek, Lacamas Creek, and Ostrander Creek of the Cowlitz River Basin in 2009.**

| Date | Location | Comments |
|---|---|---|
| 09/22 | Mill Creek | Low flows; beaver dam in lower reach |
| 09/23 | Blue Creek | Multiple beaver dams including some that were total barriers. |
| 09/30 | Lacamas Creek | Very low flows; impassible |
| 10/02 | Ostrander Creek | Very low flows; no survey because flow was too low. |

Streams were checked 2 weeks before and 2 weeks after these dates. No surveys were completed during these periods due to low water.

**Table 18. Chum and sockeye salmon returns to Cowlitz Salmon separator by year, month and species (All fish were released in the lower Cowlitz River).**

| Year | Month | Chum | | Sockeye | |
|---|---|---|---|---|---|
| | | Male | Female | Male | Female |
| | July | 1 | 3 | 1 | 6 |
| 2009 | August | 0 | 0 | 2 | 1 |
| | September | 1 | 0 | 1 | 0 |
| | October | 1 | 1 | 2 | 0 |
| | November | 1 | 1 | 0 | 0 |
| | December | 0 | 0 | 0 | 0 |
| | **Total** | **4** | **5** | **6** | **7** |
| | June | 0 | 0 | 1 | 0 |
| | July | 0 | 0 | 2 | 1 |
| 2008 | August | 0 | 2 | 0 | 1 |
| | September | 0 | 0 | 3 | 1 |
| | October | 1 | 0 | 0 | 1 |
| | November | 1 | 1 | 0 | 0 |
| | December | 0 | 0 | 0 | 0 |
| | **Total** | **2** | **3** | **6** | **4** |
| | June | 0 | 0 | 1 | 0 |
| | July | 0 | 0 | 1 | 3 |
| 2007 | August | 0 | 0 | 3 | 2 |
| | September | 0 | 0 | 1 | 0 |
| | October | 1 | 1 | 1 | 0 |
| | November | 1 | 2 | 0 | 0 |
| | December | 0 | 0 | 0 | 0 |
| | **Total** | **2** | **3** | **7** | **5** |
| | July | 1 | 0 | 6 | 3 |
| 2006 | August | 1 | 1 | 1 | 0 |
| | September | 1 | 2 | 0 | 0 |
| | October | 0 | 0 | 0 | 0 |
| | November | 1 | 0 | 0 | 0 |
| | December | 1 | 0 | 0 | 0 |
| | **Total** | **5** | **3** | **7** | **3** |
| | July | 1 | 0 | 6 | 10 |
| 2005 | August | 1 | 1 | 5 | 3 |
| | September | 0 | 1 | 1 | 0 |
| | October | 0 | 0 | 0 | 0 |
| | November | 5 | 3 | 0 | 0 |
| | December | 0 | 1 | 0 | 0 |
| | **Total** | **7** | **6** | **12** | **13** |

Biological information was collected on adult chum and sockeye that arrived at the separator (Tables 19 and 20). This information included length, sex determination, and 3 scales to age each fish. Also, genetic samples were taken on each chum and sockeye salmon to determine their origin. The genetic samples have been sent to the WDFW genetics lab and are being stored there until there are funds to analyze the samples.

**Table 19. Biological information on chum salmon that arrived at the Separator in 2009.**

| Date | Fork Length (cm) | Sex | Age | Scale card | Position | DNA # |
|---|---|---|---|---|---|---|
| 07/10/09 | 54 | Female | 5 | 3370 | 1 | 09GY1 |
| 07/13/09 | 63 | Female | 3 | 3370 | 2 | 09GY2 |
| 07/24/09 | 57 | Female | 3 | 3370 | 3 | 09GY3 |
| 07/27/09 | 65 | Female | 4 | 3370 | 4 | 09GY4 |
| 09/14/09 | 75 | Female | 4 | 3370 | 6 | 09GY6 |
| 10/11/09 | 68 | Female | 4 | 3370 | 7 | 09GY7 |
| 10/14/09 | 75 | Male | 4 | 3370 | 8 | 09GY8 |
| 11/22/09 | 70 | Female | 4 | 3370 | 9 | 09GY9 |
| 11/24/09 | 83 | Male | 4 | 3274 | 1 | 09GY10 |

**Table 20. Biological information on sockeye salmon that arrived at the Separator in 2009.**

| Date | Fork Length (cm) | Sex | Age | Scale card | Position | DNA # |
|---|---|---|---|---|---|---|
| 07/13/09 | 59 | Female | 5 | 3384 | 1 | 09GZ |
| 07/17/09 | 56 | Female | - | 3384 | 2 | 09GZ |
| 07/22/09 | 62 | Female | 5 | 3384 | 3 | 09GZ |
| Unknown | 54 | Female | 4 | 3384 | 4 | 09GZ |
| 07/27/09 | 55 | Female | 4 | 3384 | 5 | 09GZ |
| 07/30/09 | 54 | Female | 5 | 3384 | 6 | 09GZ |
| 07/30/09 | 59 | Male | 5 | 3384 | 7 | 09GZ |
| 08/19/09 | 60 | Female | 5 | 3384 | 8 | 09GZ |
| 08/19/09 | 42 | Male | 3 | 3384 | 9 | 09GZ |
| 08/20/09 | 43 | Male | 3 | 3384 | 10 | 09GZ |
| 09/15/09 | 43 | Male | 3 | 3366 | 11 | 09GZ |
| 10/26/09 | 55 | Male | 4 | 3366 | 12 | 09GZ |
| 10/30/09 | 64 | Male | - | 3366 | 13 | 09GZ |

## Radio Tracking of Chum Salmon

The radio telemetry study continued in 2009 to determine spawning habitat of chum salmon in the lower Cowlitz River. Adult chum salmon returning to the Cowlitz Salmon Hatchery separator were tagged with Lotek 7a esophageal implant radio tags. Implanted chum were released at Barrier Dam boat launch (RM 36.5) on the same day they were tagged. Chum were tracked post release by vehicle or boat.

Nine chum salmon returned to the Cowlitz Salmon Hatchery separator and seven of those were radio tagged (Table 21). Adult chum arrived from July through November this year. Radio tagged fish were tracked until they spawned or migrated out of the Cowlitz system. In 2009, fish were tracked from 2-30 days. Out of the seven tagged fish, two tags were recovered. One of these tags was recovered in a garbage can at Baker Rock (the fish was likely harvested) and the other tag was found in the Cowlitz River near Toledo Bridge. This fish may have spawned in the Cowlitz mainstem, however no carcass was recovered. All the other tagged fish likely migrated out of the Cowlitz however, this cannot be confirmed without a fixed telemetry site. Appendix 1 has detailed tracking information for each radio tagged fish.

**Table 21. Adult chum radio telemetry in the lower Cowlitz River, 2009.**

| Release Date | # of days tracked | Last location tracked | Fish status |
|---|---|---|---|
| 10-Jul | 10 | Mouth of Cowlitz | Tracked migrating out of the Cowlitz |
| 13-Jul | 30 | Barrier Boat Ramp | Unknown, likely was harvested |
| 24-Jul | 4 | RM 48.2 | Unknown |
| 24-Jul | 7 | Taylor Crane Rd. | Unknown |
| 14-Sep | 3 | Tailout at B.C. | Unknown |
| 14-Oct | 6 | Baker Rock | Only tag recovered |
| 24-Nov | 2 | Barrier Boat Ramp | Unknown |

## Juvenile to Adult Chinook Survival Study

Natural origin juvenile Chinook salmon were captured for a study that was originally initiated in 2005 to determine the survival rate of juvenile to adult wild Chinook salmon. A mark recapture method was used to examine survival. Below is a description of the marking results for 2009. No adults from this project were captured on the spawning grounds during carcass surveys this year.

Juveniles were captured using a stick seine from April 27 – June 12, 2009. The stick seine was 10 m long with ¼ inch mesh netting. Seining occurred in the lower Cowlitz River from Blue Creek to the I-5 Bridge. Once fish were seined, they were transported to the Cowlitz Trout Hatchery where they were measured (fork length (mm)) cwt tagged, adipose clipped, and released back into the river. A subsample of fish were held for a minimum of 24 h to determine tag loss and mortality related to the handling and tagging each day.

We started a week later this year than past years due to the cool spring. The cooler weather affected the growth rate of the fish and the fish needed to be at least 48 mm fork length to tag. The first two weeks of seining the flows were about 5,300 cfs however by the third week, the flows were around 8,000 cfs creating difficult seining conditions. Due to snow melt, the flows were about 8,000 to 9,000 for most of May. We continued to seine during these high flows almost every day however, catch was low. June 1st the flows were over 13,000cfs and no seining occurred. Flows below 5,000 cfs are needed to catch enough fish to make this project successful.

This year we caught the lowest number of fish since the initiation of the project in 2005 (Tables 22 and 23). We caught a total of 12,921 fall Chinook and of those 6,423 fish were tagged. After accounting for tag loss and mortality we released 5,702 tagged juvenile fall Chinook. Many of the captured fish (6,498) were too small to be tagged (< 48 mm) and were released untagged.

**Table 22. The daily number of salmonids processed during the 2009 tagging of juvenile fall Chinook.**

| (tag date) | TAGGED | UNDERSIZED | ADJUSTED FOR TAG | COHO fry | CHUM fry | STEELHEAD |
|---|---|---|---|---|---|---|
| DATE | CHINOOK | CHINOOK | LOSS | | | fry |
| 4/29/09 | 117 | 744 | 117 | 56 | 0 | 0 |
| 5/5/09 | 227 | 486 | 220 | 55 | 2 | 0 |
| 5/5/09 | 79 | 132 | 71 | 152 | 0 | 0 |
| 5/6/09 | 677 | 1604 | 0 | 17 | 3 | 0 |
| 5/7/09 | 488 | 940 | 473 | 214 | 0 | 0 |
| 5/8/09 | 87 | 171 | 87 | 33 | 0 | 0 |
| 5/12/09 | 191 | 268 | 191 | 80 | 0 | 0 |
| 5/14/09 | 69 | 72 | 69 | 164 | 0 | 0 |
| 5/15/09 | 467 | 373 | 467 | 22 | 0 | 0 |
| 5/19/09 | 384 | 418 | 384 | 22 | 0 | 0 |
| 5/20/09 | 539 | 386 | 539 | 552 | 1 | 0 |
| 5/21/09 | 170 | 70 | 170 | 12 | 0 | 0 |
| 5/22/09 | 889 | 332 | 889 | 1 | 0 | 0 |
| 5/26/09 | 186 | 75 | 180 | 18 | 0 | 0 |
| 5/27/09 | 369 | 3 | 369 | 20 | 0 | 0 |
| 5/29/09 | 654 | 300 | 654 | 97 | 0 | 0 |
| 6/1/09 | 99 | 53 | 99 | 25 | 0 | 0 |
| 6/11/09 | 389 | 52 | 380 | 10 | 0 | 0 |
| 6/12/09 | 186 | 4 | 186 | 5 | 0 | 0 |
| 6/15/09 | 156 | 15 | 156 | 11 | 0 | 0 |
| Total | 6423 | 6498 | **5702** | 1566 | 6 | 0 |

**Table 23. A summary table of the fall Chinook seining project from 2005-2009.**

| YEAR | TAGGED CHINOOK | UNDERSIZED CHINOOK | RECAP CHINOOK | TAG LOSS | ADJUSTED TAGGED | Total salmonids processed | Seining period |
|---|---|---|---|---|---|---|---|
| 2005 | 2754 | 1428 | 46 | 504 | 2250 | 4857 | 5/16-6/14 |
| 2006 | 19484 | 30328 | 141 | 503 | 18981 | 50686 | 4/18-6/11 |
| 2007 | 8185 | 16397 | 119 | 34 | 8150 | 29572 | 4/30-6/5 |
| 2008 | 21560 | 37170 | 471 | 390 | 21170 | 62782 | 4/25-6/8 |
| 2009 | 6423 | 6498 | 117 | 722 | 5701 | 14624 | 4/28-6/12 |

# Late Winter Steelhead Spawning Surveys

To monitor natural reproduction of late winter steelhead in the lower Cowlitz River, surveys were conducted on five Cowlitz River tributaries starting in early March through the end of May. Survey areas included: Monahan Creek, Campbell Creek, Delameter Creek, Arkansas Creek, and Mill Creek. We increased our survey areas to better understand the lower river tributary steelhead population. Survey areas added included Delameter and Arkansas Creek. We decided to remove Brights Creek from our survey indexes because this creek has had no redds for many years. Below is a description of the survey areas:

Monahan Creek: (4.6 river miles) was surveyed from confluence with Delameter Creek to the Weyerhaeuser Road 9000 Bridge. Delameter Creek is a tributary of Arkansas Creek, which meets the Cowlitz River at River mile 16.4.

Campbell Creek: (2.2 river miles) was surveyed from its confluence with Stillwater Creek to ½ mile above Ryderwood Water Intake structure. Stillwater Creek is a tributary of Olequa Creek, which meets the Cowlitz River at River Mile 24.5.

Delameter Creek: (1.25 river miles) was surveyed from the second Delameter Rd. bridge and River mile 1.5 to the Oller Rd. Bridge at River mile 2.75.

Arkansas Creek: (about 2 river miles) was surveyed from Growlers Gulch Rd. bridge at River mile 4.25 to Coyote Rd. bridge at River mile 6.25.

Mill Creek: (0.9 river miles) was surveyed from the confluence of Cowlitz River at River Mile 49.1 to fish barrier (falls and Power House) at river mile 0.9.

Each redd was identified by substrate disturbance and depression, and flagged with number of redds and date. Redd life varied from 10 days to 4 weeks depending on flow conditions. Surveys were conducted once every two weeks, from March to May depending on river conditions and time scheduling.

**Table 24. Winter steelhead spawning surveys in tributaries of the lower Cowlitz River, 2009.**

| Date | Flow | Visibility | # of Steelhead | | # of Redds |
|---|---|---|---|---|---|
| Monahan Creek | (high, med, low) | | Live | Dead | New |
| 03/11/09 | L | 5' | 0 | 0 | 1 |
| 03/25/09 | M | 3' | 4 | 0 | 5 |
| 04/09/09 | M | 5' | 3 | 0 | 14 |
| 04/23/09 | M | 6' | 3 | 1 | 16 |
| 05/04/09 | L | 6' | 2 | 0 | 3 |
| 05/11/09 | H | 6' | 0 | 0 | 4 |
| Campbell Creek | | | | | |
| 03/04/09 | M | 6' | 1 | 0 | 4 |
| 03/16/09 | H | 2.5' | 1 | 0 | 2 |
| 03/30/09 | L | 6' | 0 | 0 | 8 |
| 04/13/09 | M | 1.5' | 1 | 0 | 3 |
| 04/30/09 | L | 6' | 0 | 0 | 0 |
| Delameter Creek (Lower) | | | | | |
| 03/12/09 | L | 6' | 0 | 0 | 1 |
| 03/25/09 | M | 4' | 1 | 0 | 1 |
| 04/07/09 | M | 4' | 1 | 0 | 0 |
| 04/22/09 | L | 3' | 1 | 1 | 0 |
| Arkansas Creek (Lower) | | | | | |
| 03/12/09 | M | 5' | 0 | 0 | 0 |
| 03/26/09 | M | 3' | 0 | 0 | 1 |
| 04/07/09 | M | 4' | 0 | 0 | 1 |
| 04/23/09 | M | 5' | 0 | 0 | 0 |
| 05/04/09 | M | 5' | 0 | 0 | 0 |
| Mill Creek | | | | | |
| 03/04/09 | M | 3' | 0 | 0 | 0 |
| 03/18/09 | H | 1' | 0 | 0 | 0 |
| 04/01/09 | H | 2' | 1 | 0 | 0 |
| 04/16/09 | M | 5' | 0 | 0 | 0 |
| 04/29/09 | L | 5' | 0 | 0 | 4 |

## The Steelhead Genetics Study in the Lower Cowlitz Tributaries

This was a two-year study initiated in 2008 to evaluate the genetic profile of winter steelhead returning to tributaries of the lower Cowlitz River system (Small et al. 2009). The primary objectives were to determine whether native populations of steelhead are present in these streams and what impact hatchery-origin steelhead have had on the genetic diversity of natural populations.

Adult steelhead were captured with hook and line and dip nets in lower Cowlitz River tributaries such as Ostrander, Delameter, Arkansas, Monahan, Olequa, Campbell, Baxter and Stillwater Creeks. Two or three tissue samples were obtained from the tail of each fish for DNA analysis using paper punches. Scale samples were taken only from the fish caught by WDFW staff. A few samples consisted of scales only. In addition, sex, estimated length, spawning condition and general condition of the fish at release were recorded. Sampling began March 1 and ended May 22 when it was determined that steelhead spawning was completed and fish had left the tributaries.

In 2009, samples were obtained from 47 fish. Of those sampled, 42 or 89% were males. Females were very difficult to catch, primarily because they left the streams quickly after spawning as opposed to males who stayed in the streams throughout the spawning season continually searching for females. This increased their exposure to sampling and probability of capture. In addition, females were very reluctant to bite on hook and line gear and were significantly more elusive to capture with dip nets.

Four fish were identified as hatchery-origin based on missing adipose fins. Seven adult steelhead were hooked but not landed. Despite comprehensive sampling with both hook and line gear and dip nets throughout the season, only 2 fish were captured twice: one on hook and line and one with dip nets. Of the live adult fish sampled, no mortalities were observed. Only one fish was bleeding significantly at the time of release. All the other fish appeared to be in good condition when released.

Samplers used hook and line gear to target adult steelhead however, cutthroat and juvenile steelhead were encountered. Forty-two cutthroat and five steelhead were caught while fishing for steelhead. Other species caught during the study included whitefish and large-scale sucker.

Volunteers were not actively recruited for sampling this year. Anyone who contacted us and wished to participate was given the chance to do so. Three anglers inquired about participating in sampling but none chose to do so. Three experienced anglers who fished last year were contacted by staff and asked if they wanted to participate. Two of the three fished a total of three days and obtained one genetic sample.

Refer to Small et al. (2010) for more details on the study and the results.

## Summer Steelhead Creel Surveys

Anglers were interviewed from June – August to evaluate harvest rates of summer steelhead in the lower Cowlitz River. A total of 346 boats were interviewed who caught 153 fish in 2,702 hours. This was a catch per hour rate of 0.057. This is almost half the catch rate of the 2008 summer-run fishery during the same time period (0.10 catch rate). A total of 522 shore anglers were interviewed who fished 1,600 hours and caught 18 fish. This was a catch per hour rate of 0.011.

## Coho Spawning Surveys

The Cowlitz Evaluation program conducted coho spawning surveys in Olequa Creek and Brights Creek (Tables 25 and 26). The surveys were completed from November through January (Table 25). The Olequa surveys were conducted from the railroad bridge near the Winlock County park upstream into 3 different forks: north fork, middle fork, and south fork. Each fork was about 1-2 miles in length. The Brights Creek survey was from the confluence of the creek with the Cowlitz River to the waterfall barrier. Besides counting redds, live and dead coho were counted as well as whether each fish had an adipose fin. If the fish had an adipose fin, it was called a natural origin return (NOR). If the adipose was clipped it was called a hatchery origin return (HOR). Also, coho carcasses were sampled including obtaining a fork length, sex, scales, and the fish was wanded for coded wire. Most of the redds observed were in the middle fork of Olequa Creek (n=21). There was a decrease in redds counted this year compared to 2008 when 89 redds were counted (Table 25). In 2009, the peak spawning timing was missed due to high water however, total redd numbers were lower than 2008 totals based on other surveys. As expected, scale analysis showed that all carcasses sampled were three year olds. However, scales suggested that of the fish sampled, 17% were of hatchery origin in Olequa Creek and 63% were of hatchery origin in Brights Creek.

**Table 25. Coho spawning surveys completed in Olequa Creek, 2009/2010.**

| Survey Date | # Redds | # of HOR's | # of NOR's | # of HOR's | # of NOR's |
|---|---|---|---|---|---|
| North Fork | | Carcasses | | Live Fish | |
| 05-Nov | 0 | 0 | 0 | 0 | 0 |
| 03-Dec | 4 | 0 | 0 | 0 | 0 |
| 18-Dec | 0 | 0 | 0 | 0 | 0 |
| 07-Jan | 1 | 0 | 0 | 0 | 0 |
| 19-Jan | 0 | 0 | 0 | 0 | 0 |
| South Fork | | | | | |
| 05-Nov | 0 | 0 | 0 | 0 | 0 |
| 04-Dec | 7 | 0 | 0 | 0 | 0 |
| 18-Dec | 0 | 0 | 3 | 0 | 0 |
| 07-Jan | 0 | 0 | 0 | 0 | 0 |
| 19-Jan | 0 | 0 | 0 | 0 | 0 |
| Middle Fork | | | | | |
| 5-Nov | 6 | 0 | 0 | 0 | 4 |
| 30-Nov | 14 | 1 | 17 | 0 | 12 |
| 3-Dec | 1 | 0 | 3 | 0 | 0 |
| 28-Dec | 0 | 0 | 5 | 0 | 0 |
| 14-Jan | 0 | 0 | 0 | 0 | 0 |
| 22-Jan | 0 | 0 | 0 | 0 | 0 |
| **TOTAL** | **33** | **1** | **28** | **0** | **16** |

*Missed the peak spawning in mid-November due to high water.

**Table 26.** **Coho spawning surveys completed in Brights Creek and Ostrander Creek, 2009/2010.**

| Survey Date | # Redds | # of HOR's | # of NOR's | # of HOR's | # of NOR's |
|---|---|---|---|---|---|
| Brights Creek | | Carcasses | | Live fish | |
| 9-Dec | 4 | 1 | 1 | 1 | 3 |
| 22-Dec | 3 | 0 | 0 | 1 | 3 |
| 6-Jan | no survey | | | | |
| 25-Jan | 0 | 0 | 0 | 0 | 0 |
| Ostrander Creek | | | | | |
| 23-Dec | 1 | 0 | 3 | 0 | 0 |
| 20-Jan | 2 | 0 | 0 | 0 | 0 |

# Resident Fish Program

## Mayfield Lake

In 2009, there were catchable rainbow trout fish planted in Mayfield Lake, the Tilton River, Skate Creek, and Swofford Pond for harvest opportunities. All rainbow trout were adipose clipped The below tables list the pounds of fish released by date in each location. All the rainbow trout were raised and planted by Nisqually Trout Farm. Fish plants in Mayfield Lake were released in multiple locations around the lake (Table 26). A total of 79,118 pounds of trout were planted for mitigation in 2009 (Tables 27, 28, and 29). Other species planted for harvest (by WDFW) included tiger musky in Mayfield reservoir and brown trout at Swofford pond (Table 30).

## Rainbow Trout at Mayfield trap

In Mayfield Lake and the Tilton River, rainbow trout are planted yearly for a sport fishery (Table 26). Some of these rainbow trout released are caught at the Mayfield migrant trap. In 2009, 1,377 rainbow trout were captured at the trap, which is one of the lowest capture rates in recent years.

**Table 27. Resident trout plants in Mayfield Lake in 2009 by Nisqually Trout Farm.**

| Date | Pounds of fish | Mayfield Destination |
|---|---|---|
| 26-Mar | 2,800 | IK Day Use |
| 02-Apr | 2,800 | MR Trout Hatch. |
| 09-Apr | 2,400 | IK Boat launch |
| 16-Apr | 3,600 | IK Day Use |
| 23-Apr | 3,000 | MR Trout Hatch. |
| 30-Apr | 3,500 | IK Boat launch |
| 07-May | 3,000 | MF Co. Park |
| 14-May | 3,000 | IK Day Use |
| 21-May | 2,800 | MR Trout Hatch. |
| 04-Jun | 2,800 | IK Boat launch |
| 18-Jun | 3,400 | IK Day Use |
| 02-Jul | 4,200 | MR Trout Hatch. |
| 16-Jul | 4,000 | MF Co. Park |
| 30-Jul | 4,400 | IK Boat launch |
| 13-Aug | 3,600 | IK Day Use |
| 20-Aug | 980 | MR Trout Hatch. |
| **Total** | **50,280** | |

IK Day Use = Ike Kinswa Day Use Area, MR Trout Hatch. = Mossyrock Trout Hatchery, IK Boat Launch = Ike Kinswa Boat Launch, MF Co. Park = Mayfield County Park

**Table 28. Resident trout plants in Swofford Pond in 2009 by Nisqually Trout Farm.**

| Date | Pounds of fish |
|---|---|
| 31-Mar | 1,720 |
| 07-Apr | 1,720 |
| 14-Apr | 1,577 |
| **Total** | **5,017** |

**Table 29. 2009 Rainbow trout plants by date and pounds of fish in the Tilton River and Skate Creek, by Nisqually Trout Farm.**

| Date | Skate Creek | Tilton River |
|---|---|---|
| 28-May | 1,606 | 1,607 |
| 11-Jun | 850 | 1,607 |
| 25-Jun | 2,938 | 2,582 |
| 09-Jul | 2,372 | 2,144 |
| 23-Jul | 2,372 | 2,144 |
| 06-Aug | 1,919 | 1,680 |
| **Total** | **12,057** | **11,764** |

**Table 30. Number of northern pikeminnows caught in the Mayfield migrant trap.**

| Year | Mayfield trap |
|---|---|
| 2000 | 50 |
| 2001 | 275 |
| 2002 | 327 |
| 2003 | 406 |
| 2004 | 399 |
| 2005 | 301 |
| 2006 | 433* |
| 2007 | 1421* |
| 2008 | 428 |
| 2009 | 797 |

* Captured hundreds of young-of-the-year pikeminnow not included in 2006 & 2007.

**Table 31. Other fish plants in 2009 (WDFW funded).**

| DATE | NUMBER | WEIGHT | LIFE STAGE | SPECIES | LOCATION |
|---|---|---|---|---|---|
| 05-18 | 7,505 | 1,364lbs | Juvenile | Brown trout | Swofford |
| 05-13 | 1,463 | 700lbs | Juvenile | Tiger Musky | Mayfield |

## Creel Census

Sporadic creel surveys were conducted on Mayfield Lake from May through August (Table 32). A total of 142 anglers were interviewed who fished 355 hours and caught 92 fish for a catch-per-unit-effort (C/E) of 0.26. This compares to Tipping (1998) survey from May through August with a C/E of 0.09. The 2003, 2004, 2005, 2006 catch-per-unit-effort (C/E) was 0.60, 0.66, 0.35, and 0.51 in Mayfield Lake. The C/E has decreased from last year were it was 0.39 fish per hour.

**Table 32. 2009 creel results for Mayfield Lake.**

| | Boater Anglers | | | | Shore Anglers | | | |
|---|---|---|---|---|---|---|---|---|
| Month | # interviewed | Hours | Fish | C/E | # interviewed | Hours | Fish | C/E |
| May | 7 | 12 | 4 | 0.33 | 18 | 53.5 | 19 | 0.36 |
| June | 9 | 27 | 2 | 0.07 | 64 | 128 | 21 | 0.16 |
| July | 26 | 78 | 37 | 0.47 | 8 | 12 | 1 | 0.83 |
| August | 8 | 38 | 8 | 0.21 | 2 | 7 | 5 | 0.71 |

In Riffe reservoir, sporadic creel surveys were completed during the summer months, May, June, July, and August (Table 33). Overall, the effort and catch was lower compared to previous years. Most of the fish caught in the fishery were coho salmon however, Chinook were also observed.

**Table 33. Riffe Lake angler hours and catch per hour (all fish). C/E= catch per hour.**

**Boat anglers.**

| | May | | June | | July | | August | | Mean |
|---|---|---|---|---|---|---|---|---|---|
| Year | Hours | C/E | Hours | C/E | Hours | C/E | Hours | C/E | Mean |
| 1985 | NA | NA | 1,207 | .31 | 1,675 | .51 | 748 | .75 | .36 |
| 1986 | 591 | .36 | 1,315 | .35 | 1,437 | .83 | 2,140 | .46 | .50 |
| 1987 | 1,647 | .33 | 2,108 | .22 | 2,452 | .51 | 2,695 | .57 | .41 |
| 1989 | 475 | .27 | 460 | .29 | 607 | .46 | 118 | .73 | .44 |
| 1990 | 422 | .10 | 776 | .22 | 332 | .17 | 342 | .41 | .23 |
| 1991 | 508 | .16 | 521 | .20 | 387 | .47 | 365 | .31 | .29 |
| 1992 | 730 | .23 | 534 | .26 | 407 | .42 | 401 | .19 | .28 |
| 1993 | 631 | .43 | 774 | .35 | 633 | .50 | 658 | .26 | .39 |
| 1994 | 433 | .54 | 771 | .54 | 587 | .57 | 500 | .57 | .56 |
| 1995 | 345 | .51 | 703 | .63 | 763 | .47 | 643 | .29 | .48 |
| 1996 | 198 | .11 | 386 | .29 | 538 | .23 | 518 | .52 | .29 |
| 1997 | 298 | .16 | 217 | .93 | NA | NA | NA | NA | NA |
| 1998 | 164 | .19 | 983 | .35 | 830 | .37 | 821 | .27 | .30 |
| 1999 | 304 | .06 | 942 | .27 | 827 | .25 | 1,037 | .25 | .21 |
| 2000* | 723 | .10 | 545 | .39 | 91 | .17 | 244 | .23 | .22 |
| 2001 | NA | NA | 337 | .46 | 269 | .64 | 129 | .80 | .63 |
| 2002 | NA | NA | 124 | .35 | 128 | .45 | 82.5 | .41 | .40 |
| 2003 | NA | NA | 234 | .47 | 101 | .21 | NA | NA | .34 |
| 2004 | NA | NA | 141 | .52 | 375 | .30 | 99 | .88 | .57 |
| 2005 | NA | NA | 24 | .45 | 124 | .24 | NA | NA | .35 |
| 2006 | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | May | | June | | July | | August | | Mean |
|---|---|---|---|---|---|---|---|---|---|
| Year | Hours | C/E | Hours | C/E | Hours | C/E | Hours | C/E | Mean |
| 2007 | NA | NA | NA | NA | 11 | 0 | NA | NA | NA |
| 2008 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2009 | 14 | .07 | 63 | .06 | 31 | .29 | NA | NA | .14 |

**Table 33. (continued) Riffe Lake angler hours and catch per hour (all fish). C/E= catch per hour.**

**Shore anglers.**

| | May | | June | | July | | August | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Hours | C/E | Hours | C/E | Hours | C/E | Hours | C/E | Mean |
| 1985 | NA | NA | 2,067 | .34 | 1,544 | .28 | 744 | .33 | .32 |
| 1986 | 1,462 | .18 | 1,656 | .36 | 2,290 | .34 | 570 | .05 | .23 |
| 1987 | 1,658 | .40 | 2,734 | .31 | 1,661 | .30 | 790 | .14 | .29 |
| 1989 | 565 | .28 | 1,177 | .42 | 627 | .30 | 200 | .21 | .30 |
| 1990 | 573 | .48 | 700 | .45 | 666 | .16 | 444 | .25 | .34 |
| 1991 | 808 | .22 | 554 | .19 | 710 | .19 | 300 | .14 | .19 |
| 1992 | 837 | .23 | 584 | .29 | 305 | .30 | 129 | .18 | .25 |
| 1993 | 516 | .48 | 1,147 | .44 | 692 | .30 | 292 | .30 | .38 |
| 1994 | 446 | .42 | 849 | .90 | 795 | .66 | 367 | .23 | .55 |
| 1995 | 341 | .45 | 517 | .52 | 440 | .32 | 227 | .13 | .36 |
| 1996 | 594 | .16 | 543 | .17 | 694 | .20 | 343 | .11 | .16 |
| 1997 | 175 | .36 | 272 | .93 | NA | NA | NA | NA | .65 |
| 1998 | 407 | .26 | 682 | .45 | 716 | .24 | 472 | .27 | .31 |
| 1999 | 327 | .29 | 833 | .34 | 1,162 | .37 | 741 | .21 | .30 |
| 2000* | 767 | .25 | 987 | .65 | 145 | .13 | 126 | .17 | .30 |
| 2001 | NA | NA | 31 | .90 | 760 | .38 | 87 | .13 | .47 |
| 2002 | NA | NA | 428 | .38 | 337 | .29 | 126 | .24 | .30 |
| 2003 | NA | NA | 626 | .42 | 221 | .05 | 45 | .11 | .19 |
| 2004 | 77 | .38 | 790.75 | .38 | 321 | .11 | 109 | .12 | .25 |
| 2005 | NA | NA | 519.65 | .28 | 307 | .12 | 120 | .05 | .15 |
| 2006 | NA | NA | 223.5 | .51 | 193.5 | .45 | 107.25 | .26 | .41 |
| 2007 | 23.35 | .30 | 178 | .096 | 64 | .12 | 160.5 | .17 | .17 |
| 2008 | NA | NA | 42 | .55 | 545.5 | .43 | 115.5 | .31 | .43 |
| 2009 | 105 | .20 | 1105 | .19 | 284 | .28 | 41 | .02 | .17 |

* No excess coho juveniles from CSH planted after 1999.

# Coho Sport Harvest in Upper Cowlitz Basin

## Coho Creel Surveys

Creel surveys were conducted in the Upper Cowlitz and Cispus Basins to determine the harvest rates on hatchery coho transported upstream (Table 34). Creel surveys were conducted at three fish release locations: Franklin Bridge in Packwood on the Cowlitz River, Lake Scanewa at the Day Use Park, and the Forest Road 2810 site located on the Cispus River.

Intensive creel surveys have been conducted since 2007. The first two years of the creel surveys were focused primarily at Franklin Bridge in Packwood. This year we continued to conduct surveys at Packwood but also, emphasized the Day Use Park at Lake Scanewa to better understand that fishery and harvest rate. The surveys were conducted approximately ½ mile upstream and ½ mile downstream of these locations. All sport fishery effort on the Cowlitz and Cispus Rivers were by bank anglers and the majority of fishing effort occurred at these two locations of because of limited public access. At Lake Scanewa, there were bank and boat anglers. There was only one boat launch on the lake that anglers used, which is located at the Day Use Park.

The surveys at Franklin Bridge started on September 23rd and were completed on December 27th. At Lake Scanewa, the surveys started on September 23rd and were completed on December 13th when the lake froze over. At the Cispus River, we didn't focus on trying to determine harvest because of the low numbers of fish released, when releases occurred (mid-November), and the minimal angler effort. A few sporadic surveys were completed but harvest couldn't be determined or extrapolated.

The creel survey study design was stratified by weekends and weekdays. The data obtained on survey days were expanded for that week to non-survey days. Creel surveys were 8 to 10 hours per day or until the anglers were done fishing. The surveys generally started around 9 am and were completed around 6 pm, or when anglers finished fishing. A complete census of harvest during each survey day was attempted at Lake Scanewa and Franklin Bridge locations. The survey data was expanded to determine the effort and catch at Franklin Bridge and at the Day Use Park on Lake Scanewa. Once the data were expanded, the data for the week (Monday – Sunday) were pooled to obtain a weekly total for number of anglers, hours fished, and fish caught and harvested. Effort estimates were made by observing the total number of anglers coming and going during the survey.

In 2009, 21,019 hatchery adult coho were transported above Cowlitz Falls Dam to the three release locations (Table 34). This was the largest number of fish transported in the last three years. Lake Scanewa and Franklin Bridge had about equal number of fish released. The Cispus River had less fish released with the goal to increase the percentage of natural origin fish on the spawning grounds in that river system.

**Table 34. Total live adult hatchery coho transported to each upstream location in 2007, 2008, and 2009.**

| Site | 2007 | 2008 | 2009 |
|---|---|---|---|
| Lake Scanewa | 2,140 | 4,138 | 7,375 |
| Franklin bridge | 2,652 | 6,617 | 7,376 |
| Cispus River | 899 | 2,989 | 1,182 |
| Tilton River | 1,456 | 1,793 | 3,066 |
| Mayfield Lake | 123 | 7 | 11 |
| Riffe Lake | 3,923 | 0 | 0 |
| **Total** | **13,200** | **17,552** | **21,019** |

Creel surveys started September 23rd when large numbers of fish were released in the Upper Basin. The surveys were completed when the fish transportation goals were met and hatchery fish were no longer transported upstream. The creel program had a high survey rate for the total fishing days available. At Franklin Bridge, 63% of the total fishing days were surveyed and at Lake Scanewa, 58% of the total fishing days were surveyed (Table 35). In 2009, the fishing regulation was a 6 fish limit and release of all wild fish.

**Table 35. Number of days creel surveys were conducted per week at each Upper Basin location.**

| | Franklin Bridge | Lake Scanewa | Cispus River |
|---|---|---|---|
| Sept 23 - 27 | 3 | | |
| Sept 28 - Oct 4 | 5 | 5 | 0 |
| Oct 5 - 11 | 5 | 5 | 0 |
| Oct 12 - 18 | 5 | 5 | 0 |
| Oct 19 - 25 | 5 | 5 | 0 |
| Oct 26 - Nov 1 | 4 | 5 | 0 |
| Nov 2 - 8 | 5 | 4 | 0 |
| Nov 9 - 15 | 4 | 3 | 0 |
| Nov 16 - 22 | 6 | 4 | 1 |
| Nov 23 - 29 | 5 | 4 | 2 |
| Nov 30 - Dec 6 | 4 | 5 | 3 |
| Dec 7 - 13 | 5 | 1 | 1 |
| Dec 14 - 20 | 4 | 0 | 0 |
| Dec 21 - 27 | 2 | 0 | 0 |
| Total | 62 | 46 | 7 |
| days sampled out of season (98 days) | 63% | 58% | 7% |

* 98 total fishing days at Franklin Bridge and 79 total fishing days at Lake Scanewa (lake froze over on December 9th limiting fishing opportunity).

## Results and Discussion

At Franklin Bridge, for the season an estimated 1,120 coho were caught with 923 harvested (Table 36). An estimated 966 shore anglers participated in the fishery and fished over 4,042 hours from September 23rd through December 27th. Harvest rates were highest the week of November 9 – 15th and December 7 – 13th with about 2 fish per angler and a catch per unit effort of 0.44 and 0.37 fish per hour. This year we did not observe a higher catch rate immediately after fish were released. This may have been related to water visibility or velocities near the release location. Also, fish were released on most days so effort was more similar between days within a week. In previous years, releases occurred 2-3 days per week. Also, four natural origin return (NOR) coho were caught and released at Franklin Bridge. A low catch rate on NOR fish was expected because all NORs were released into Lake Scanewa. An estimated 206 hatchery coho were caught and released at Franklin Bridge. Fish were released because they were either dark or foul hooked. Lastly, anglers were only targeting coho at this location.

At Lake Scanewa, for the season, boat and shore anglers caught 532 hatchery coho and harvested 294 (Tables 37 and 38). Boat anglers were more successful than shore anglers. Harvest rates were highest during the weeks of November 23 – December 6th for boat anglers and November 30th – December 6th for shore anglers. During those weeks, harvest was 2.8 and 2.3 fish per angler with a catch per unit effort of 0.13 and 0.4 fish per hour. An estimated 153 natural origin coho (22% of the catch) were caught and released during the fishery this season. This catch and release was about 2.7% of the natural origin coho transported upstream.

The fishery at Lake Scanewa was dependent on weather conditions and lake visibility. Rainy and windy days had less effort and if winds came up in the middle of the day many boats come in for the day. Overall, the effort for this fishery was variable with people coming and going throughout the day. Also, we did not observe a higher catch rate immediately after fish were released. Catch rates did increase later in the season as the air temperature dropped and the lake cleared up. Salmon and trout anglers were not separated in the totals. The majority of anglers that targeted trout were fishing from the shore, however there were a few boat anglers fishing for trout. Also, some waterfowl hunters launched boats at the Day Use Park and these boats were removed from the analysis.

Table 36. Total estimated effort and catch at Franklin Bridge, Packwood in 2009.

| | Fish released (HOR) | # of Anglers | # of hours fished | Adults caught | Adults harvested | % Harvested | Fish caught/ angler |
|---|---|---|---|---|---|---|---|
| Sept 23 - 27 | 644 | 67 | 207.8 | 24 | 22 | 3.4% | 0.4 |
| Sept 28 - Oct 4 | 659 | 53 | 207 | 36 | 33 | 5.0% | 0.7 |
| Oct 5 - 11 | 786 | 99 | 447 | 131 | 126 | 16.0% | 1.3 |
| Oct 12 - 18 | 687 | 53 | 223.5 | 80 | 58 | 8.4% | 1.5 |
| Oct 19 - 25 | 679 | 126 | 662 | 156 | 124 | 18.3% | 1.2 |
| Oct 26 - Nov 1 | 703 | 82 | 335 | 66 | 50 | 7.1% | 0.8 |
| Nov 2 - 8 | 654 | 87 | 342.5 | 89 | 63 | 9.6% | 1.0 |
| Nov 9 - 15 | 669 | 123 | 467 | 241 | 208 | 31.1% | 2.0 |
| Nov 16 - 22 | 654 | 40 | 151 | 24 | 22 | 3.4% | 0.6 |
| Nov 23 - 29 | 260 | 45 | 181 | 34 | 24 | 9.2% | 0.8 |
| Nov 30 - Dec 6 | 260 | 70 | 368 | 93 | 68 | 26.2% | 1.3 |
| Dec 7 - 13 | 258 | 66 | 274 | 128 | 101 | 39.1% | 1.9 |
| Dec 14 - 20 | 0 | 28 | 81 | 15 | 12 | | 0.5 |
| Dec 21 - 27 | 0 | 27 | 95.5 | 12 | 12 | | 0.4 |
| **Total** | **6,913** | **966** | **4042.3** | **1,129** | **923** | **16.3%** | **1.04** |

Table 37. Total estimated effort and catch by shore anglers at Lake Scanewa in 2009.

| | Fish released (HOR) | # of Anglers | # of hours fished | Adults caught | Adults harvested | % Harvested | Fish caught/ angler |
|---|---|---|---|---|---|---|---|
| Sept 23 - 27 | 346 | 26 | 55 | 0 | 0 | 0.0% | 0.0 |
| Sept 28 - Oct 4 | 623 | 36 | 97 | 7 | 3 | 0.4% | 0.2 |
| Oct 5 - 11 | 824 | 23 | 64 | 1 | 0 | 0.0% | 0.1 |
| Oct 12 - 18 | 1125 | 21 | 62 | 7 | 4 | 0.3% | 0.3 |
| Oct 19 - 25 | 750 | 27 | 88 | 4 | 4 | 0.5% | 0.1 |
| Oct 26 - Nov 1 | 595 | 29 | 74 | 3 | 0 | 0.0% | 0.1 |
| Nov 2 - 8 | 687 | 7 | 20 | 0 | 0 | 0.0% | 0.0 |
| Nov 9 - 15 | 502 | 0 | 0 | 0 | 0 | 0.0% | 0.0 |
| Nov 16 - 22 | 387 | 2 | 6 | 0 | 0 | 0.0% | 0.0 |
| Nov 23 - 29 | 133 | 22 | 48 | 8 | 3 | 2.1% | 0.4 |
| Nov 30-Dec 6 | 141 | 11 | 20 | 30 | 10 | 6.8% | 2.8 |
| Dec 7 - 13 | 28 | 1 | 5 | 1 | 1 | 3.6% | 1.0 |
| **Total** | **6,141** | **142** | **383** | **54** | **21** | **0.3%** | |

**Table 38. Total estimated effort and catch by boat anglers at Lake Scanewa in 2009.**

| | Fish released (HOR) | # of boats | # of hours fished | Adults caught | Adults harvested | % harvested | Fish caught/boat |
|---|---|---|---|---|---|---|---|
| Sept 23 - 27 | 346 | 38 | 350 | 7 | 7 | 2.0% | 0.2 |
| Sept 28 - Oct 4 | 623 | 44 | 471 | 17 | 16 | 2.6% | 0.4 |
| Oct 5 - 11 | 824 | 69 | 704 | 41 | 23 | 2.8% | 0.6 |
| Oct 12 - 18 | 1125 | 53 | 807 | 20 | 18 | 1.6% | 0.4 |
| Oct 19 - 25 | 750 | 34 | 504 | 32 | 18 | 2.4% | 0.9 |
| Oct 26 - Nov 1 | 595 | 22 | 260 | 13 | 7 | 1.2% | 0.6 |
| Nov 2 - 8 | 687 | 54 | 792 | 116 | 59 | 8.6% | 2.1 |
| Nov 9 - 15 | 502 | 50 | 597 | 107 | 50 | 10.0% | 2.1 |
| Nov 16 - 22 | 387 | 12 | 80 | 18 | 5 | 1.3% | 1.5 |
| Nov 23 - 29 | 133 | 24 | 326 | 55 | 39 | 29.3% | 2.3 |
| Nov 30-Dec 6 | 141 | 22 | 197 | 50 | 28 | 19.9% | 2.3 |
| Dec 7 - 13 | 28 | 2 | 8 | 2 | 2 | 7.1% | 1.0 |
| **Total** | **6,141** | **424** | **5,096** | **478** | **272** | **4.4%** | |

## Coho Harvest Comparison Among Years at the Franklin Bridge, Packwood Site

The number of fish transported to the Packwood site on the Upper Cowlitz River was highest in 2009 compared to the previous two years. For the month of October, even though there were more fish transported in 2009 than in 2008, there were more anglers fishing in 2008 during this time period. The catch per unit effort (CPUE) was variable between weeks in a year and among years. The CPUE didn't increase as more fish were transported to the Upper Cowlitz Basin. This may be because fish dispersed from the area where released. The 2009 year had the highest number of fish harvested (Table 40) however; it also had the highest number of fish released. In 2009, the catch rate was 16% compared to 2007 when the catch rate was 15%. Comparing these two years about 40% more fish were released (7,800 fish) in 2009, than in 2007. In 2008, the catch rate was 13% and about 25% more fish were released (4,300 fish) than in 2007. Harvest in 2008 may have been similar to 2009 if a flood event had not occurred in mid-December.

## Comparison with Catch Record Card Data

The preliminary catch record card (CRC) data was available for 2007 and 2008. I compared those years' data to the creel data we collected in the Upper Cowlitz Basin (Table 39). According to the catch record card data, the creel surveys (after extrapolation) accounted for about 70% of the catch overall. There were a few months, such as December of 2007 and 2008 that harvest was higher than reported on the catch record cards. However, based on the CRC data, we underestimated the harvest from our creel surveys. Some reasons for the different results could be: anglers mis-report catch areas, fish were caught outside creel areas, anglers left before or after creel surveys, or the variation between days on harvest levels could affect the data extrapolation.

**Table 39. A comparison of the preliminary catch record card (CRC) data to the estimated harvest data collected from the creel surveys conducted in 2007 and 2008.**

| Location | | Sept | Oct | Nov | Dec | Jan | Total |
|---|---|---|---|---|---|---|---|
| Cowlitz River above Cowlitz Falls | 2007 Creel | no data | no data | 187* | 129* | | 316 |
| | 2007 CRC | 19 | 118 | 280 | 118 | | 535 |
| | 2008 Creel | | 598 | 182 | 40** | no data | 820 |
| | 2008 CRC | 82 | 798 | 316 | 13 | 6 | 1,215 |
| Cispus River | 2007 Creel | | no data | 24 | | | 24 |
| | 2007 CRC | | 44 | 19 | | | 63 |
| | 2008 Creel | | 56 | 10 | no data | | 66 |
| | 2008 CRC | | 89 | 76 | 19 | | 184 |

*In 2007, Lake Scanewa harvest was not included in the creel surveys. Therefore, the creel estimate only accounts for Franklin Bridge, Packwood harvest and should be lower than CRC data.
**In 2008, creel surveys were only completed for ½ the month of December.

**Table 40. Comparison of fish harvested at Franklin Bridge, Packwood in 2007, 2008, and 2009.**

| Week | 2009 | 2008 | 2007 |
|---|---|---|---|
| Sept 23 - 27 | 22 | | |
| Sept 28 - Oct 4 | 33 | | |
| Oct 5 - 11 | 126 | 142 | |
| Oct 12 - 18 | 58 | 186 | |
| Oct 19 - 25 | 124 | 188 | |
| Oct 26 - Nov 1 | 50 | 76 | |
| Nov 2 - 8 | 63 | 39 | |
| Nov 9 - 15 | 208 | 2 | 30 |
| Nov 16 - 22 | 22 | 17 | 54 |
| Nov 23 - 29 | 24 | 55 | 103 |
| Nov 30 - Dec 6 | 68 | 11 | 21 |
| Dec 7 - 13 | 101 | 15 | 39 |
| Dec 14 - 20 | 12 | | 44 |
| Dec 21 - 27 | 12 | | 25 |
| **Total** | **923** | **731** | **316** |

## Creel Summary

A total of 1,108 shore anglers and 424 boats caught 1,760 fish during the creel surveys in 2009. Most of the effort and highest catch rate occurred at Franklin Bridge in Packwood. It doesn't appear that catch rates/effort increases with increased fish (releases). Recommendations for a successful fishery into the future include frequent releases of fish into all locations and advertising the fishery. If the number of hatchery fish need to be reduced, then smaller loads of fish should be transported to continue frequent releases of fish (i.e. daily releases). Additionally, it doesn't appear that the fishery in Lake Scanawa is intercepting large numbers of natural origin coho salmon.

# References

Blankenship, J.A. and J.A. Henning. 2010. The differentiation of fall and spring Chinook stocks at Mayfield Collection Facility, 2006 – 2009. Washington Department of Fish and Wildlife. Toledo, WA.

Henning, J.A. and S. M. Blankenship. 2009. The differentiation of fall and spring Chinook stocks at Mayfield Collection Facility, 2008. Washington Department of Fish and Wildlife. Toledo, WA.

Murray, K. 2010. Spatial and temporal analysis of Chinook salmon redds from historical and current aerial surveys on the Cowlitz River, Washington. Master's Thesis. University of Washington. 35p.

Small, M., A. R. Marshall, J. Henning, and J. Von Bargen. (2009). Genetic relationships among naturally spawning Steelhead (*Oncorhynchus mykiss*) in lower Cowlitz River tributaries and hatchery Steelhead stocks released in the Cowlitz Basin: implications for recovery planning. Washington Department of Fish and Wildlife. Olympia, WA 38p.

Small, M., A. R. Marshall, J. Henning, and J. Von Bargen. (2010). Genetic relationships among naturally spawning Steelhead (*Oncorhynchus mykiss*) in lower Cowlitz River tributaries and hatchery Steelhead stocks released in the Cowlitz Basin: implications for recovery planning. Washington Department of Fish and Wildlife. Olympia, WA 46p.

# Appendix 1. Chum salmon radio telemetry information for each fish tagged and location tracked in 2009.

| Date Activated | Frequency | Code | Sex | FL | DNA |
|---|---|---|---|---|---|
| 07/10/09 | 149.420 | 159 | F | 54cm | 09gy#1 |
| Not Recovered | Date | Time | | Site Description | RM |
| | 07/10/09 | 12:00 p.m. | | Barrier Boat Ramp | 49.3 |
| | 07/13/09 | 8:45 a.m. | | Barrier pool | 49.6 |
| | 07/14/09 | 1:15 p.m. | | Barrier pool | 49.6 |
| | 07/16/09 | 1:30 p.m. | | Barrier pool | 49.6 |
| | 07/17/09 | 12:00 p.m. | | Barrier pool | 49.6 |
| | 07/20/09 | 12:15 p.m. | | Top of S curves | 45.5 |
| | 07/20/09 | 4:00 p.m. | | Bottom of S curves | 45.4 |
| | 07/21/09 | 7:15 a.m. | | Bottom of S curves | 45.4 |
| | 07/21/09 | 3:30 p.m. | | Belfor Bar | 44.5 |
| | 07/22/09 | 8:50 a.m. | | Belfor Bar | 44.5 |
| | 07/22/09 | 4:15 p.m. | | Coal mine | 44.2 |
| | 07/23/09 | 12:00 p.m. | | Wallace rock pit | 28 |
| | 07/24/09 | 1:00 p.m. | | Gearhart Gardens | 1.7 |
| | 07/24/09 | 1:40 p.m. | | Mouth of Cowlitz | 0 |
| Date Activated | Frequency | Code | Sex | FL | DNA |
| 07/13/09 | 149.520 | 161 | F | 63cm | 09gy#2 |
| Not Recovered | Date | Time | | Site Description | RM |
| | 07/13/09 | 2:50 p.m. | | Barrier Boat Ramp | 49.3 |
| | 07/14/09 | 9:10 a.m. | | Barrier Boat Ramp | 49.3 |
| | 07/14/09 | 1:15 p.m. | | Barrier Boat Ramp | 49.3 |
| | 07/15/09 | 9:15 a.m. | | Barrier Boat Ramp | 49.3 |
| | 07/16/09 | 9:10 a.m. | | Barrier Boat Ramp | 49.3 |
| | 07/16/09 | 1:30 p.m. | | Barrier Boat Ramp | 49.3 |
| | 07/17/09 | 12:00 p.m. | | Barrier Boat Ramp | 49.3 |
| | 07/20/09 | 8:25 a.m. | | Barrier Pool | 49.6 |
| | 07/20/09 | 11:50 a.m. | | Barrier Pool | 49.6 |
| | 07/21/09 | 7:25 a.m. | | Barrier Pool | 49.6 |
| | 07/21/09 | 3:15 p.m. | | Barrier Pool | 49.6 |
| | 07/22/09 | 9:00 a.m. | | Middle of ladder | 49.8 |
| | 07/22/09 | 4:00 p.m. | | Lower ladder | 49.7 |
| | 07/23/09 | 10:00 a.m. | | Barrier Pool | 49.6 |
| | 07/24/09 | 9:30 a.m. | | Barrier Pool | 49.6 |
| | 07/24/09 | 3:45 p.m. | | Barrier Pool | 49.6 |
| | 07/27/09 | 8:55 a.m. | | Barrier Pool | 49.6 |
| | 07/27/09 | 2:20 p.m. | | Barrier Pool | 49.6 |
| | 07/28/09 | 10:15 a.m. | | Barrier Boat Ramp | 49.3 |

| Date Activated | Frequency | Code | Sex | FL | DNA |
|---|---|---|---|---|---|
| 07/13/09 | 149.520 | 161 | F | 63cm | 09gy#2 |
| Not Recovered | Date | Time | | Site Description | RM |
| | 07/29/09 | 9:00 a.m. | | Boulder Garden | 49 |
| | 07/30/09 | 9:30 a.m. | | Boulder Garden | 49 |
| | 07/31/09 | 1:00 p.m. | | Barrier Boat Ramp | 49.3 |
| | 08/03/09 | 9:15 a.m. | | Boulder Garden | 49 |
| | 08/03/09 | 12:00 p.m. | | Slot above alcove | 49.1 |
| | 08/04/09 | 9:30 a.m. | | Slot above alcove | 49.1 |
| | 08/05/09 | 4:00 p.m. | | Slot above alcove | 49.1 |
| | 08/06/09 | 12:00 p.m. | | Slot above alcove | 49.1 |
| | 08/10/09 | 8:30 a.m. | | Slot above alcove | 49.1 |
| | 08/11/09 | 3:50 p.m. | | Slot above alcove | 49.1 |
| | 08/14/09 | 9:00 a.m. | | Slot above alcove | 49.1 |
| | 08/17/09 | 3:30 p.m. | | Slot above alcove | 49.1 |
| | 08/18/09 | 3:00 p.m | | Boulder Garden | 49 |
| | 08/20/09 | 10:15 a.m. | | Barrier Boat Ramp | 49.3 |
| | 08/21/09 | 12:00 p.m. | | Barrier Boat Ramp | 49.3 |
| | 08/24/09 | 1:30 p.m. | | Barrier Boat Ramp | 49.3 |
| | 08/27/09 | 8:15 a.m. | | Barrier Boat Ramp | 49.3 |
| | 09/01/09 | 11:00 a.m. | | Barrier Boat Ramp | 49.3 |
| | 09/02/09 | 9:15 a.m. | | Barrier Boat Ramp | 49.3 |
| | 10/23/10 | Tag recovered in garbage can at Baker Rock | | | 47.6 |
| Date Activated | Frequency | Code | Sex | FL | DNA |
| 07/24/09 | 149.520 | 165 | F | 57cm | 09gy#3 |
| Not Recovered | Date | Time | | Site Description | RM |
| | 07/24/09 | 11:40 a.m. | | Barrier Boat Ramp | 49.3 |
| | 07/24/09 | 3:50 p.m. | | Barrier Boat Ramp | 49.3 |
| | 07/27/09 | 2:40 p.m. | | Lewis' River House | 48.2 |
| | 07/28/09 | | | Could not locate | |
| Date Activated | Frequency | Code | Sex | FL | DNA |
| 07/27/09 | 149.520 | 162 | M | 65cm | 09Gy#4 |
| Not Recovered | Date | Time | | Site Description | RM |
| | 07/27/09 | 2:15 p.m. | | Barrier Boat Ramp | 49.3 |
| | 07/28/09 | 10:15 a.m. | | Boulder Garden | 49 |
| | 07/29/09 | 2:45 p.m. | | Ethel Bar | 43.6 |
| | 07/31/09 | 1:25 p.m. | | Ethel Bar | 43.6 |
| | 08/03/09 | 9:00 a.m. | | Blue Creek Ramp | 42.5 |
| | 08/03/09 | 3:15 p.m. | | Blue Creek Ramp | 42.5 |
| | 08/04/09 | 11:30 a.m. | | Taylor Crane Rd. | 22.7 |
| | 08/05/09 | | | Could not locate | |

| Date Activated | Frequency | Code | Sex | FL | DNA |
|---|---|---|---|---|---|
| 09/14/09 | 149.520 | 164 | M | 75 | 09gy#5 |
| Not Recovered | Date | Time | | Site Description | RM |
| | 09/14/09 | 3:50 p.m | | Barrier Boat Ramp | 49.3 |
| | 09/15/09 | 1:00 p.m. | | Tailout of B.C. Boat ramp | 42.2 |
| | 09/16/09 | | | Could not locate | |
| Date Activated | Frequency | Code | Sex | FL | DNA |
| 10/14/09 | 149.520 | 163 | M | 75cm | 09gy#8 |
| Recovered | Date | Time | | Site Description | RM |
| | 10/14/09 | 4:30 p.m. | | Barrier Boat Ramp | 49.3 |
| | 10/15/09 | 9:00 a.m. | | Baker Rock | 47.7 |
| | 10/16/09 | 1:30 p.m. | | Baker Rock | 47.7 |
| | 10/19/09 | 12:00 p.m. | | Baker Rock | 47.7 |
| | 10/20/09 | 3:45 p.m. | | Baker Rock | 47.7 |
| | 12/01/09 | Tag recovered | | Near Toledo Bridge | 34.8 |
| Date Activated | Frequency | Code | Sex | FL | DNA |
| 11/24/09 | 149.520 | 158 | M | 83 | 09gy#10 |
| Not Recovered | Date | Time | | Site Description | RM |
| | 11/24/09 | 3:00 p.m. | | Barrier Boat Ramp | 49.3 |
| | 11/25/09 | | | Could not locate | |

# Appendix 2
# The Differentiation of Fall and Spring Chinook Stocks at Mayfield Collection Facility, 2006-2009

# The Differentiation of Fall and Spring Chinook Stocks at Mayfield Collection Facility, 2006-2009

Developed for
Tacoma Public Utilities, Tacoma Power

Report by

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## Introduction

Chinook salmon (*Oncorhynchus tshawytscha*) in the Cowlitz River Basin are included in the Lower Columbia River Evolutionarily Significant Unit (ESU). Recovery efforts in the Cowlitz system include transporting adult salmon and releasing them above dams to spawn (Henning and Blankenship, 2006). Fishery managers have focused on reintroducing fall Chinook into the Tilton River and spring Chinook to the upper Cowlitz and Cispus Rivers. Juvenile fall Chinook produced in the Tilton River Basin migrate downstream through Mayfield Reservoir and enter the Mayfield Dam Collection Facility where they are identified to species, enumerated, and wire tagged. Juvenile spring Chinook that originate from the upper Cowlitz and Cispus Rivers are captured at the Cowlitz Falls Collection Facility and transported to the lower Cowlitz River. The Cowlitz Falls Collection Facility has low capture efficiency for subyearling spring Chinook, with a seasonal average capture efficiency of 25% over the last 3 years (J. Serl, personal communication February 16, 2007). Therefore, juveniles not captured in the trap may enter Riffe Reservoir through Cowlitz Falls Dam. If these juveniles subsequently navigate through Riffe Reservoir and Mossyrock Dam, there is the potential for these fish to enter the Mayfield Collection Facility via the Mayfield Reservoir and confound production estimates at the Mayfield Collection Facility. To date, there are no physical characteristics to differentiate juvenile fall and spring Chinook. A length criteria was evaluated in 2007 to determine if it could be used to differentiate stocks, however the correlation between date and fork length was uninformative regarding temporal run (Henning and Blankenship, 2006). Therefore, a stock identification method based on genetic information has been investigated as a means of determining run of origin for juvenile Chinook migrating through Mayfield Dam.

This report analyzes the stock composition of juvenile Chinook captured at the Mayfield Collection Facility in 2009. In addition, this is the final report of a four-year investigation of Chinook stock composition observed at the Mayfield Dam Collection Facility. Data are included from the 2006 – 2008 studies. As described in previous studies, our primary objective was to identify and quantify run-of-origin (i.e., spring and fall) for Chinook migrants captured at the Mayfield Collection Facility using genetic data to provide an estimate of run composition independent from the current management regime. Run identity was determined using genetic mixed stock analysis.

## Materials and Methods

*Field Sampling*

In 2009, genetic samples were collected randomly from juvenile Chinook salmon migrating through the Mayfield Dam from August 21 – December 7, which was slightly later than previous years' collection timeframe (Table 1). Genetic samples were obtained from a small non-lethal fin clip. In addition to obtaining a tissue sample, collection date, length and weight data were taken on the juvenile samples. To reduce assignment error related to data content, only individuals with genotypes consisting of at least nine loci were used for genetic analysis. For the new collection from 2009, N=333 juveniles were analyzed.

**Table 1** Summary of tissue samples analyzed for emigrating juveniles captured at the Mayfield Collection Facility2006 - 2009.

| Date | 2006 | 2007 | 2008 | 2009 | Total |
|---|---|---|---|---|---|
| **Jul 1 - 15** | 20 | 35 | 0 | 0 | 55 |
| **Jul 16 - 30** | 79 | 20 | 49 | 0 | 148 |
| **Aug 1 - 15** | 16 | 29 | 89 | 0 | 134 |
| **Aug 16 - 31** | 64 | 40 | 103 | 2 | 209 |
| **Sep 1 - 15** | 57 | 48 | 86 | 23 | 214 |
| **Sep 16 - 30** | 58 | 44 | 158 | 27 | 287 |
| **Oct 1 - 15** | 30 | 78 | 106 | 76 | 290 |
| **Oct 16 - 31** | 30 | 53 | 95 | 94 | 272 |
| **Nov 1 - 15** | 0 | 31 | 56 | 37 | 124 |
| **Nov 16 - 30** | 0 | 17 | 38 | 58 | 113 |
| **Dec 1 - 15** | 0 | 0 | 0 | 14 | 14 |
| **Dec 16 - 31** | 0 | 0 | 0 | 0 | 0 |
| **unknown date** | 0 | 0 | 1 | 2 | 3 |
| **Total** | 354 | 395 | 781 | 333 | 1863 |

*Laboratory*

We performed polymerase chain reaction (PCR) amplification using the 13 fluorescently end-labeled microsatellite marker loci standardized as part of the Genetic Analysis of Pacific Salmonids (GAPS) project (Seeb et al. 2007). GAPS genetic loci are: *Ogo*2, *Ogo*4 (Olsen et al. 1998); *Oki*100 (unpublished); *Omm*1080 (Rexroad et al. 2001); *Ots*201b (unpublished); *Ots*208b, *Ots*211, *Ots*212, and *Ots*213 (Grieg et al. 2003); *Ots*3M, *Ots*9 (Banks et al. 1999); *Ots*G474 (Williamson et al. 2002); *Ssa*408 (Cairney et al. 2000). PCR reaction volumes were 10 µL, and contained 2 µL 5x PCR buffer (Promega), 0.6 µL MgCl2 (1.5 mM final) (Promega), 1.0 µL dNTP mix (0.2 mM final) (Promega), and 0.1 µL (5 units/mL) GoTaq DNA polymerase (Promega). Loci were amplified as part of multiplexed sets, so primer molarities and annealing temperatures varied. Multiplex One had an annealing temperature of 50°C, and used 0.37 Molar (M) *Oki*100, 0.35 M *Ots*201b, and 0.20 M *Ots*208b, and 0.20 M *Ssa*408. Multiplex Two had an annealing temperature of 60°C, and used 0.10 M *Ogo*2, and 0.25 M of a non-GAPS locus (*Ssa* 197). Multiplex Three had an annealing temperature of 56°C, and used 0.18 M *Ogo*4, 0.18 M *Ots*213, and 0.16 M *Ots*G474. Multiplex Four had an annealing temperature of 53°C, and used 0.26 M *Omm*1080, and 0.12 M *Ots*3M. Multiplex Five had an annealing temperature of 60°C, and used 0.30 M *Ots*212, 0.20 M *Ots*211, and 0.10 M *Ots*9. All thermal cycling was conducted on either a PTC200 thermal cycler (MJ Research) or 9700 (Applied Biosystems) as follows: 94°C (2 min); 39 cycles of 94°C for 10 sec., 30 sec. annealing, and 72°C for 1 min.; a final 72°C extension and then a 10°C hold. PCR products were visualized by electrophoresis on an ABI 3730 automated capillary sequencer (Applied Biosystems). Fragment analysis was completed using GeneMapper 3.7 (Applied Biosystems). Standardization of genetic data to GAPS allele standards was conducted following Seeb et al. (2007).

*Mixed Stock Analysis*

Population composition of mixture collections (e.g., emigrating juveniles) were estimated by using a partial Bayesian procedure based on the likelihood of unknown-origin genotypes being derived from reference stocks/populations, given the allele frequencies for those reference stocks/populations. In brief, the mixed stock analysis (MSA) procedure is as follows. Within a mixture, we first generated the conditional probability of each genotype occurring in each reference population, based on the allele frequencies in the reference populations, using equation 10 of Rannala and Mountain (1997) (i.e., probability of the genotype, conditioned on the allele frequencies for each reference population). For each genotype in the mixture, we then calculated the probability (i.e., posterior probability) that the sample was from each reference population by taking the Rannala and Mountain (1997) conditional probability and multiplying it by a prior, and then dividing by a normalizing constant. Initially, the prior was uniform, 1/N, where N is the number of populations used for the reference baseline. The initial probability matrix provided information about the likely source population for each unknown individual, but more importantly, provided an estimate of which reference populations were contributing to the unknown mixture. If the reference populations did not contribute equally to the mixture, the initial use of a uniform prior can be improved. The mean probability for a reference baseline population in the mixture analyzed (i.e., mean posterior probability over all unknown individuals) is the estimated contribution of that reference population to the mixture. Therefore, the population composition of the mixture was represented by the mean posterior probabilities of all reference collections from the initial matrix. This newly gained information about the population composition of the mixture replaced the uniform prior during an additional round of probability estimation to generate a second probability matrix. Once again, the mean posterior probabilities that represent estimates of baseline population contributions to the mixture were used as new priors. This iterative refinement of the probability matrix continued until the mean posterior probabilities change less than a predefined threshold from round to round. This procedure results in the maximum likelihood solution for stock composition (Millar 1987). The stock composition point estimate was then reported as a summation of the individual stock assignments. The MSA procedure was implemented using the program ONCOR (ST Kalinowski unpublished).

Assignment error (i.e., variance around composition point estimates) can be quantified by various means, and the error itself is influenced by several factors, from power and completeness of the reference baseline to composition of the mixture analyzed. One quantitative measure for assignment "quality" is the posterior probability of each assignment, which is the proportion of the total likelihood attributed to each baseline reporting group. For example, if an individual was assigned to fall-run with a probability 0.90, then 90% of the total probability for that individual was attributed to fall-run and 10% was attributed to the other reference baseline group(s). While a higher posterior probability may denote higher "quality", currently there is no agreed upon absolute probability threshold of "correct" assignment. Rather, a tolerated error for a given application is generally determined. Other quantitative measures of error can be obtained from analyzing the reference baseline itself. We report a bootstrap resampling procedure following Anderson et al. (2007) to estimate statistical expectations of assignment given the source populations were known. The Anderson et al. (2007) procedure resamples the baseline collections to produce a "new" baseline of identical size as the original, generates an "unknown" collection of user-specified size and composition, and then assigns the "unknowns" following the method described above (process repeated 1000 times). While the simulations do not directly analyze the actual mixtures (i.e., Mayfield juveniles), they do provide a statistical expectation for assignment error given the distinctiveness of reference collections.

An important factor modulating the assignment error is the source populations used in the analysis (i.e., reference baseline). Regarding the juvenile collections, because these individuals were captured exiting the Cowlitz system, they must have originated from the Cowlitz system, so the assignments were conducted using only the Cowlitz_H_fa and Cowlitz_H_sp GAPS reference collections. Therefore, stock composition (or individual assignments) of juvenile collections were extracted from the MSA and reported by collection (Cowlitz_H_fa and Cowlitz_H_sp), as these were the only collections used for analysis.

## Results/Discussion

*2009 Juvenile Migrants*

Of the N=333 juvenile Chinook salmon collected from Mayfield facility and analyzed from 2009, N=317 assigned to Cowlitz_H_fa and N=16 assigned to Cowlitz_H_sp. Accepting all assignments regardless of posterior probability, these individual assignment data estimate that the Mayfield collection in 2009 was composed of 95% fall-run and 5% spring-run. Please see conclusion section for discussion on variance of this reported point estimate.

*Summary of 2006 – 2009 Juvenile Migrants*

All juveniles genotyped (N=1863) were analyzed as a single "mixture" to maximize the information available to the assignment algorithm. Following the assignment, results were partitioned by time strata. Accepting all assignments regardless of posterior probability, these individual assignment data estimate that the Mayfield collections were composed 86%, 93%, 94%, and 95% Cowlitz_H_fall for years 2006 – 2009, respectively (Figure 1). The average estimated proportion of Cowlitz_H_fall over all years was 92%. Please see conclusion section for discussion on variance of these reported point estimates. The cumulative proportions of Cowlitz_H_fall captured through the sampling seasons are shown in Figure 2. The slight shift to later outmigration time observed 2006 – 2009 is a reflection of the sampling effort (see Table 1). Additionally, there was no observed relationship between capture date, size, and population assignment (Figure 3), corroborating the findings presented by Henning and Blankenship (2006).

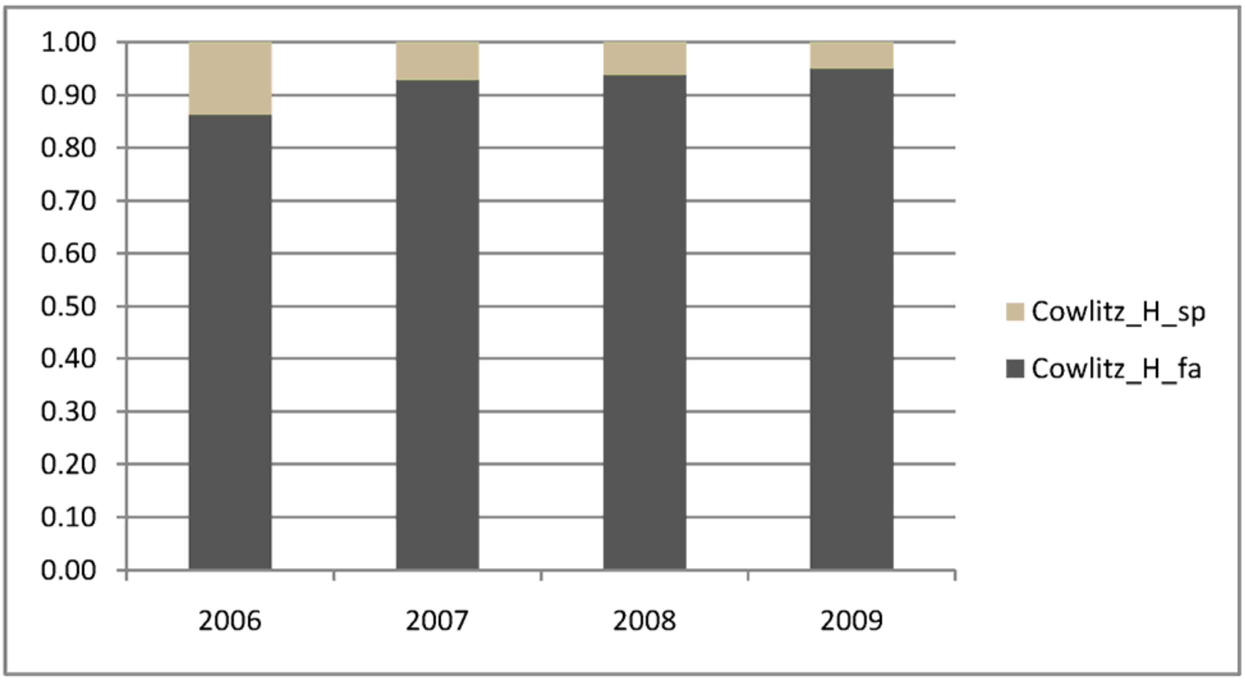


Figure 1. Proportion of individually assigned juvenile Chinook salmon by collection year.

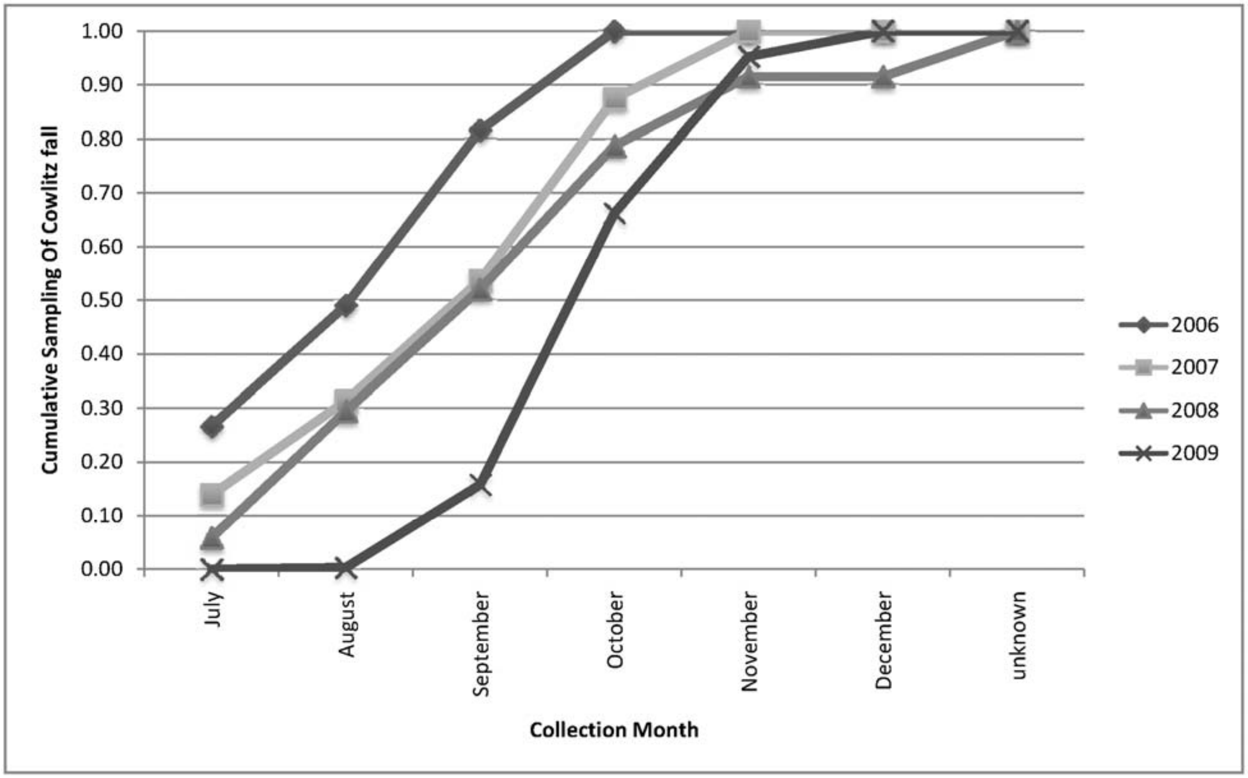


Figure 2. Cumulative proportion of Cowlitz fall Chinook collected by month during 2006 – 2009.

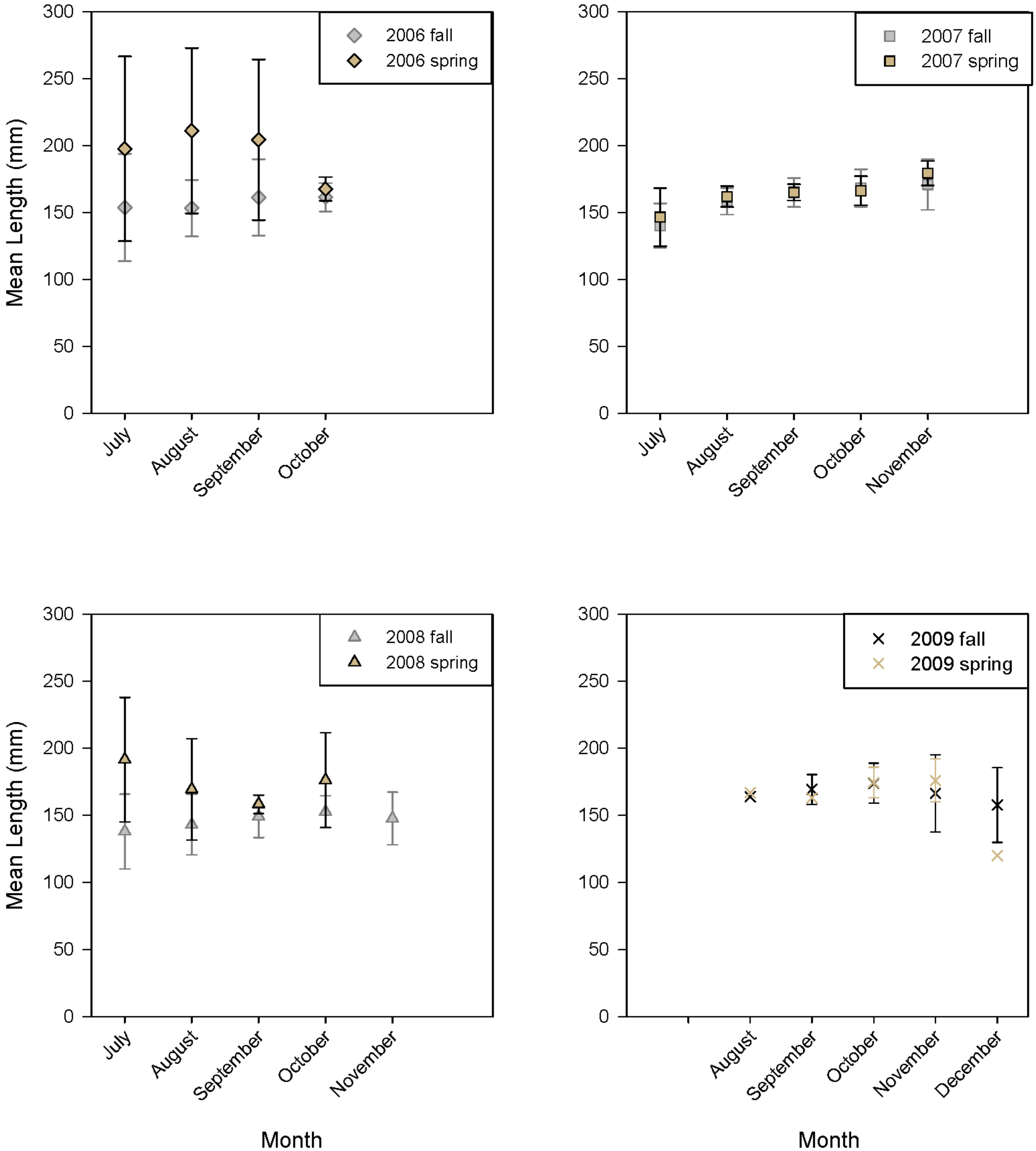


Figure 3. Mean length of juveniles captured by month and population assignment for years 2006 - 2009.

The probability distributions for assignments are shown in Table 2. The fall-run assignments showed a trend toward higher assignment probabilities than spring run. This is expected given the assignment errors observed fo the reference collections (see below). If assignments with posterior probabilities above 0.90 are considered, then the estimated composition of the juveniles (N=1632) was 96% fall and 4% spring.

**Table 2** Distribution of assignment probabilities for 1,863 juvenile Chinook salmon analyzed in 2006 – 2009.

| Collection | # Assigned | > 0.9 | 0.8 > x >0.5 |
|---|---|---|---|
| **Cowlitz_H_fa** | | | |
| **2006** | 304 | 91% | 9% |
| **2007** | 367 | 89% | 11% |
| **2008** | 734 | 91% | 9% |
| **2009** | 317 | 94% | 6% |
| **Cowlitz_H_sp** | | | |
| **2006** | 50 | 58% | 42% |
| **2007** | 28 | 39% | 61% |
| **2008** | 47 | 36% | 64% |
| **2009** | 16 | 25% | 75% |

Two general issues influence assignment probabilities: 1) the completeness of the reference baseline (i.e., all source populations present); and 2) the accurate characterization of reference collection genetic diversity and their distinctiveness. All populations that could contribute to Cowlitz River juvenile production are present in the reference baseline, so the assignment probabilities will not be misleading due to absent source populations (Issue #1). While the Cowlitz fall and spring reference collections have statistically different allele frequencies (data not shown), they are closely related genetically. This genetic affinity may result in certain genotypes having similar "likelihoods" calculated for both reference collections, which may result in low assignment probabilities and/or incorrect estimation of origin (Issue #2). We show this genetic similarity in Figure 4, a factorial correspondence analysis (FCA) plot on allele frequencies for the Cowlitz GAPS reference collections. In this FCA, the relationship between any two individuals in n-dimensional space (n = number of alleles) is represented by their $\chi^2$ distance. In this plot, the ordination is not based on all n-dimensions, but rather the three orthogonal vectors that represent the three largest sources of variance (i.e., eigen values) derived from the weighted contingency table (contingency table is individuals X alleles).

To what degree does the genetic similarity affect assignment probabilities? While we cannot currently calculate a specific assignment error for each juvenile analyzed, we can obtain a general expectation for error given the reference baseline. Following the Anderson et al. (2007) bootstrap resampling procedure, we obtained composition results for 1000 simulated collections of N=500 fall-run individuals from the reference baseline data. MSA was performed as described in methods on simulated datasets composed entirely of fall, and on average, 92.2% of individuals were assigned to fall run and 7.8% of individuals were incorrectly assigned to spring run. Therefore, it was statistically possible to obtain a fall run stock proportion estimate of 93% - 95% during 2007 – 2009 (i.e., observed results) if the collections were composed completely of fall-run juveniles. Expected assignment error would not completely account for the 86% fall (14% spring) estimate observed in 2006. Given the preponderance of fall-run individuals present in the actual juvenile collection, a hypothetical error rate of 8% would make detecting rare spring individuals difficult. This result can be shown by creating simulated mixtures containing 95% fall-run and 5% spring-run juveniles, and observing the accuracy of assignment and the types of assignment errors. Following Anderson et al. (2007), 1000 dataset of N=500 individuals (500,000 total individuals) were created, with each dataset being composed of 95% fall. Assignments were

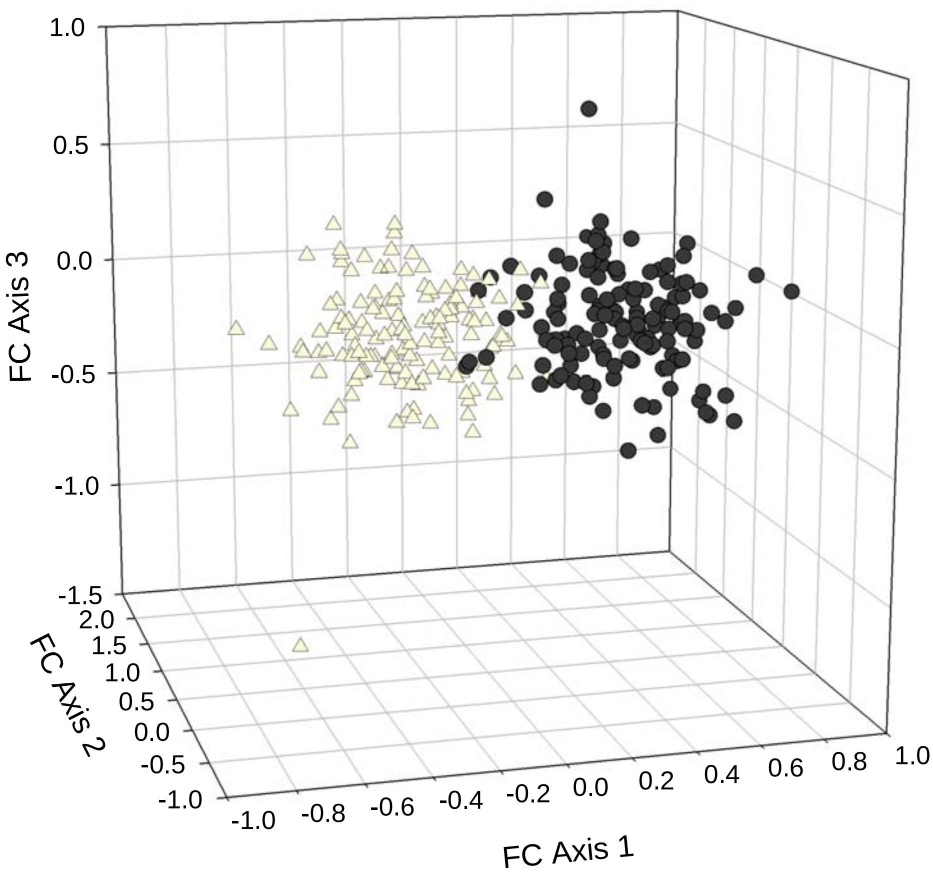


Figure 4. Factorial correspondence plot of Cowlitz Hatchery fall and spring GAPS reference baseline collections.

conducted as described in the methods and are summarized in Table 3. Given the simulation parametric value of 95% fall, N=475,000 individuals should have assigned to fall and 25,000 individuals should have assigned to spring, if no assignment error was present. In other words, "actual fall" should only be present in the "estimated fall" cell and "actual spring" should only be present in the "estimated spring" cell. The assignment errors are the "actual fall" estimated as spring (N=44,587) and the "actual spring" estimated as fall (N=6,389). The magnitudes of Type-1 and Type-2 assignment errors were calculated from these erroneously assigned individuals

(Table 4). Ninety-one percent of the fall-origin individuals were estimated to be fall, giving a 9% Type-1 error for fall. Additionally, of the individuals estimated to be fall, 99% were of fall-origin, giving a 1% Type-2 error for fall. These observed errors show that if an individual is of fall origin it will likely be assigned as fall (i.e., high confidence) and if an individual is not of fall origin it will likely be excluded from assignment to fall (i.e., high power). In contrast, there are much larger assignment errors for spring run. Notably, the Type-2 error for spring is 71%. Despite a small assignment error for fall run, most of the individuals present are fall run in origin, which results in a large proportion of estimated spring individuals being falsely assigned. In fact, more fall individuals falsely assigned to spring than there were spring present in the dataset. Therefore, the reference collections have insufficient power to reliably detect spring run at low abundance levels.

*Conclusions*

Due to the genetic similarity between Cowlitz fall and spring Chinook, there are errors when individuals of unknown origin are assigned to population using genetic mixed stock analysis methods. Cumulatively, assignment error biases downward the estimates of fall Chinook in mixtures of juveniles from the Mayfield Collection Facility. For example, a collection composed entirely of fall run, will appear (on average) to be 92% fall and 8% spring. The question then arises as to what is the variance around point estimates of stock composition? We chose to approach this issue using simulation, where mixtures of known composition were constructed following Anderson et al. (2007) and the simulation results were compared to estimates from the actual mixtures of juveniles collected from the Mayfield facility. Figure 5 shows the distribution of fall-run assignment given simulated mixtures of known proportions of fall and spring individuals. The 2006 collection year will be used to illustrate how the simulation distribution (i.e., Figure 5) may be used to infer the variance of stock composition estimates. For the 2006 juvenile collection, the point estimate of Cowlitz fall stock contribution was 86%. Given the simulation distribution, a value of 86% is contained within the 95% confidence intervals for mixtures composed of between 98% - 91% fall. Therefore, we infer that the 2006 collection is likely composed of between 98% to 91% fall Chinook. Using the same logic, the composition of 2007 through 2009 collections are 100%-99% fall, 100% fall, and 100% fall, respectively.

**Table 3** Baseline bootstrap resampling results for 1000 replicated collections of N=500 individuals representing a mixtures composed of 95% fall and 5% spring juveniles. Shown are the numbers of simulated individuals (actual) assigned to reference collections (estimated).

| | | **Estimated** | |
|---|---|---|---|
| | Collection | Cowlitz_H_fa | Cowlitz_H_sp |
| **Actual** | Cowlitz_H_fa | 430475 | 44587 |
| | Cowlitz_H_sp | 6389 | 18549 |

**Table 4** Assignment error summary derived from simulation results shown in Table 3.

| Collection | Error: Type 1 | Error: Type 2 | Confidence [1] | Power [2] |
|---|---|---|---|---|
| **Cowlitz_H_fa** | 9% | 1% | 91% | 99% |
| **Cowlitz_H_sp** | 26% | 71% | 74% | 29% |

[1] Confidence (or specificity) is 1 – Type 1 error
[2] Power (or sensitivity) is 1 – Type 2 error

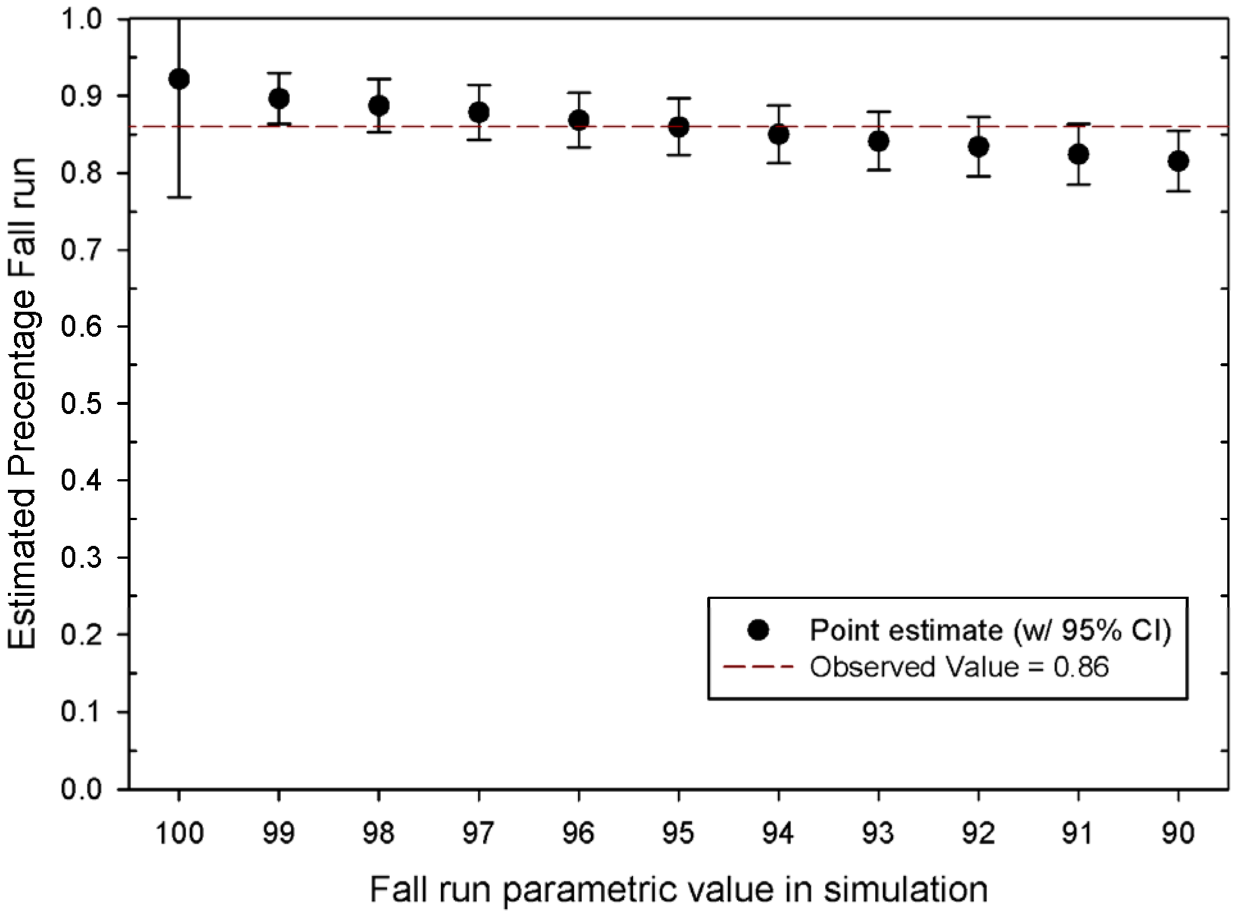


Figure 5. Estimated proportions of Cowlitz fall for simulated mixtures composed of known quantities of Cowlitz fall. Closed circles are mean estimates of fall contribution over 1000 datasets and 95% CI are the confidence interval based on simulation standard deviations. Reference line is the point estimate of fall stock contribution for the 2006 juvenile collection (i.e., 86%).


## Acknowledgements

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**Literature cited**

Anderson EC, Waples RS, Kalinowski ST (2007) An improved method for estimating the accuracy of genetic stock identification. Canadian Journal of Fisheries and Aquatic Sciences **65**: 1475–1486.

Banks MA, Blouin MS, Baldwin BA, Rashbrook VK, Fitzgerald HA, Blankenship SM, Hedgecock D (1999) Isolation and inheritance of novel microsatellites in chinook salmon (Oncorhynchus tschawytscha). *Journal of Heredity,* **90**:281-288.

Cairney M, Taggart JB, Hoyheim B (2000) Characterization of microsatellite and minisatellite loci in Atlantic salmon (*Salmo salar* L.) and cross-species amplification in other salmonids. *Mol Ecol,* **9**:2175-2178.

Greig C, Jacobson DP, Banks MA (2003) New tetranucleotide microsatellites for fine-scale discrimination among endangered chinook salmon *(Oncorhynchus tshawytscha*). *Mol Ecol Notes,* **3**:376-379.

Henning JA and Blankenship SM (2006) The Differentiation of Fall and Spring Chinook Stocks at Mayfield Collection Facility, 2006. Report to Tacoma Public Utility, Tacoma Power, available from Washington Department of Fish and Wildlife.

Kalinowski ST, Manlove KR, Taper ML (2007) ONCOR: A computer program for genetic stock identification. Available at http://www.montana.edu/kalinowski/kalinowski_software.htm

Millar RB (1987) Maximum likelihood estimation of mixed stock fishery composition. Canadian Journal of Fisheries and Aquatic Sciences **44**: 583–590

Olsen JB, Bentzen P, Seeb JS (1998) Characterization of seven microsatellite loci derived from pink salmon. *Molecular Ecology,* **7**:1087-1089.

Rannala B, Mountain JL (1997) Detecting immigration by using multilocus genotypes. *Proceedings of the National Academy of Sciences of the United States of America,* **94**:9197-9201.

Rexroad CE, Coleman RL, Martin AM, Hershberger WK, Killefer J (2001) Thirty-five polymorphic microsatellite markers for rainbow trout (*Oncorhynchus mykiss*). *Animal Genetics,* **32**:317-319.

Seeb LW, Antonovich A, Banks MA*, et al.* (2007) Development of a Standardized DNA Database for Chinook Salmon. *Fisheries* **32**.

Williamson K, Cordes J, May B (2002) Characterization of microsatellite loci in chinook salmon (*Oncorhynchus tshawytscha*) and cross-species amplification in other salmonids. *Molecular Ecology Notes,* **2**:17-19.