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# Lower Cowlitz River Monitoring and Evaluation, 2013

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*Washington Department of Fish and Wildlife*
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# Table of Contents

**ACKNOWLEDGEMENTS** ....... **II**

**TABLE OF CONTENTS** ....... **IV**

**LIST OF TABLES** ....... **VI**

**LIST OF FIGURES** ....... **VIII**

**EXECUTIVE SUMMARY** ....... **10**

**INTRODUCTION** ....... **12**

**METHODS** ....... **16**

STUDY SITE ....... 16
NATURAL AND HATCHERY POPULATIONS ....... 17
TRIBUTARY WEIR OPERATION ....... 19
STEELHEAD SPAWNER SURVEYS ....... 22
CHINOOK SPAWNER SURVEYS ....... 24
COHO SPAWNER SURVEYS ....... 25
ESTIMATES OF SPAWNER ABUNDANCE AND PHOS ....... 27
SPOT CREEL SURVEYS FOR CHINOOK AND COHO SALMON ....... 30
CHINOOK AND COHO HATCHERY BROODSTOCK COMPOSITION ....... 31
MAYFIELD DAM DOWNSTREAM MIGRANT TRAP OPERATION ....... 32

**RESULTS** ....... **34**

TRIBUTARY WEIR OPERATION ....... 34
STEELHEAD SPAWNER ABUNDANCE, DISTRIBUTION, AND DIVERSITY (PHOS) ....... 42
CHINOOK SPAWNER ABUNDANCE, DISTRIBUTION, AND DIVERSITY (PHOS) ....... 42
COHO SPAWNER ABUNDANCE, DISTRIBUTION, AND DIVERSITY (PHOS) ....... 45
COWLITZ RIVER FISHERY ENCOUNTER AND RELEASE RATES OF CHINOOK AND COHO SALMON ....... 45
HATCHERY BROODSTOCK COMPOSITION FOR CHINOOK AND COHO SALMON ....... 47
JUVENILE CATCHES IN MAYFIELD DAM DOWNSTREAM MIGRANT TRAP ....... 53

**DISCUSSION** ....... **54**

STEELHEAD SPAWNER ABUNDANCE ....... 54
CHINOOK SPAWNER ABUNDANCE ....... 55
COHO SPAWNER ABUNDANCE ....... 56
RELEASE MORTALITY OF NATURAL-ORIGIN FISH FROM COWLITZ RIVER FISHERIES ....... 57
HATCHERY RETURNS AND COMPOSITION OF HATCHERY BROODSTOCK ....... 58
JACK-ADULT LENGTH CUTOFFS ....... 59
PROPORTION OF HATCHERY-ORIGIN SPAWNERS (PHOS) ....... 59

**REFERENCES** ....... **62**

## List of Tables

Table 1. Anadromous salmonid populations identified in the Cowlitz River basin and their recovery priority as designated in the Lower Columbia River Salmon Recovery and Fish and Wildlife Sub-basin Plan (LCFRB 2010). 18

Table 2. Summary of hatchery production in the Cowlitz River basin. 19

Table 3. Capture and disposition of steelhead at Delameter Creek weir, 2012-2013 return. 35

Table 4. Capture and disposition of steelhead at Olequa Creek weir, 2012-2013 return. 36

Table 5. Abundance (± 95% confidence interval) and composition of steelhead spawners above tributary weirs in the lower Cowlitz River, spawn year 2013. 36

Table 6. Capture and disposition of coho salmon at Ostrander Creek weir, 2013-2014 return.. 38

Table 7. Capture and disposition of coho salmon at Delameter Creek weir, 2013-2014 return.. 39

Table 8. Capture and disposition of coho salmon at Olequa Creek weir, 2013-2014 return.. 40

Table 9. Capture and disposition of coho salmon at Lacamas Creek weir, 2013-2014 return. 41

Table 10. Abundance (±95% confidence interval) and composition of adult coho salmon spawners above tributary weirs in the lower Cowlitz River, 2013-2014. 42

Table 11. Total number of winter steelhead redds observed in foot surveys of lower Cowlitz River tributaries, 2013. 42

Table 12. Spatial and temporal distribution of natural-origin (NOR) and hatchery-origin (HOR) Chinook Salmon spawners in the lower Cowlitz River, 2013. 44

Table 13. Age composition of natural-origin and hatchery-origin spring Chinook salmon spawners in the lower Cowlitz River, 2013. 44

Table 14. Age composition of natural-origin and hatchery-origin fall Chinook salmon spawners in the lower Cowlitz River, 2013. 44

Table 15. Summary of spot creel surveys conducted on the lower Cowlitz River, 2013. 46

Table 16. Encounter and release rates estimated from spot creel surveys of adult fall Chinook and coho Salmon in the Cowlitz River, 2013.. 46

Table 17. Disposition of natural (NOR) and hatchery-origin (HOR) spring Chinook salmon returns to Cowlitz Salmon Hatchery in 2013. 48

Table 18. Disposition of natural (NOR) and hatchery (HOR) fall Chinook salmon returns to Cowlitz Salmon Hatchery in 2013.. 49

Table 19. Disposition of natural (NOR) and hatchery-origin (HOR) coho salmon returns to Cowlitz Salmon Hatchery in 2013. 50

Table 20. Age and length summary for spring Chinook broodstock at the Cowlitz Salmon Hatchery.. 51

Table 21. Age and length summary for fall Chinook broodstock at the Cowlitz Salmon Hatchery.. 51

Table 22. Age and length summary for coho salmon broodstock at the Cowlitz Salmon Hatchery.. 52

Table 23. Monthly totals of juvenile Chinook, coho, cutthroat, and steelhead captured at the Mayfield Dam downstream migrant trap in 2013.. 53

## List of Figures

Figure 1. Map of the lower Cowlitz River basin showing locations of major tributaries below Mayfield Dam.. ..... 17

Figure 2. Location of resistance board weirs on four lower Cowlitz River tributaries in 2013. ..... 21

Figure 3. Resistance board weir on Olequa Creek, a lower Cowlitz River tributary.. ..... 22

Figure 4. Winter-run steelhead spawner survey reaches in 2013 and modeled distribution of steelhead in lower Cowlitz River tributaries.. ..... 23

Figure 5. Fall Chinook salmon spawner survey area in the main stem Cowlitz River, 2013. ..... 25

Figure 6. Coho salmon spawner survey reaches in 2013 and modeled distribution of coho salmon in lower Cowlitz River tributaries.. ..... 27

Figure 7. Creel survey locations on Cowlitz River, 2013. ..... 31

## Executive Summary

For more than half a century the Cowlitz River has been divided by a series of three dams, constructed in 1963 to 1968 to support hydroelectric development in the basin. These dams greatly reduced natural salmon and steelhead populations, and large hatcheries were constructed and operated to mitigate this impact. Currently, an extensive reintroduction program in the Cowlitz River is underway to restore the anadromous migration corridor between the upper and lower Cowlitz River basins. Hatchery programs have been modified to support this reintroduction while continuing to support fisheries in the lower Cowlitz River. Successful recovery of natural salmonid populations in the Cowlitz River will require minimizing the impacts of the hatchery programs on lower Cowlitz River populations. This report describes the efforts to implement the first year of the lower Cowlitz River Monitoring and Evaluation Plan. The focus of this effort is to estimate spawner abundance and composition, hatchery returns and composition, and Cowlitz River fishery impacts on lower Cowlitz River populations of winter steelhead, coho salmon and spring and fall Chinook salmon.

Mark-recapture estimates of steelhead spawner abundance for spawn year 2013 were made for Delameter and Olequa creeks. The mark-recapture estimate of steelhead abundance above the weir locations was 86 fish (CV = 9.5%) for Delameter Creek and 133 fish (CV = 15.9%) for Olequa Creek. Mark recapture estimates of coho spawner abundance for spawn year 2013 were made for Ostrander, Delameter, and Olequa creeks. The mark-recapture estimate of coho spawner abundance above the weir locations was 109 fish (CV = 16.0%) on Ostrander Creek, 174 fish (CV = 15.1%) on Delameter Creek and 250 fish (CV = 20.1%) on Olequa Creek. In 2013, the estimation method for total tributary spawner abundance was similar for both steelhead and coho. This method used mark-recapture estimates above weir locations and the modeled spawning distribution for each species.

The total number of steelhead spawners in lower Cowlitz River tributaries (excluding Toutle and Coweeman rivers) for spawn year 2013 was estimated to be 559 (508 natural-origin and 51 hatchery-origin) with a proportion of hatchery origin spawners (pHOS) of 0% to 13.9% above weirs and 9.2% for non-weir tributaries. The total number of adult coho spawners in lower Cowlitz River tributaries (excluding Toutle and Coweeman rivers) for spawn year 2013 was estimated to be 1,694 (1,565 natural-origin and 20 hatchery-origin) with a pHOS of 0% above weirs and 1.7% in non-weir tributaries.

The estimation method for spring and fall Chinook salmon for spawn year 2013 was based on an expansion of peak aerial redd counts and age composition from carcass recoveries. The abundance of spring Chinook salmon spawners was estimated to be 960 spawners (pHOS = 89%). The abundance of fall Chinook salmon spawners was estimated to be 4,436 spawners (pHOS = 19%).

Estimated returns of natural-origin (NOR) and hatchery-origin (HOR) adult steelhead, coho salmon, spring Chinook salmon, and fall Chinook salmon returning to the lower Cowlitz River in 2013 are summarized in the table below. These are the best available estimates with the caveat

that the methodologies to minimize bias and include precision are still being derived. Integrated (I) and Segregated (S) hatchery programs are noted. Table does not include NOR returns to the Tilton or upper Cowlitz River. The table is partially completed because the lower Cowlitz River Monitoring & Evaluation Plan was only partially implemented in 2013. More complete implementation of the M&E Plan is underway for 2014.

| | Cowlitz Fisheries | | Spawning Ground | | Cowlitz Separator Returns | | |
|---|---|---|---|---|---|---|---|
| | Encounter Rate | Mortality | Abundance | Broodstock | Broodstock[b] | Up-River | Surplus |
| LC NOR Winter Steelhead[a] | NA | NA | 508 | 3 | 0 | 0 | 0 |
| HOR (S/I)[c] Winter Steelhead | NA | NA | 51 | 0 | NA | NA | NA |
| LC NOR Coho[a] | 0.13 | NA | 1,565 | 0 | 0 | 0 | 0 |
| HOR (S) Coho | NA | NA | 20 | 0 | 871 | 8,365 | 1,677 |
| HOR (I) Coho | NA | NA | NA | 0 | 573 | 7,941 | 0 |
| LC NOR Spring Chinook | NA | NA | 99 | 0 | 0 | 0 | 0 |
| HOR (S) Spring Chinook | NA | NA | 789 | 0 | 1,753 | 1,906 | 104 |
| LC NOR Fall Chinook | 0.58 | NA | 3,477 | 17 | 0 | 0 | 0 |
| HOR (S) Fall Chinook | NA | NA | 843 | 0 | 1,815 | 7,705 | 98 |
| HOR (I) Fall Chinook | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

NA = Data were either not collected or not available for this report, 0 = Zero fish
[a]Steelhead and coho spawner estimates are for lower Cowlitz River tributaries but not the main stem.
[b]Broodstock represents the number of fish collected for broodstock, not the number spawned.
[c]HOR Winter steelhead returning in 2013 were a combination of early-winter hatchery stock (non-native, segregated) and late-winter hatchery stock (native, segregated). Integration of the late-winter stock began in 2013.

## Introduction

Historically, large numbers of adult coho (*Oncorhynchus kisutch*), chum (*O. keta*), and Chinook salmon (*O. tshawytscha*), steelhead (*O. mykiss*) and cutthroat trout (*O. clarki*) returned to the Cowlitz River. Estimates from 1948 indicated that the Cowlitz River produced 244,824 total adult salmonids with a spawning escapement of 82,681 (HARZA 2000). Hydroelectric dam construction on the main stem Cowlitz River began in 1963 with the construction of Mayfield Dam by Tacoma Power. Mayfield Dam included both upstream adult and downstream juvenile passage facilities when built. Mossyrock Dam was constructed upstream of Mayfield Dam in 1968 and was too tall to include upstream passage. As a result, anadromous fish were blocked from accessing the upper Cowlitz River and production from the lower Cowlitz River hatcheries was emphasized to mitigate for lost anadromous fish production. Mayfield Dam, Mossyrock Dam and associated lands and structures are known as the Cowlitz River Project. Cowlitz Falls Dam, owned by Lewis County PUD, was built upstream of Mossyrock Dam in 1994. Cowlitz Falls Fish Facility was built by Bonneville Power Administration in 1996. Downstream collection at this facility provided an ability to re-introduce anadromous salmonids to the upper Cowlitz River basin.

Cowlitz River populations of steelhead, Chinook and coho are listed as threatened under the Endangered Species Act (ESA) by the National Marine Fisheries Service (NMFS). Cowlitz River steelhead are included in the Lower Columbia River steelhead distinct population segment (DPS) that was listed as *threatened* on March 19, 1998 and reaffirmed on January 5, 2006 (www.nwr.noaa.gov/ESA-Salmon -Listing/Salmon-Populations). Critical habitat designation for this DPS became effective on January 2, 2006. Cowlitz River spring and fall run Chinook are included in the Lower Columbia River Chinook evolutionarily significant unit (ESU) that was listed with a *threatened* status on March 24, 1999. The listing status of these Chinook populations was reaffirmed on June 28, 2005. The Lower Columbia River and southwest Washington coho populations were originally combined into a large ESU. The Lower Columbia River ESU was listed separately as *threatened* on June 28, 2005 and included coho populations in the Cowlitz River. The NMFS conducted a five year review of 17 pacific salmon and steelhead ESU and DPS within the Pacific Northwest region, including steelhead, Chinook and coho in the Lower Columbia River and on August 15, 2011 published the determination that continued listing of these populations was warranted.

Listings under the Federal Endangered Species Act had significant impact on the Tacoma Power process to relicense Mayfield and Mossyrock Dams and shaped the new license for these dams. Tacoma Power and stakeholders signed a Settlement Agreement on August 10, 2000 and the new license for the Cowlitz River project became effective on July 18, 2003. Through formal consultation with NMFS, Tacoma Power received a Biological Opinion on March 23, 2004 for the operation of Mayfield and Mossyrock Dams. The emphasis of the Settlement Agreement is the restoration and recovery of wild, indigenous salmonid runs to healthy and harvestable levels. The Settlement Agreement states that "Fisheries obligations will be met through a combination of effective upstream and downstream passage, habitat restoration and improvement, an adaptive management program to restore natural production coupled with continued artificial production to compensate for unavoidable impacts at levels consistent with ESA recovery, and providing fish production for sustainable fisheries."

Currently, an extensive reintroduction program is underway to restore the anadromous migration corridor between the upper and lower Cowlitz River basins. The key to this effort is improving juvenile downstream passage of fish rearing above Cowlitz Falls Dam and Mayfield Dam. Plans to improve this passage are currently being implemented. Hatchery programs are implemented to support this reintroduction and to support fisheries in the lower Cowlitz River. Successful reintroduction of salmonids to the upper Cowlitz River includes minimizing the impacts of the hatchery programs on lower Cowlitz River populations. At present, there is uncertainty about key metrics for these lower Cowlitz River populations.

The Settlement Agreement directed a Fisheries and Hatchery Management Plan (FHMP) to be developed every seven years and the initial plan was completed in 2004. The FMHP was updated and submitted to the Federal Energy Regulatory Commission in 2011. This updated plan included an adaptive management process to use new information about key population parameters for Cowlitz River salmonid populations to make management decisions. Appendix J of the updated plan outlined a monitoring and evaluation program to obtain this new information. Specifically, the monitoring and evaluation program was designed to obtain unbiased estimates of key metrics with a precision level recommended for monitoring the recovery of Pacific Northwest salmon and steelhead listed under the Federal Endangered Species Act (Crawford and Rumsey 2011).

This report provides the results of the monitoring and evaluation work that Tacoma Power has contracted with Washington Department of Fish and Wildlife (WDFW) to conduct in the lower Cowlitz River basin during 2013. In order to provide a more comprehensive reporting of fish in the lower Cowlitz River, the report also includes spawner returns to the Cowlitz Salmon Hatchery separator (operated by WDFW and Tacoma Power) and outmigrants from the Mayfield Dam downstream migrant trap (operated by Tacoma Power). Together, this information will provide input to improve the results of the FHMP adaptive management process.

In 2013, monitoring objectives for the lower Cowlitz River Monitoring and Evaluation Program were to:

1. Conduct spawner surveys for winter steelhead in select tributaries with an emphasis on spawning above the weir locations (FHMP Update – Appendix J, MA-J),
2. Conduct spawner surveys for coho salmon at selected stream survey index reaches (FHMP Update – Appendix J, MA-A),
3. Obtain spring and fall Chinook population estimates, pHOS, and age composition of natural spawners (FHMP Update - Appendix J, MA-A),
4. Operate resistance board weirs on select tributaries in order to: (1) minimize HOR escapement of summer and winter steelhead and coho in major lower Cowlitz River tributaries, (2) collect NOR winter run steelhead for an integrated hatchery broodstock

program, (3) generate mark-recapture estimates of NOR winter steelhead and NOR coho in lower Cowlitz tributaries, and 4) enumerate fall Chinook handled at the weirs (FHMP Update – Appendix J, MA-J),

5. Improve catch estimates of NOR and HOR fall Chinook and determine the ratio of hatchery fish retained and wild fish released in the fishery (FHMP Update- Appendix J, MA-C), and
6. Collect biological data from hatchery broodstock for spring and fall Chinook salmon and coho salmon (FHMP Update – Appendix J, MA-E).

## Methods

*Study Site*

The Cowlitz River is located in southwest Washington State and drains approximately 2,480 square miles of the west slope of the Cascade mountain range over a distance of 151 miles before the Cowlitz joins the Columbia River about 68 river miles upstream from the Pacific Ocean (Serl and Morrill 2011). The Cowlitz River is divided into an upper and lower basin by three main stem hydroelectric dams. The major tributaries to the upper Cowlitz River are the Cispus and Tilton rivers. The major tributaries on the lower Cowlitz River include the Toutle and Coweeman rivers and Salmon, Lacamas, Olequa, Arkansas, Delameter and Ostrander creeks (Figure 1). The Cowlitz River basin has three active volcanoes in its headwaters; the Cowlitz River originates on Mt. Rainier, the Muddy Fork of the Cispus River originates on Mt. Adams, and the Toutle River originates on Mt. St. Helens.

Anadromous fish populations on the Cowlitz River occur in three general areas – the upper Cowlitz River basin is above Cowlitz Falls Dam, the Tilton River basin is between Mayfield and Mossyrock dams, and the lower Cowlitz River basin is below Mayfield Dam. Although both the Toutle and Coweeman rivers flow into the Cowlitz River below Mayfield dam, salmon and steelhead populations in these rivers are managed and monitored separately from the rest of the lower Cowlitz River main stem and tributaries and are not included as "lower Cowlitz tributaries" as defined by Appendix J of the updated FHMP (Tacoma Power 2011). The Barrier Dam, located just below Mayfield Dam, diverts fish into the Cowlitz Salmon Hatchery separator. Fish returning to the separator are either released into the upper Cowlitz River basin or the Tilton River basin or are retained for hatchery broodstock. A trap-and-haul operation provides passage between the lower Cowlitz River (below Barrier Dam) and upper Cowlitz River (above Cowlitz Falls Dam) in both the upstream and downstream direction. A trap-and-haul operation provides passage from the lower Cowlitz River (below Barrier Dam) to the Tilton River (above Mayfield Dam) in the upstream direction. Downstream outmigrants from the Tilton River use the original juvenile bypass system at Mayfield Dam.

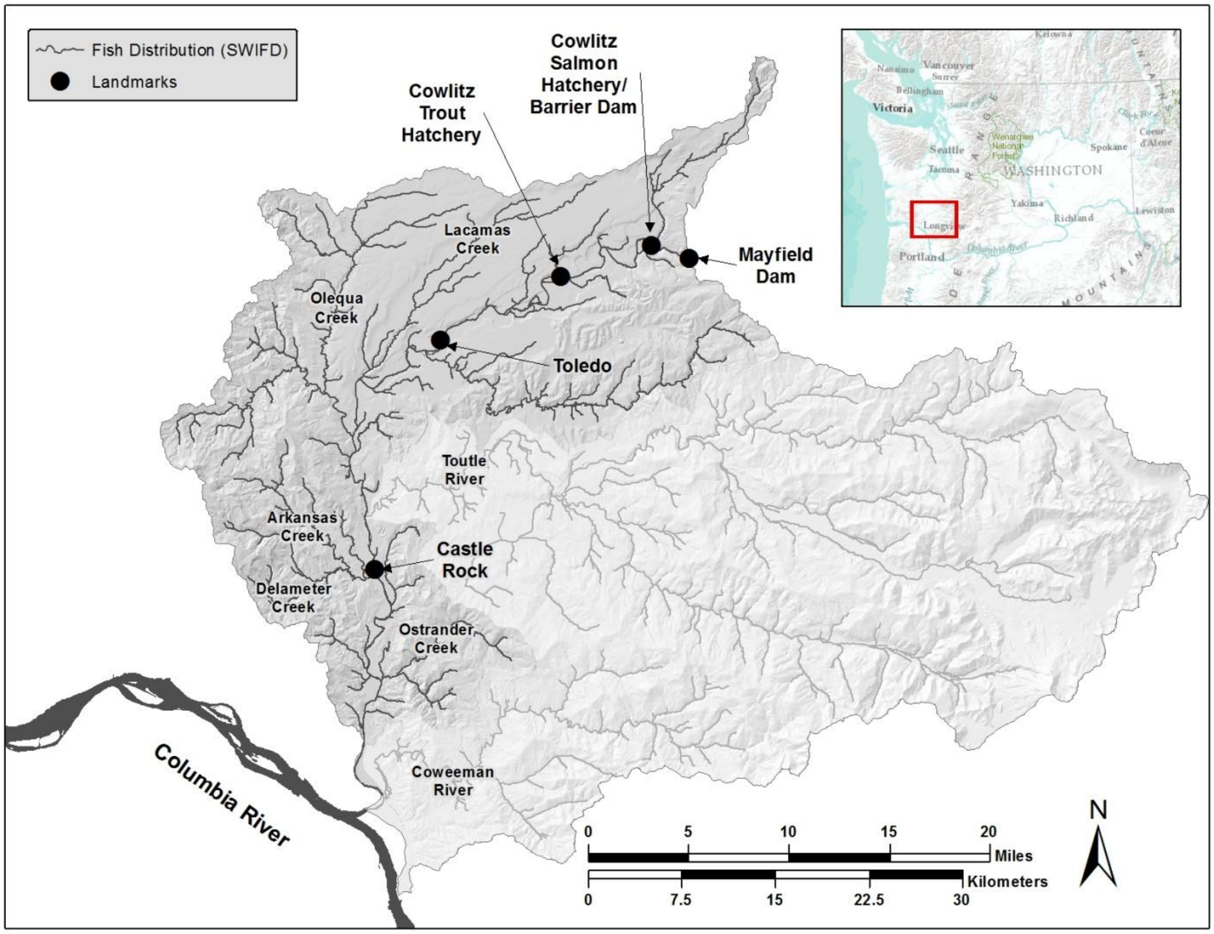


Figure 1. Map of the lower Cowlitz River basin showing locations of major tributaries and landmarks below Mayfield Dam. Although the Toutle and Coweeman rivers flow into the Cowlitz River, fish populations in these tributaries are managed (and monitored) separately from the remainder of the lower Cowlitz River.

### *Natural and Hatchery Populations*

Populations identified for recovery in the Cowlitz River basin include Chinook (spring-run and fall-run), chum (summer and fall), coho, and winter steelhead (Table 1). Although Spring Chinook are observed to spawn in the lower Cowlitz River (see Results), none of the three spring Chinook populations in the basin recognized for recovery occur in the lower Cowlitz River. Of the two fall Chinook populations, the lower Cowlitz River population is designated as a "contributing" recovery priority. One summer chum and one fall chum population are identified (both designated "contributing" recovery priority) for the combined area of the lower and upper Cowlitz River, Coweeman River, and Toutle River. Of the four steelhead populations, the lower Cowlitz River is designated a "contributing" recovery priority. Of the four coho populations, the lower Cowlitz River population is designated as a "primary" recovery priority. Anadromous cutthroat also exist in both the Tilton and upper Cowlitz basins, but are not listed under the Endangered Species Act.

Table 1. Anadromous salmonid populations identified in the Cowlitz River basin and their recovery priority as designated in the Lower Columbia River Salmon Recovery and Fish and Wildlife Sub-basin Plan (LCFRB 2010).

| Species | Population | Recovery Priority |
|---|---|---|
| Spring Chinook | Tilton | Stabilizing |
| | Upper Cowlitz | Primary |
| | Cispus | Primary |
| Fall Chinook | Lower Cowlitz | Contributing |
| | Upper Cowlitz/Cispus/Tilton | Stabilizing |
| Summer Chum | Lower Cowlitz/ Upper Cowlitz /Coweeman/Toutle | Contributing |
| Fall Chum | Lower Cowlitz/ Upper Cowlitz /Coweeman/Toutle | Contributing |
| Steelhead | Lower Cowlitz | Contributing |
| | Tilton | Contributing |
| | Upper Cowlitz | Primary |
| | Cispus | Primary |
| Coho | Lower Cowlitz | Primary |
| | Tilton | Stabilizing |
| | Upper Cowlitz | Primary |
| | Cispus | Primary |

The Cowlitz Hatchery complex consists of the Cowlitz Salmon Hatchery, sited about 2 miles below Mayfield Dam, and the Cowlitz Trout Hatchery, sited about 7 miles downstream of the salmon hatchery (Figure 1). The Cowlitz Salmon Hatchery has facilities for adult recovery and brood-stock collection, adult holding and spawning facilities, early incubation for all species and juvenile rearing for coho and fall and spring Chinook salmon. The Cowlitz Trout Hatchery rears winter steelhead, summer steelhead and sea-run cutthroat trout.

The hatchery stock for spring Chinook salmon is currently maintained as a segregated stock originally derived from the natural Cowlitz River population (Table 2) and will transition to an integrated program as recolonization and juvenile trapping efficiency at Cowlitz Falls Fish Facility progresses. There are currently two hatchery stocks of fall Chinook salmon, a segregated stock and a stock integrated with the lower river natural population. The integrated stock of fall Chinook salmon is currently being developed. Winter steelhead production consists of three integrated stocks. Portions of the winter steelhead production are integrated with the Upper Cowlitz and Tilton populations. The integrated stock with lower Cowlitz tributary populations is currently being developed. Summer steelhead production is maintained as a segregated hatchery program of Skamania stock origin. There are currently two hatchery coho stocks – a segregated coho stock and a stock integrated with the upper Cowlitz natural population. The sea-run cutthroat production is currently maintained as a segregated hatchery program.

The Upper Cowlitz River reintroduction is based on trap and haul of both juveniles and adults to reconnect the historically productive habitat upstream of Cowlitz Falls to the lower Cowlitz River migration corridor. Cowlitz hatchery stocks for late winter steelhead, coho and spring Chinook were derived from the natural populations in the Cowlitz River. Therefore these stocks were used as the basis for reintroducing anadromous fish to the upper Cowlitz River basin. Adults returning to the Barrier Dam, both natural and hatchery origin, are transported by Tacoma Power in a truck for release into the upper Cowlitz River basin at Lake Scanewa or release sites on the upper Cowlitz or Cispus rivers. These adults include naturally produced and integrated hatchery coho and winter steelhead. Spring and fall Chinook salmon transported to the upper Cowlitz are a combination of naturally produced and segregated hatchery stock.

Table 2. Summary of hatchery production in the Cowlitz River basin.

| Species | Program Type | Management Objective | Stock Origin |
|---|---|---|---|
| Spring Chinook | Segregated[a] | Harvest & re-colonization of the Upper Cowlitz/Cispus basins | Cowlitz River |
| Fall Chinook | Segregated[b] | Harvest & re-colonization/nutrient enhancement for upper Cowlitz/Cispus basins | Cowlitz River |
| | Integrated[b] | Harvest and sustainable lower Cowlitz population | Cowlitz River |
| Winter Steelhead | Integrated | Harvest & sustainable lower Cowlitz population | Cowlitz River |
| | Integrated | Harvest & re-colonization of upper Cowlitz/Cispus basins | Cowlitz River |
| | Integrated | Harvest & re-colonization of Tilton basin | Cowlitz River |
| Summer Steelhead | Segregated | Harvest | Skamania |
| Coho | Segregated | Harvest | Cowlitz River |
| | Integrated | Harvest & re-colonization of Upper Cowlitz/Cispus basins | Cowlitz River |
| Cutthroat Trout | Segregated | Harvest | |

[a]Spring Chinook segregated hatchery program will transition to an integrated program once downstream trapping efficiency improves at Cowlitz Falls Fish Facility.

[b]Integrated and segregated fall Chinook stocks are not differentially marked and either stock may be transported into the upper Cowlitz and Tilton basins.

### *Tributary Weir Operation*

Resistance board weir operations on lower Cowlitz tributaries began in 2011 when WDFW was funded by the Columbia River Salmon and Steelhead Recreational Advisory Board (CRSSRAB) to construct, install, and operate four resistance board weirs on select lower Cowlitz

River tributaries.  As of 2012 the operation and maintenance of the weirs were funded jointly by Tacoma Power and CRSSRAB (5 months and 7 months respectively).  The original objective for these weirs was to exclude non-indigenous (Skamania stock) hatchery summer steelhead from straying into lower Cowlitz River tributaries and interacting (i.e., spawning and competing) with natural-origin winter steelhead.  Once established, the weirs have served multiple purposes of monitoring and evaluation, fish management (e.g., control proportion of hatchery-origin spawners), and brood stock collection (winter-run steelhead).

Resistance board weirs were operated on four tributaries to the lower Cowlitz River in 2013 (Figure 2). Weir installation on Ostrander Creek (entering the Cowlitz River at river mile, RM 8.7) was completed  on September 4, 2013, Delameter Creek (entering the Cowlitz River at RM 16.6) on July 15, 2011, Olequa Creek (entering the Cowlitz River at RM 29.8) on June 1, 2011, and Lacamas Creek (entering the Cowlitz River at RM 27.6) on December 20, 2013. Once installed, weirs were operated daily twelve months of the year consistent with established field protocols described by the American Fisheries Society (Zimmerman and Zabkar 2007). The Delameter and Olequa weirs were operated throughout the winter-run steelhead return (spawn year 2013) and were used to make mark-recapture estimates of steelhead spawner abundance. The Ostrander, Delameter, and Olequa weirs were operated throughout the coho salmon return (spawn year 2013) and were used to make mark-recapture estimates of coho spawner abundance. Operation of the Lacamas weir was not of sufficient duration in 2013 to make spawner estimates for either species. Although a weir was originally installed on Salmon Creek in 2011, this weir was removed in July 2013 due to adverse flow regimes and unsuitable site conditions.

Weirs were installed at a location as low as practical in each tributary so that the majority of available spawning habitat was above the weir site. Weir locations were selected based on numerous criteria including accessibility, landowner agreement, stream width, hydrology, substrate, and streambed uniformity. Each weir was comprised of a series of joined panels anchored to a substrate rail (Figure 3). The downstream end of each panel floats at the water surface due to resistance boards positioned perpendicular to the current and 55-gallon barrels attached to the underside of the panels for additional buoyancy. Fish travelling upstream are guided along the substrate rail into a live box. A set of cod fingers contains fish once they have entered the live box. Live fish travelling in a downstream direction (i.e., steelhead kelts) were funneled into a downstream live box or seined from holding areas above the weir. Carcasses travelling in a downstream direction washed up on the weir panels and were removed for processing.

Weir traps were checked daily. All fish were identified to species. Biological data collected from salmonids included fork length (FL), age (scale sample), sex (jack, male, female), run type (summer versus winter steelhead), mark status (ad-clipped, unmarked), coded-wire tag status (positive, negative), and capture type (maiden, recapture). Jack coho were assigned when less than 47-cm FL (age data for validation were collected but have not yet been analyzed). A genetic sample (fin tissue) was collected from all steelhead. Recaptures were determined by tag and opercle punch status (yes, no) and tag information (Floy tag numbers, opercle punch) was noted for recaptures. After processing, live maiden-captured salmonids were tagged (Floy Tag & Mfg., Inc. Seattle, WA) with two sequentially numbered T-bar tags placed on opposite sides of the dorsal fin (posterior edge) and opercle punched to indicate that they had been sampled. Natural-origin fish (unmarked salmonids and all other species) were released in the direction of travel. Hatchery-origin fish (adipose clipped salmonids) were returned to the creek downstream of the weir.

Data were entered into the standardized Traps-Weirs-Surveys (TWS) database used to archive WDFW adult monitoring data for all Lower Columbia tributaries. Ages were determined from scale samples by the WDFW Ageing Lab (Olympia, WA). Steelhead genetic samples were archived with the WDFW Genetics Lab (Olympia, WA).

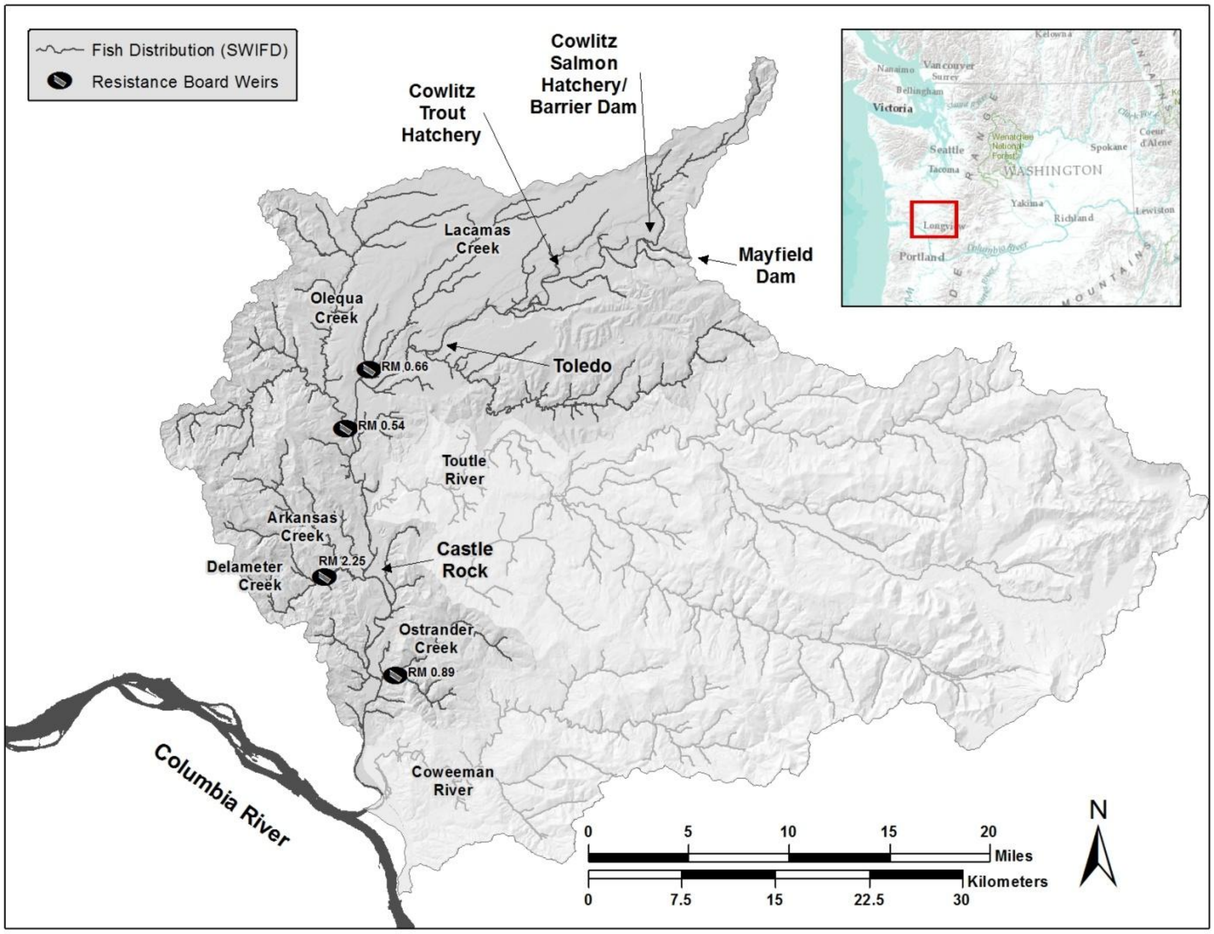


Figure 2. Location of resistance board weirs on four lower Cowlitz River tributaries in 2013.

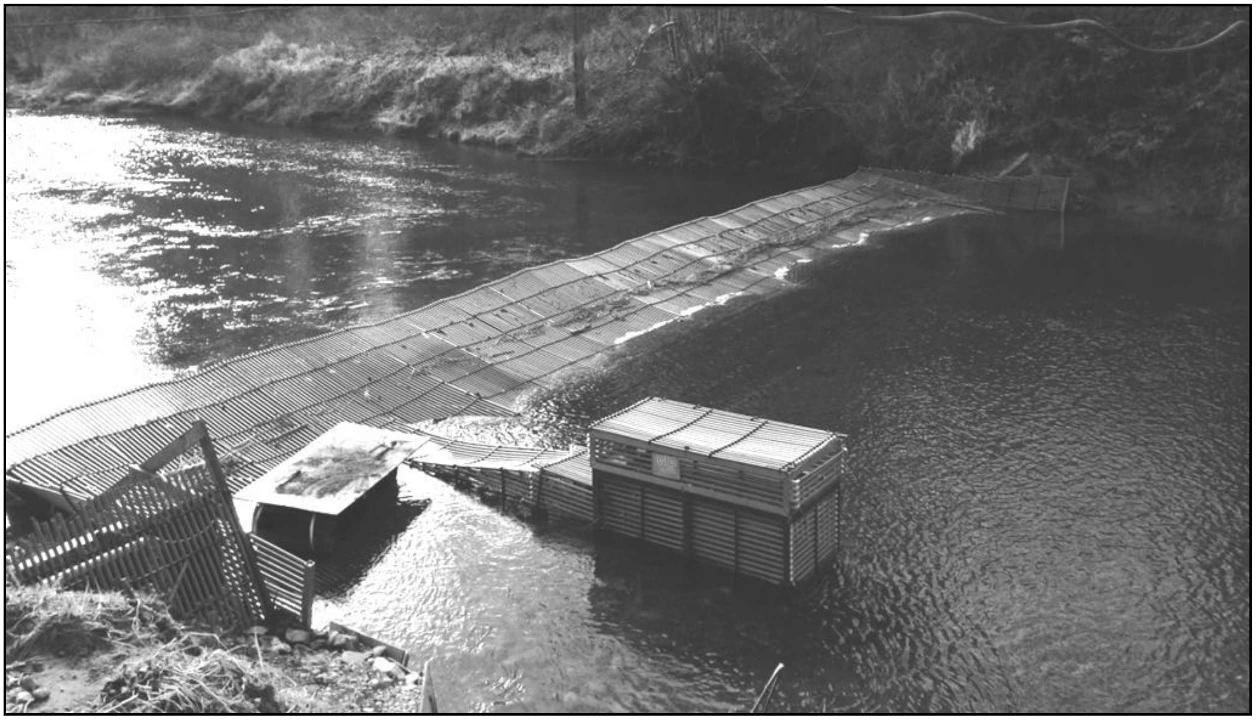

Figure 3. Resistance board weir on Olequa Creek, a lower Cowlitz River tributary. Stream flow is from right to left. Floating panels are anchored to a substrate rail at their upstream end. Buoyancy is provided by resistance boards are attached to the underside of the panels on their downstream end. Live box shown in this picture captures fish moving in an upstream direction.

*Steelhead Spawner Surveys*

Census surveys covered the entire steelhead spawning distribution above the weirs in Delameter and Olequa creeks and some areas below the weirs but upstream of the confluence with the main stem Cowlitz River (Figure 4). Methodology for redd counts followed established field protocols described by the American Fisheries Society (Gallagher et al. 2007). The upper extent for the surveys was selected from modeled steelhead spawning distribution in the lower Cowlitz River tributaries. Steelhead spawner distribution was modeled from GIS-derived basin characteristics including stream gradient, upstream basin area, elevation, and mean annual precipitation (Fransen et al. 2006 adapted to lower Cowlitz River tributaries in 2011 FHMP Update).

Three reaches above the weir on Olequa Creek and two reaches below the weir on Delameter Creek were not included in the census surveys because they were not spawning habitat. The lowest reach in Arkansas, Delameter, Stillwater, and Brim creeks are low gradient with silt and bedrock substrate. The lowest reach in King Creek is fast-flowing water with bedrock substrate.

Spawner surveys were conducted once every two weeks, from early March to late May depending on river/creek conditions. Each reach was surveyed by foot or raft in a downstream direction. Surveyors used polarized sunglasses and recorded clarity in feet and visibility on a ranked scale from 1 to 5 (1 = poor visibility, 2 = fair visibility, 3 = good visibility, 4 = very good visibility and 5 = excellent visibility). Non-surveyable conditions were recorded with a notation of “6” on the datasheets.

During surveys each steelhead redd was identified using established criteria: substrate disturbance (i.e., color change) and depression (i.e., clearly defined pit and tailspill). Redds were documented as new, still visible, or not visible. A fourth category (not observed), meaning that the surveyor had missed the location of a previously flagged redd, was assigned during data entry. New redds were flagged with a redd number, date, distance between the flag and redd, and surveyor. Garmin Oregon 550 units generated waypoints and a latitude and longitude for each new redd. Data were entered into the standardized Traps-Weirs-Surveys (TWS) database used to archive WDFW adult monitoring data for all Lower Columbia tributaries.

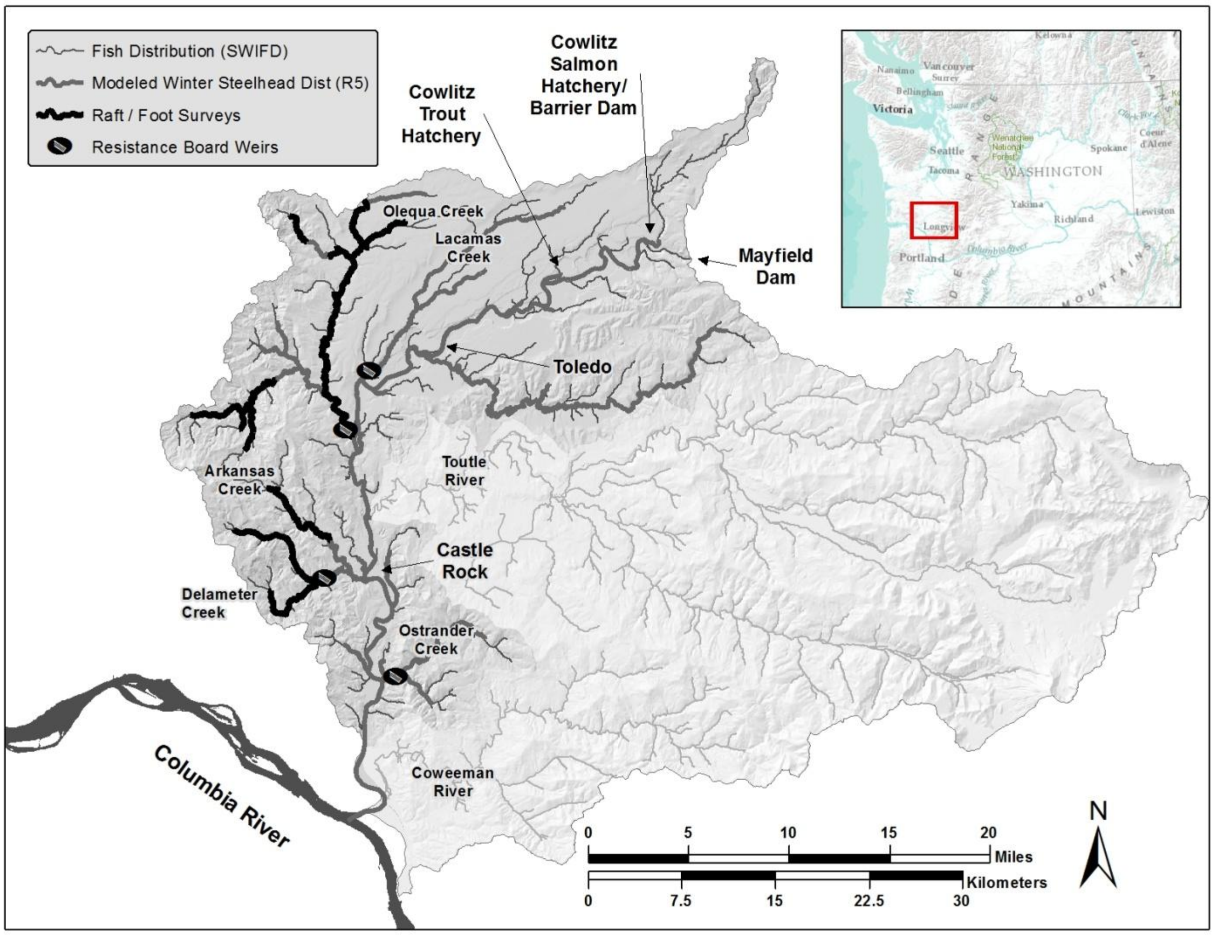


Figure 4. Winter-run steelhead spawner survey reaches in 2013 and modeled distribution of steelhead in lower Cowlitz River tributaries. Modeled distribution is based on GIS-derived basin characteristics are per the Cowlitz Monitoring and Evaluation Plan (FHMP Appendix J) published in 2011.

*Chinook Spawner Surveys*

Chinook spawner surveys were conducted on the main stem Cowlitz River between the Castle Rock and the Barrier Dam (Figure 5). Aerial surveys and carcass sampling followed established protocols described by the American Fisheries Society (Crawford et al. 2007; Jones et al. 2007). Helicopter aerial surveys were conducted between mid-September and mid-November, as conditions permitted. The purpose of the aerial surveys was to determine peak redd counts for spring and fall Chinook salmon. Boat surveys were conducted weekly between late August and mid-November. The purpose of the boat surveys was to biologically sample Chinook carcasses.

Chinook redds were identified based on size, coloration, location, defined pit or bowl, and downstream tailspill. For each aerial survey, redd observations were tallied by reach and the location of each redd was georeferenced using the time of the observation and the speed of travel for the aircraft. On a given survey, redd counts were the sum of all observed redds and included redds observed in previous surveys (still visible) as well as redds newly constructed since the last survey (new redds).

Carcasses were sampled for run (spring, fall), sex (male, female), fork length, scales (age), mark status (adipose clipped or unmarked), coded-wire tag presence (positive, negative), and fin tissue (genetics). Spring and fall Chinook were distinguished by a combination of spawn timing and phenotype in the field and later verified by scale growth pattern. Snouts were retained from fish which scanned positive for coded-wire tags. Genetic samples were collected from fresh (clear eyes and red/pink gills) carcasses in order to implement a future genetic mark-recapture study design (Rawding et al. 2014) as outlined in Appendix J of the FHMP Update. All age classes of hatchery Chinook salmon returning in 2013 to the Cowlitz River were mass marked, meaning that hatchery fish were identifiable by the presence of a clipped adipose fin (assuming a 100% clipping rate). Fall Chinook were biologically sampled at a rate of 1 to 4 and spring Chinook were sampled at a rate of 1 to 1.

Data were entered into the standardized Traps-Weirs-Surveys (TWS) database used to archive WDFW adult monitoring data for all Lower Columbia tributaries. Scale ages were determined by the WDFW Ageing Lab. Snouts collected with coded wire tags were decoded by the WDFW Coded-Wire Tag Laboratory.

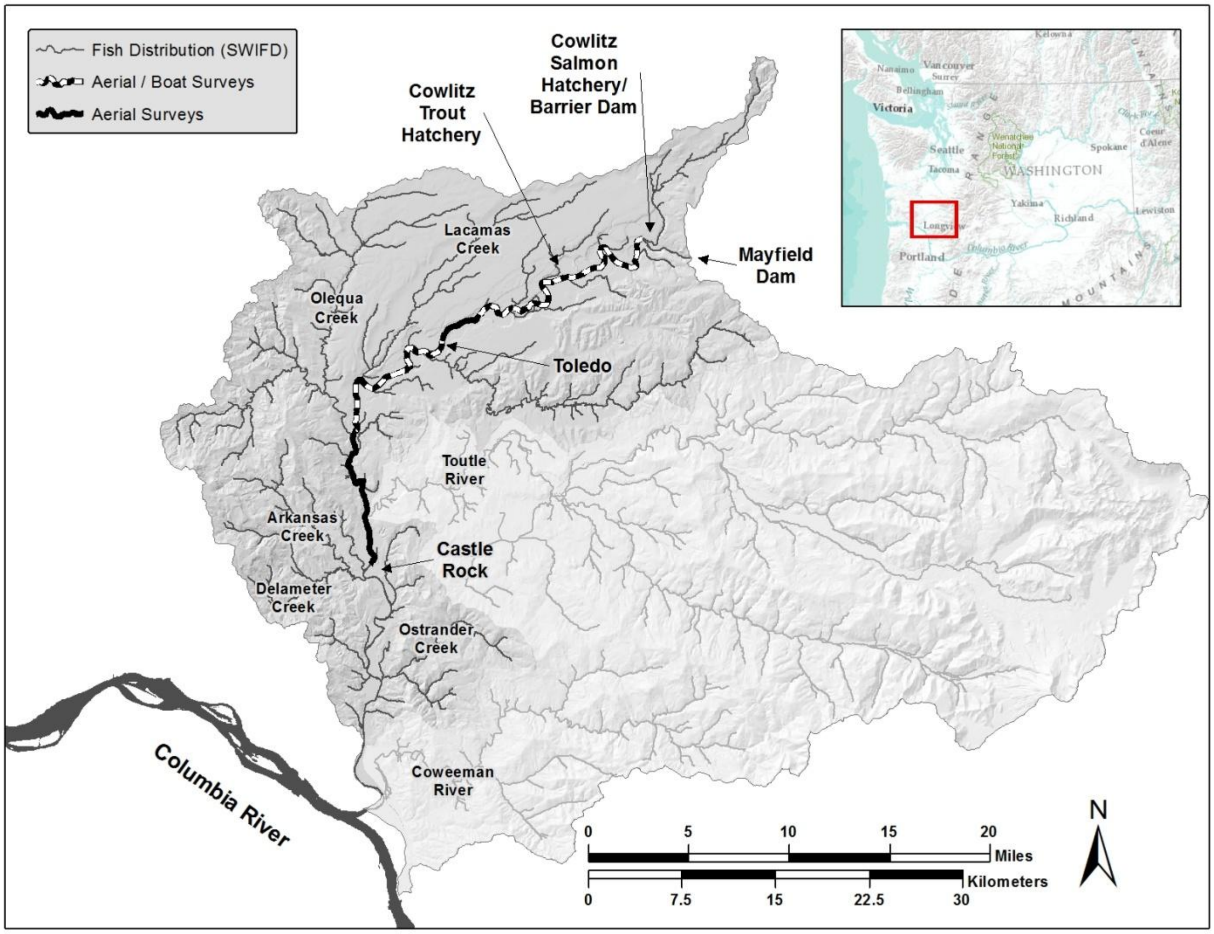


Figure 5. Fall Chinook salmon spawner survey area in the main stem Cowlitz River, 2013.

*Coho Spawner Surveys*

Spawner surveys were conducted in twenty-nine one-mile index reaches throughout the modeled spawning distribution of coho salmon in lower Cowlitz River tributaries (Figure 6). Redd counts and carcass sampling followed established protocols described by the American Fisheries Society (Crawford et al. 2007; Gallagher et al. 2007). Survey reaches were selected using the Generalized Random Tessellation Stratified (GRTS) method applied to a selected survey frame. GRTS is a spatially balanced design for selecting survey reaches needed to obtain unbiased estimates of the redd density and distribution (Stevens and Olsen 2004). The GRTS design is applied across the Lower Columbia River ESU with a goal of surveying the lesser of 30 reaches or 30% of the stream miles occupied by each population (D. Rawding, Washington Department of Fish and Wildlife, personal communication). GRTS sites are surveyed according to a rotating panel which is evenly divided into sites that are visited annually, every third year, and every ninth year. The survey frame for GRTS site selection was based on modeled coho spawning distribution in the lower Cowlitz River tributaries. A predictive model of the upper extent of coho spawner distribution was modeled using presence-absence data which was related to GIS-derived basin characteristics including stream gradient, upstream basin area, elevation, and mean annual precipitation using logistic regression (Fransen et al. 2006 adapted to lower Cowlitz River tributaries in 2011 FHMP Update). This upper extent was then truncated where migration barriers were known to exist. The bottom of coho spawner distribution was defined as the lowest extent of spawning gravels; however, main stem areas of the lower Cowlitz River were excluded from modeled distribution.

Spawner surveys were conducted in a downstream direction by foot or raft every 7 to 10 days between November and January. Surveyors used polarized sunglasses and recorded clarity in feet and visibility on a ranked scale from 1 to 5 (1 = poor visibility, 2 = fair visibility, 3 = good visibility, 4 = very good visibility and 5 = excellent visibility). Non-surveyable conditions were recorded with a notation of “6” on the datasheets.

Observations of redds, carcasses, and live coho spawners were recorded during each survey. Redds were identified by substrate disturbance (i.e., color change) and depression (i.e., clearly defined pit and tailspill) and were recorded as new, still visible, or not visible. A fourth category (not observed), meaning that the surveyor had missed the location of a previously flagged redd, was assigned during data entry. New redds were flagged with a redd number, date, distance between the flag and redd, and surveyor. Garmin Oregon 550 units generated waypoints and a latitude and longitude for each new redd. Carcasses were sampled for sex (jack, male, female), fork length, scales (age), mark status (adipose-clip or unmarked), coded-wire tag presence (positive, negative), and recaptures from fish tagged at the weirs (Floy and opercle punch). A male coho less than 47-cm FL was considered a jack coho, subsequent scale data will be used to adjust this length threshold (not available at the time of this report). Snouts were retained from fish which scanned positive for coded-wire tags. Live fish were recorded as holders or spawners, as defined by WDFW Region 5 spawner survey protocols (L. Brown, WDFW, personal communication). “Holders” were fish found to be milling around/holding in areas where spawning does not occur (pools and long glides without spawning substrate). “Spawners” were any fish not defined as a holder, including fish found in areas with spawnable habitat (in, on, or around, tailouts, riffles, and glides with spawning substrate).

Data were entered into the standardized Traps-Weirs-Surveys (TWS) database used to archive WDFW adult monitoring data for all Lower Columbia tributaries. Scale ages were determined by the WDFW Ageing Lab. Snouts collected with coded wire tags were decoded by the WDFW Coded-Wire Tag Laboratory.

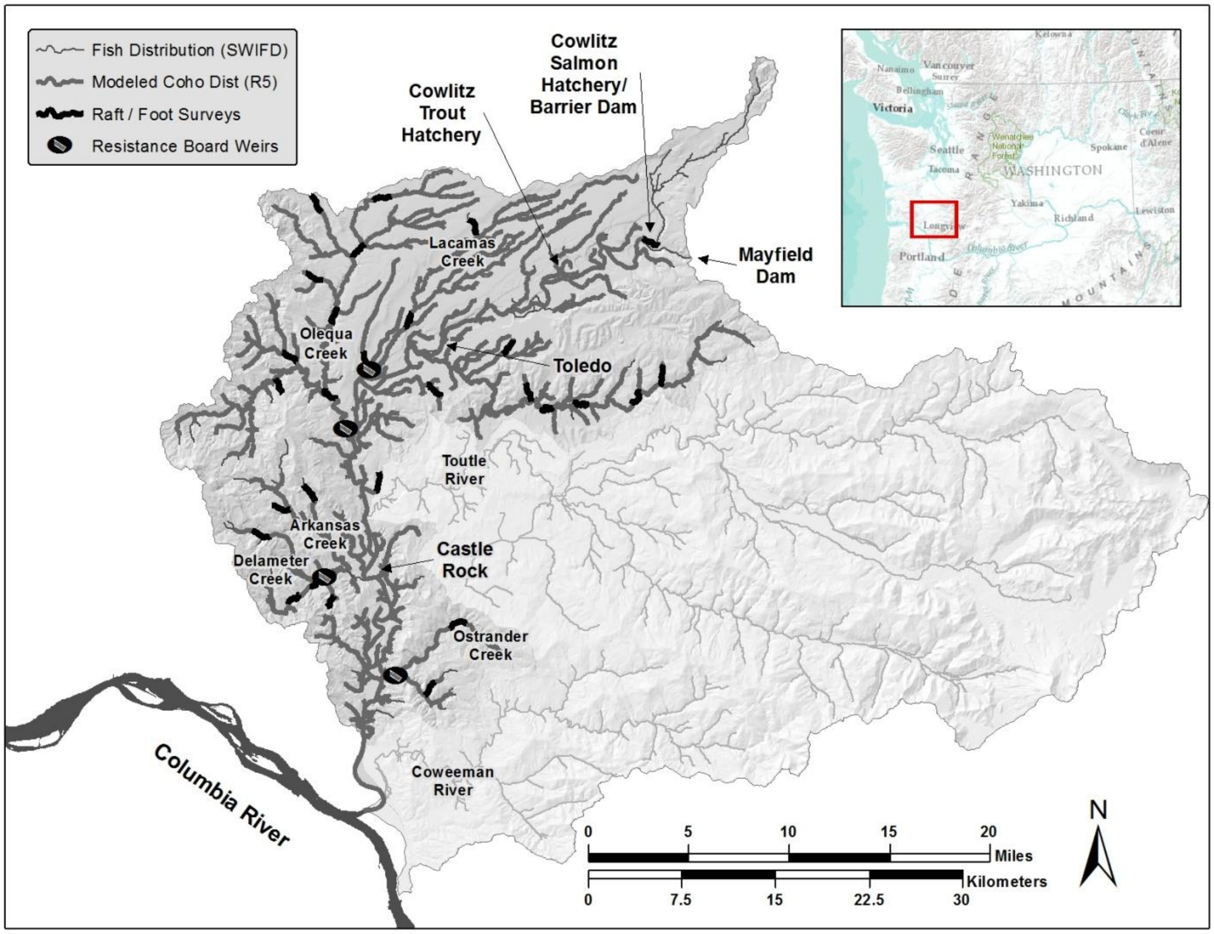


Figure 6. Coho salmon spawner survey reaches in 2013 and modeled distribution of coho salmon in lower Cowlitz River tributaries. Modeled distribution is based on GIS-derived basin characteristics per the Cowlitz Monitoring and Evaluation Plan (FHMP Appendix J) published in 2011.

### *Estimates of Spawner Abundance and pHOS*

Chinook salmon spawner abundance was estimated by the peak redd counts adjusted by an expansion factor of 2.84 fish per redd. This expansion factor was developed for fall Chinook salmon based on fixed wing aerial surveys and a carcass tagging mark-recapture study conducted in 1992 (Hymer 1994) and was subsequently modified for helicopter aerial surveys (WDFW, unpublished data). The same expansion factor was applied to spring Chinook salmon redds based on the assumption that visibility was similar between aerial surveys which collected peak counts for the two run types. No precision estimate for the redd expansion factor is currently available. The proportion of hatchery-origin spawners (pHOS) was calculated from carcass recoveries. The ratio of adipose clipped carcasses to total carcasses for each reach were weighted by reach-specific redd counts to estimate pHOS for spring and fall Chinook. Redd counts used for these calculations were from the peak spawning week identified from aerial surveys.  Natural-origin and hatchery-origin spawners were apportioned to age class based on scale samples for unmarked and adipose-clipped Chinook of each run type.

Coho and steelhead spawner abundance were estimated for lower Cowlitz River tributaries. No study design or estimation method is currently implemented for main stem spawning of coho and steelhead. In 2013, the same estimation method was applied to both species and made use of mark-recapture estimates above weir locations and the modeled spawning distribution for each species (Fransen et al. 2006 adapted to lower Cowlitz River tributaries in 2011 FHMP Update). A variance estimator is available for the mark-recapture estimate; however, methods for calculating variance need to be developed when error is propagated through multiple estimates (e.g., combining abundance and proportion of hatchery-origin spawners). The intended analysis for coho salmon was that redd densities from GRTS coho survey reaches would be applied to the unsurveyed stream length within the distribution frame, excluding areas above weirs, and expanded by the number of females per redd and the proportion of females in the population to obtain adult coho salmon abundance estimates. This estimate would be added to mark-recapture estimates for areas above weirs to estimate the total lower Cowlitz tributary coho abundance. However, GRTS reach coho salmon redd counts displayed substantial overdispersion resulting in a median redd density of zero redds per mile although some reaches had very high redd densities. Methods are being developed throughout the lower Columbia region that will enable the use of such overdispersed redd data to estimate coho salmon abundance. Owing to this overdispersion an alternative *ad hoc* approach which expanded coho salmon densities above weirs to other areas was used to estimate coho salmon abundance in lower Cowlitz tributaries in 2013.

Spawner abundance in tributaries above weir locations was estimated with a Petersen mark-recapture estimator with Chapman modification ($\widehat{N}_{weir}$) and its associated variance $V(\widehat{N}_{weir})$ (Seber 1982):

(1) $\widehat{N}_{weir} = (n_1 + 1) * \frac{n_2+1}{m_2+1} - 1$

(2) $V(\widehat{N}_{weir}) = \frac{(n_1+1)*(n_2+1)*(n_1-m_2)*(n_2-m_2)}{(m_2+1)*(m_2+1)*(m_2+2)}$

where $n_1$ are fish tagged and released above the weir, $n_2$ are the total kelts (steelhead) or carcasses (coho) recovered above the weir, and $m_2$ are the number of previously tagged fish (recaptures) recovered above the weir.

Weir efficiency (WE) as the number of fish tagged and passed above the weir ($n_1$) divided by the estimated spawner abundance above that weir ($\widehat{N}_{weir}$, equation 1):

(3) $WE = \frac{n_1}{\widehat{N}_{weir}}$

A weighted average fish per mile $\overline{fpm}$ was estimated based on spawners ($\widehat{N}_{weir}$, equation 1) and modeled spawning habitat miles above each weir ($H_{weir}$) weighted by the proportion of modeled spawning habitat in that tributary versus all tributaries with weir mark-recapture data ($p.H_{weir}$):

(4) $\overline{fpm} = \sum(\frac{\widehat{N}_{weir}}{H_{weir}} * p.H_{weir})$

Spawner abundance in non-monitored tributaries ($\widehat{N_{nm}}$, below weir locations) was estimated by multiplying the average fish per mile ($\overline{fpm}$, equation 4) by the miles of spawning distribution not above weir sites ($H_{nm}$):

(5) $\widehat{N_{nm}} = \overline{fpm} * H_{nm}$

The proportion of hatchery-origin spawners above weir locations ($pHOS_{weir}$) was estimated from the natural-origin ($n_2^{NOR}$) and hatchery-origin fish ($n_2^{HOR}$) recovered above the weir. Hatchery-origin fish were recovered above the weir because some hatchery-origin fish swam over the weir during high flow events when the panels were submerged.

(6) $\widehat{pHOS}_{weir} = n_2^{HOR} / (n_2^{HOR} + n_2^{NOR})$

The proportion of hatchery-origin spawners in each tributary had the weirs not operated ($\widehat{pHOS}_{noweir}$) was estimated from the estimated hatchery-origin spawners above the weir ($\widehat{pHOS}_{weir}$, equation 6), the hatchery-origin spawners captured at the weir and released downstream ($N_h$), and the total spawner estimate above the weir ($\widehat{N_m}$, equation 1):

(7) $\widehat{pHOS}_{noweir} = (\widehat{pHOS}_{weir} * \widehat{N_m} + N_h) / (\widehat{N_m} + N_h)$

The proportion of hatchery-origin spawners for all non-monitored tributaries ($pHOS_{nm}$) was the average of the proportion of hatchery-origin spawners had the weir not operated in each tributary ($\widehat{pHOS}_{noweir}$, equation 7):

(8) $\widehat{pHOS}_{nm} = \overline{pHOS}_{noweir}$

Total natural-origin spawner abundance was the sum of spawner abundance above each weir ($\widehat{N}_{weir}$, equation 1) multiplied by respective pHOS ratios ($1 - pHOS_{weir}$ , equation 6) and the spawner abundance in non-monitored tributaries ($N_{nm}$ , equation 4) multiplied by the pHOS ratio for non-monitored tributaries ($1 - \widehat{pHOS}_{nm}$, equation 8):

(9) $N_{NOS} = \sum((1 - \widehat{pHOS}_{weir}) * \widehat{N}_m) + \left(1 - \widehat{pHOS}_{nm}\right) * \widehat{N_{nm}}$

Total hatchery-origin spawner abundance was the sum of spawner abundance above each weir ($\widehat{N}_{weir}$, equation 1) multiplied by respective pHOS ratios ($pHOS_{weir}$ , equation 7) and the spawner abundance in non-monitored tributaries ($N_{nm}$ , equation 5) multiplied by the pHOS ratio for non-monitored tributaries ($\widehat{pHOS}_{nm}$, equation 8):

(10) $N_{HOS} = \sum(\widehat{pHOS}_{weir} * \widehat{N}_m) + (\widehat{pHOS}_{nm} * N_{nm})$

*Spot Creel Surveys for Chinook and Coho Salmon*

Spot creel surveys were conducted for spring and fall Chinook salmon and coho salmon between August 12, 2013 and November 20, 2013. Surveys were conducted on a daily basis when possible. Subsets of all boat and shore anglers were interviewed between the mouth of the Cowlitz River and Barrier Dam (Figure 7). In 2013, the Cowlitz Monitoring and Evaluation staff surveyed the areas from Camelot (just below town of Castle Rock) to the Barrier Dam. Additional surveys below the I-5 Bridge were conducted by WDFW staff from the Vancouver office. This report includes results from the Cowlitz Monitoring and Evaluation staff surveys only. Combining the surveys above and below the I-5 Bridge will require additional considerations based on uncertainties described in the Discussion section of this report. Observed information included fishing method (boat, shore), start time, count of fish kept by species and hatchery-origin or natural-origin. Coho were determined to be jacks when less than 47 cm fork length (FL). Fall Chinook were determined to be jacks when less than 56 cm FL. Landed catch was sampled for scales and coded-wire tags. Angler reported information included count of fish released by species and hatchery-origin or natural-origin. Landed catch was inspected and/or sampled for species, sex (jack, male, female), length, mark status (unmarked, adipose clipped), opercle or caudal punches (size and shape), scales (age), tags type (color) and number. All fish were scanned for coded-wire tags. For fish that scanned positive, heads were collected, retained in a bag with uniquely numbered snout label, and were sent to the WDFW Coded-Wire Tag Lab in Olympia, Washington for processing.

Encounter rates and release rates were calculated for adult fall Chinook and coho salmon. Information on releases of captured steelhead was not collected in 2013 but will be gathered in 2014. The encounter rates of natural-origin to hatchery-origin (NOR caught/HOR caught) were calculated by location. A total encounter rate was weighted by the retained fish caught at all locations. The release rate was calculated separately for fish of hatchery and natural origin.

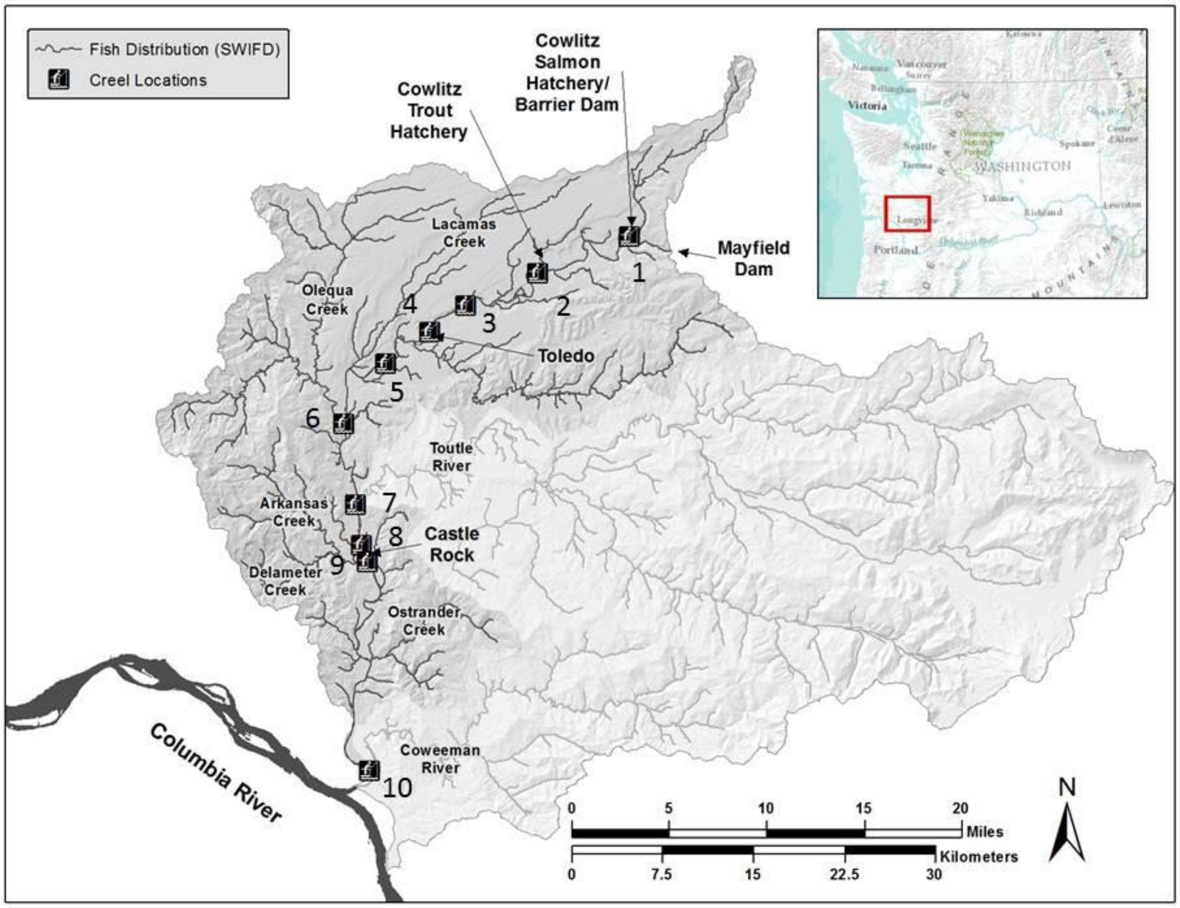


Figure 7. Creel survey locations on Cowlitz River, 2013. Locations include Barrier Dam (1), Blue Creek (2), Mission Bar (3), Toledo Ramp (4), I-5 Ramp (5), Olequa Ramp (6), Toutle Confluence (7), Castle Rock Ramp (8), Camelot (9), and Gerhart Gardens (10).

*Chinook and Coho Hatchery Broodstock Composition*

Chinook and coho spawner disposition at the Cowlitz Salmon Hatchery were summarized from the Cowlitz Salmon Hatchery Separator database maintained by Tacoma Power (Scott Gibson, Tacoma Power, personal communication). Data were summarized as jack, male, and female using pre-established jack/male cutoffs for spring Chinook (59 cm FL), fall Chinook (47 cm FL), and coho (42 cm FL) salmon.

Spring Chinook, fall Chinook, and coho salmon retained for brood stock were biologically sampled at the Cowlitz Salmon Hatchery. Spring Chinook broodstock were sampled at a 1 in 3 rate. Unmarked fall Chinook (collected from the river and used in the integrated program) were sampled at a 1 in 1 rate and adipose-clipped fall Chinook (used for either the integrated or segregated hatchery program) were sampled at a 1 in 4 rate. Coho have both a segregated and integrated hatchery program. Unmarked/coded-wire tagged coho (Upper Cowlitz origin, used for integrated program) and adipose-clipped/coded-wire tagged coho (integrated hatchery-origin) were sampled at a 1 in 1 rate. Forty samples of adipose-clipped coho (segregated hatchery-origin) were sampled throughout the return.

Data collected included species, run, sex (male, female), fork length, scales (age), coded-wire tag status (positive, negative – snouts were retained from all positive scans), and mark status (unmarked, adipose or other clips). Distinctions between jacks and adult males were made based on age results.

Biological sampling data were entered into the standardized Traps-Weirs-Surveys (TWS) database used to archive WDFW adult monitoring data for all Lower Columbia tributaries. Scale ages were determined by the WDFW Ageing Lab. Snouts collected with coded wire tags were decoded by the WDFW Coded-Wire Tag Laboratory.

*Mayfield Dam Downstream Migrant Trap Operation*

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. The system is either operated in passive mode (fish are bypassed directly into the downstream transport pipeline) or 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 and are held in the raceways until processing.

Operation of the downstream migrant trap at Mayfield Dam was conducted by Tacoma Power staff. In 2013, the migrant trap operation began on April 1st and continued through January 11, 2014. While pumps were on, the trap was run continuously and checked three to six times per week, depending on catch levels. Fish in the trap were examined by lowering the water in the migrant trap raceways, which facilitates fish exiting from the raceways and into the counting house troughs. Once the fish were in the counting house, they were hand netted into a recirculation trough containing tricaine methanesulfonate (MS-222) and baking soda (Sodium Bicarbonate). The louver pumps were shut off from January through the end of March, which affected the attraction flow to the trap and bypass flume. In past years while the pumps were off, the trap was run occasionally to test whether fish were migrating into the facility without pumps on. No occasional tests were performed in 2013.

All fish were enumerated by species and life stage. Chinook were assigned as fry/parr (parr marks absent or present, < 95 mm FL), sub-yearling smolts (parr marks absent or very faint, 95-160 mm FL) or yearling smolts (parr marks absent or very faint, >160-mm FL). Coho were classified as fry (< 60 mm FL), parr (parr marks present, 60-100 mm FL), or smolts (parr marks absent or very faint, > 100 mm FL). Cutthroat and steelhead were classified as parr (distinct parr marks, 100-150 mm FL) or smolt (parr marks absent or very faint, 150-230 mm FL). Juvenile and adult salmonids were released downstream of Mayfield Dam. Rainbow trout and tiger muskies were returned to Mayfield Lake above Mayfield Dam. Juvenile salmonids were examined for visual marks and clips and steelhead kelts were examined for injury or damage.

Historically salmonid smolts captured in this trap were either coded wire tagged or blank wire tagged depending on species, life stage, and origin in order to uniquely mark fish as being of Tilton origin when they returned to the Mayfield Dam separator as adults. However, in 2012, tagging efforts were shifted upstream to the Cowlitz Falls Fish Facility.

## Results

*Tributary Weir Operation*

Between July 1, 2012 and June 30, 2013 (corresponding to the 2013 steelhead spawn year), natural-origin and hatchery-origin steelhead were handled in both upstream and downstream traps on Delameter and Olequa creeks. Hatchery-origin steelhead spawners and kelts, identified by an adipose clip, were captured between November 19, 2012 and April 30, 2013. Based on phenotype and entry timing, all hatchery steelhead were categorized winter-run, but could not be definitively distinguished as early winter-run versus Cowlitz winter-run hatchery origin. The early-winter run steelhead program has been discontinued on the Cowlitz River but returns from this program were still occurring in 2013. Genetic samples collected from these fish could be used to make this distinction in the future.

Between September 1, 2013 and February 28, 2014 (corresponding to the 2013 coho spawn year), natural-origin and hatchery-origin coho salmon were handled in upstream weir traps and as carcasses above the weirs on Ostrander, Delameter, Olequa, and Lacamas creeks. Because the Lacamas Creek weir installation was not completed until December 20, 2013, data from this weir were not used for a mark-recapture estimate for the 2013 spawn year.

Additional species handled in the weir trap included largescale sucker (*Catostomus macrocheilus*), northern pikeminnow (*Ptychocheilus oregonensis*), mountain whitefish (*Prosopium williamsoni*), pink salmon (*Oncorhynchus gorbuscha*), chum salmon (*O. keta*), sockeye salmon (*O. nerka*), fall Chinook salmon (*O. tshawytscha*), cutthroat trout (*O. clarkii*), and brown bullhead (*Ameiurus nebulosus*).

On Delameter Creek, all steelhead captured in the upstream trap were maiden captures, meaning that they had not been handled previously. A total of 54 natural-origin steelhead were released upstream, 2 hatchery-origin steelhead were released downstream of the weir, and 2 natural-origin steelhead were retained for broodstock (Table 3). Steelhead captured in the downstream direction (trap or seine) included 15 recaptured (tagged) and 5 maiden (untagged) natural-origin steelhead and no untagged hatchery-origin steelhead. Twelve out of 15 recaptures had retained both tags; an estimated 1.3% of tagged steelhead are estimated to have lost both tags. The mark-recapture estimate of steelhead abundance above the weir location was 86 fish (CV = 9.5%), corresponding to 9.6 steelhead per mile of habitat (Table 5). The proportion of hatchery-origin steelhead was 0%, which was lower than the 2.6% pHOS estimate had the weir not been operating (see equation 6 in Methods section). Seasonal weir efficiency, the number of fish captured divided by the spawner abundance estimate, was estimated to be 71%.

On Olequa Creek, all steelhead captured in the upstream trap were maiden captures. A total of 46 natural-origin steelhead were released upstream, and 3 hatchery-origin steelhead were released downstream of the weir (Table 4). Steelhead captured in the downstream direction (trap or seine) included 13 tagged and 19 untagged natural-origin steelhead (includes one fish not identified as male or female) and 5 untagged hatchery-origin steelhead. Thirteen out of 13 recaptures had retained both floy tags (100% retention). The mark-recapture estimate of steelhead abundance above the weir location was 133 fish (CV = 15.9%), corresponding to 2.9 steelhead per mile of habitat (Table 5). The proportion of hatchery-origin steelhead was 13.9%, which was lower than the 15.8% pHOS estimated had the weir not been operating. Seasonal weir efficiency, the number of fish captured divided by the spawner abundance estimate, was estimated to be 35%.

A total of three natural-origin steelhead were collected for the integrated steelhead broodstock program. On Delameter Creek, a 60-cm FL female was collected on February 13, 2013, not spawned, and returned to the creek above the weir and a 69-cm FL male collected on April 4, 2013, spawned, and returned to the creek above the weir. On Olequa Creek, a male was collected on April 4, 2013, spawned, and returned to the creek above the weir.

Table 3. Capture and disposition of steelhead at Delameter Creek weir, 2012-2013 return. Table includes the trap orientation (Upstream Trap, Downstream Trap) and the direction which fish were released (Upstm = Upstream, Dnstm = Downstream, Broodstock).

| | | Upstream Trap | | | Downstream Trap |
|---|---|---|---|---|---|
| | | Rel. Upstm | Rel. Dnstm | Broodstock | Rel. Dnstm |
| Natural Maiden | M | 22 | 0 | 1 | 0 |
| | F | 32 | 0 | 1 | 5 |
| Hatchery Maiden | M | 0 | 1 | 0 | 0 |
| | F | 0 | 1 | 0 | 0 |
| | **Sub-total** | **54** | **2** | **2** | **5** |
| Natural Recapture | M | 0 | 0 | 0 | 4 |
| | F | 0 | 0 | 0 | 11 |
| Hatchery Recapture | M | 0 | 0 | 0 | 0 |
| | F | 0 | 0 | 0 | 0 |
| | **Sub-total** | **0** | **0** | **0** | **15** |
| | **Grand Total** | **54** | **2** | **2** | **20** |

Table 4. Capture and disposition of steelhead at Olequa Creek weir, 2012-2013 return. Table includes the trap orientation (Upstream Trap, Downstream Trap) and the direction which fish were released (Upstm = Upstream, Dnstm = Downstream, Broodstock).

| | | Upstream Trap | | | Downstream Trap |
|---|---|---|---|---|---|
| | | Rel. Upstm | Rel. Dnstm | Broodstock | Rel. Dnstm* |
| Natural Maiden | M | 13 | 0 | 1 | 7 |
| | F | 33 | 0 | 0 | 11 |
| Hatchery Maiden | M | 0 | 3 | 0 | 3 |
| | F | 0 | 0 | 0 | 2 |
| | **Sub-total** | **46** | **3** | **1** | **23** |
| Natural Recapture | M | 0 | 0 | 0 | 1 |
| | F | 0 | 0 | 0 | 12 |
| Hatchery Recapture | M | 0 | 0 | 0 | 0 |
| | F | 0 | 0 | 0 | 0 |
| | **Sub-total** | **0** | **0** | **0** | **13** |
| | **Grand Total** | **46** | **3** | **1** | **46** |

* one additional untagged maiden-caught steelhead was released downstream but male/female was unknown.

Table 5. Abundance (± 95% confidence interval) and composition of steelhead spawners above tributary weirs in the lower Cowlitz River, spawn year 2013.

| Metric | Delameter | Olequa |
|---|---|---|
| Spawner abundance above weir | 86 (± 14) | 133 (± 42) |
| Spawner/mile | 9.6 | 2.9 |
| Percent females | 59.2% | 71.7% |
| pHOS above weir | 0.0% | 13.9% |
| pHOS if no weir | 2.6% | 15.8% |
| Weir efficiency | 71.0% | 34.6% |

On Ostrander Creek, all coho captured in the upstream trap were maiden captures. A total of 49 natural-origin coho adults were released upstream (Table 6). An additional 1 natural-origin coho jack was released upstream and 7 hatchery-origin coho jacks were released downstream from the weir. To be consistent with coho spawner abundance estimates elsewhere in the Lower Columbia River, jacks were not included in the mark-recapture analysis. Coho carcasses recovered from the weir panels included 10 recaptured (tagged) and 11 maiden (untagged) natural-origin coho adults and 1 maiden hatchery-origin coho adult. Coho carcasses recovered from the spawning grounds above the weir included just one maiden natural-origin coho adult and no hatchery-origin coho adults. All recaptured coho had retained both tags and their opercle punch (100% retention). Low numbers of carcass recoveries from spawner surveys necessitated using recoveries from weir wash-ups for the mark-recapture abundance estimate. Mark-recapture estimate of coho abundance above the weir location was 109 fish (CV = 16.5%), corresponding to 8.1 coho per mile of habitat (Table 10). The proportion of hatchery-origin coho with or without a weir was 0%. Seasonal weir efficiency was estimated to be 45%.

On Delameter Creek, all coho captured in the upstream trap were maiden captures. A total of 95 natural-origin coho adults were released upstream (Table 7). An additional 6 natural-origin coho jacks were released upstream and 6 hatchery-origin coho jacks were released downstream from the weir. Jacks were not included in the mark-recapture analysis. Coho carcasses recovered from the weir panels included 11 recaptured and 8 maiden natural-origin coho adults and no hatchery-origin coho adults. Coho carcasses recovered from the spawning grounds above the weir included just 2 recaptured and 2 maiden natural-origin coho adults and 0 hatchery-origin coho adults. Tag retention was estimated to be 99.2%; all recaptured coho with tags had retained both tags, but 1 out of 11 recaptured coho had lost both tags (retained opercle punch). Low numbers of carcass recoveries from spawner surveys necessitated using recoveries from weir wash-ups for the mark-recapture abundance estimate. Mark-recapture estimate of coho abundance above the weir location was 174 fish (CV = 15.1%), corresponding to 11.8 coho per mile of habitat (Table 10). The proportion of hatchery-origin coho was 0%, which was lower than the 3.8% pHOS estimated had the weir not been operating. Seasonal weir efficiency was estimated to be 55%.

On Olequa Creek, all coho captured in the upstream trap were maiden captures. A total of 86 natural-origin coho adults were released upstream and 3 hatchery-origin adults were released downstream from the weir (Table 8). An additional 20 natural-origin coho jacks were released upstream and 5 hatchery-origin coho jacks were released downstream. Jacks were not included in the mark-recapture analysis. Coho carcasses recovered from the weir panels included 9 recaptured and 16 maiden natural-origin coho adults and no hatchery-origin coho adults. Coho carcasses recovered from the spawning grounds above the weir included 1 recaptured and 39 maiden natural-origin coho adults and 0 hatchery-origin coho adults. Tag retention was 100%; all recaptured coho had retained both tags and the opercle punch. Low numbers of carcass recoveries from spawner surveys necessitated using recoveries from weir wash-ups for the mark-recapture abundance estimate. Mark-recapture estimate of coho abundance above the weir location was 250 fish (CV = 20.1%), corresponding to 2.4 coho per mile of habitat (Table 10). The proportion of hatchery-origin coho was 0%, which was lower than the 1.1% pHOS estimated had the weir not been operating. Seasonal weir efficiency was estimated to be 34%.

On Lacamas Creek, all coho captured in the upstream trap were maiden captures. A total of 15 natural-origin coho adults were released upstream and 1 hatchery-origin coho adult was released downstream of the weir (Table 9). No coho jacks were handled in the upstream weir trap. Coho carcasses recovered from the weir panels included 3 recaptured and 5 maiden natural-origin coho adults and 1 maiden hatchery-origin coho adult. Coho carcasses recovered from the spawning grounds above the weir included 0 recaptured and 29 maiden natural-origin coho adults and 2 maiden hatchery-origin adults. Tag retention was 100%; all recaptured coho had both tags and an intact opercle punch.  Mark-recapture estimate was not made for coho salmon in Lacamas Creek because the weir operation began once the majority of the spawners had entered the creek.

Table 6. Capture and disposition of coho salmon at Ostrander Creek weir, 2013-2014 return. Table includes capture of fish moving in the upstream direction (upstream trap) and downstream direction (carcass recoveries).

| | | Upstream Trap | | Carcass Recoveries | |
|---|---|---|---|---|---|
| | | Rel. Upstm | Rel. Dnstm | Weir Fallback | Surveys |
| Natural Maiden | J | 1 | 0 | 0 | 0 |
| | M | 30 | 0 | 9 | 1 |
| | F | 19 | 0 | 2 | 0 |
| Hatchery Maiden | J | 0 | 7 | 1 | 0 |
| | M | 0 | 0 | 0 | 0 |
| | F | 0 | 0 | 0 | 0 |
| **Adult Sub-total** | | **49** | **0** | **11** | **1** |
| Natural Recapture | J | 0 | 0 | 0 | 0 |
| | M | 0 | 0 | 8 | 0 |
| | F | 0 | 0 | 2 | 0 |
| Hatchery Recapture | J | 0 | 0 | 0 | 0 |
| | M | 0 | 0 | 0 | 0 |
| | F | 0 | 0 | 0 | 0 |
| **Adult Sub-total** | | **0** | **0** | **10** | **0** |
| **Grand Total (Adults)** | | **49** | **0** | **21** | **1** |
| **Grand Total (Jacks)** | | **1** | **7** | **1** | **0** |

Table 7. Capture and disposition of coho salmon at Delameter Creek weir, 2013-2014 return. Table includes capture of fish moving in the upstream direction (upstream trap) and downstream direction (carcass recoveries).

| | | Upstream Trap | | Carcass Recoveries | |
|---|---|---|---|---|---|
| | | Rel. Upstm | Rel. Dnstm | Weir Fallback | Surveys |
| Natural Maiden | J | 6 | 0 | 0 | 0 |
| | M | 63 | 0 | 6 | 2 |
| | F | 32 | 0 | 2 | 0 |
| Hatchery Maiden | J | 0 | 6 | 1 | 0 |
| | M | 0 | 5 | 0 | 0 |
| | F | 0 | 2 | 0 | 0 |
| **Adult Sub-total** | | **95** | **7** | **8** | **2** |
| Natural Recapture | J | 0 | 0 | 0 | 0 |
| | M | 0 | 0 | 8 | 2 |
| | F | 0 | 0 | 3 | 0 |
| Hatchery Recapture | J | 0 | 0 | 0 | 0 |
| | M | 0 | 0 | 0 | 0 |
| | F | 0 | 0 | 0 | 0 |
| **Adult Sub-total** | | **0** | **0** | **11** | **2** |
| **Grand Total (Adults)** | | **95** | **7** | **19** | **2** |
| **Grand Total (Jacks)** | | **6** | **6** | **1** | **0** |

Table 8. Capture and disposition of coho salmon at Olequa Creek weir, 2013-2014 return. Table includes capture of fish moving in the upstream direction (upstream trap) and downstream direction (carcass recoveries).

| | | Upstream Trap | | Carcass Recoveries | |
|---|---|---|---|---|---|
| | | Rel. Upstm | Rel. Dnstm | Weir Fallback | Surveys* |
| Natural Maiden | J | 20 | 0 | 2 | 5 |
| | M | 58 | 0 | 12 | 23 |
| | F | 28 | 0 | 4 | 16 |
| Hatchery Maiden | J | 0 | 5 | 0 | 0 |
| | M | 0 | 2 | 0 | 0 |
| | F | 0 | 1 | 0 | 0 |
| **Adult Sub-total** | | **86** | **3** | **16** | **39** |
| Natural Recapture | J | 0 | 0 | 2 | 0 |
| | M | 0 | 0 | 9 | 1 |
| | F | 0 | 0 | 0 | 0 |
| Hatchery Recapture | J | 0 | 0 | 0 | 0 |
| | M | 0 | 0 | 0 | 0 |
| | F | 0 | 0 | 0 | 0 |
| **Adult Sub-total** | | **0** | **0** | **9** | **1** |
| **Grand Total (Adults)** | | **86** | **3** | **25** | **40** |
| **Grand Total (Jacks)** | | **20** | **5** | **4** | **5** |

* 2 additional unmarked maiden-captured adult carcasses were recovered but male/female could not be determined.

Table 9. Capture and disposition of coho salmon at Lacamas Creek weir, 2013-2014 return. Table includes capture of fish moving in the upstream direction (upstream trap) and downstream direction (carcass recoveries).

| | | Upstream Trap | | Carcass Recoveries | |
|---|---|---|---|---|---|
| | | Rel. Upstm | Rel. Dnstm | Weir Fallback | Surveys* |
| Natural Maiden | J | 0 | 0 | 0 | 1 |
| | M | 10 | 0 | 4 | 14 |
| | F | 4 | 0 | 0 | 15 |
| Hatchery Maiden | J | 0 | 0 | 0 | 0 |
| | M | 0 | 1 | 1 | 0 |
| | F | 0 | 0 | 0 | 2 |
| **Adult Sub-total** | | **15** | **1** | **5** | **31** |
| Natural Recapture | J | 0 | 0 | 0 | 0 |
| | M | 0 | 0 | 3 | 0 |
| | F | 0 | 0 | 0 | 0 |
| Hatchery Recapture | J | 0 | 0 | 0 | 0 |
| | M | 0 | 0 | 0 | 0 |
| | F | 0 | 0 | 0 | 0 |
| **Adult Sub-total** | | **0** | **0** | **3** | **0** |
| **Grand Total (Adults)** | | **15** | **1** | **8** | **31** |
| **Grand Total (Jacks)** | | **0** | **0** | **0** | **1** |

* Weir was installed on December 20, 2013 and captures represented a portion of the return timing. One additional unmarked non-tagged adult carcass was recovered but male/female could not be determined.

Table 10. Abundance (±95% confidence interval) and composition of adult coho salmon spawners above tributary weirs in the lower Cowlitz River, 2013-2014.

| Metric | Ostrander | Delameter | Olequa |
|---|---|---|---|
| Spawner abundance above weir | 109 (± 35) | 174 (± 51) | 250 (± 99) |
| Spawner/mile | 8.1 | 11.8 | 2.4 |
| Percent females | 38% | 34% | 33% |
| pHOS above weir | 0% | 0% | 0% |
| pHOS if no weir | 0% | 3.8% | 1.1% |
| Weir efficiency | 45% | 55% | 34% |

*Steelhead Spawner Abundance, Distribution, and Diversity (pHOS)*

In Delameter Creek, 49 steelhead redds were observed above the weir location, corresponding to a 0.92 redd-per-female ratio when combined with the mark-recapture data (Table 11). In Olequa Creek, 73 steelhead redds were observed above the weir location, corresponding to a 1.30 redd-per-female ratio when combined with mark-recapture data.

The total number of steelhead spawners in lower Cowlitz River tributaries for spawn year 2013 is estimated to be 559 (508 natural-origin and 51 hatchery-origin) based on 3.93 steelhead per mile above weirs (weighted average), 89 miles of spawning habitat modeled outside of the mark-recapture reaches above weirs, and a pHOS of 9.2% for non-weir tributaries.

Table 11. Total number of winter steelhead redds observed in foot surveys of lower Cowlitz River tributaries, 2013.

| Tributary | Number redds | Redds/female |
|---|---|---|
| **Delameter Creek sub-basin** | | |
| Above weir (Delameter & Monahan creeks) | 49 | 0.92 |
| Below weir (Delameter & Arkansas creeks) | 28 | --- |
| **Olequa Creek sub-basin** | | |
| Above weir (Olequa Creek and its tributaries) | 73 | 1.30 |
| Below weir (Olequa Creek) | 4 | --- |
| **Total** | **154** | |

*Chinook Spawner Abundance, Distribution, and Diversity (pHOS)*

Peak redd counts for spring Chinook occurred on the September 25, 2013 aerial flight with redds distributed throughout the survey area between the Castle Rock and Barrier Dam (Table 12). Spawner escapement of spring Chinook was estimated to be 960 spawners (338 redds *

2.84). The proportion of hatchery spawners was estimated to be 89%. A total of 45 scale samples were analyzed for spring Chinook salmon; spawners ranged from 2 to 5 years with the majority of spawners being 4 or 5 years old (Table 13). Four coded-wire tags, all from the Cowlitz Salmon Hatchery, were recovered from carcasses.

Peak redd counts for fall Chinook occurred on the November 6, 2013 aerial flight with redds distributed throughout the survey area but most concentrated between Toledo Bridge and Mill Creek. Spawner escapement estimates of fall Chinook spawner escapement was 4,436 spawners (1,562*2.84, rounded). The proportion of hatchery-origin spawners was estimated to be 19%. A total of 299 scale samples were analyzed for fall Chinook salmon; spawners ranged from 2 to 6 years with the majority of natural-origin and hatchery-origin spawners being 4 years old (Table 14). Seven coded-wire tags were recovered from carcasses and represented Cowlitz Salmon hatchery ($n = 2$), Kalama Falls hatchery ($n = 1$), Lewis River wild ($n = 1$), and Tilton natural production ($n = 3$, unmarked blank wire tags).

Of note, fall Chinook salmon were also observed at tributary weirs in 2013. A total of 15 fall Chinook (73% hatchery) were captured at the Ostrander weir, 10 fall Chinook (60% hatchery) were captured at the Delameter weir, and 4 fall Chinook (25% hatchery) were captured at the Olequa weir. Project staff observed that hatchery-origin fall Chinook released downstream of the weir did not return to the main stem fishery but proceeded to build redds in the tributary reaches between the weirs and the main stem Cowlitz.

One hundred and fifty-nine genetic samples were collected from fresh (clear eyes and red/pink gills) Chinook carcasses in order to implement a future genetic mark-recapture study.

Table 12. Spatial and temporal distribution of natural-origin (NOR) and hatchery-origin (HOR) Chinook salmon spawners in the lower Cowlitz River, 2013.

| | Spring Chinook | | | | Fall Chinook | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Redds | | Carcass | | Redds | | | Carcass | |
| Reach | 9/11 | 9/25 | NOR | HOR | 10/9 | 10/25 | 11/6 | NOR | HOR |
| Kelso to Castle Rock R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Castle R Br to Toutle R Br | 3 | 8 | 0 | 0 | 0 | 23 | 2 | 0 | 0 |
| Toutle River to I-5 Bridge | 18 | 53 | 0 | 0 | 81 | 77 | 60 | 8 | 3 |
| I-5 Bridge to Toledo Bridge | 2 | 34 | 0 | 0 | 59 | 56 | 55 | 134 | 43 |
| Toledo Bridge to Skook Creek | 1 | 65 | 0 | 0 | 101 | 155 | 224 | 177 | 34 |
| Skook Cr to Blue Cr Boat Rp | 2 | 74 | 1 | 2 | 233 | 239 | 263 | 177 | 34 |
| Blue Cr Boat Rp to Baker Rock | 0 | 32 | 3 | 27 | 179 | 283 | 481 | 367 | 96 |
| Timber Trails side channel | 2 | 1 | 0 | 0 | 46 | 76 | 96 | 19 | 8 |
| Baker Rock to Mill Creek | 13 | 18 | 2 | 20 | 113 | 169 | 271 | 186 | 35 |
| Mill Creek to Barrier Dam | 47 | 53 | 0 | 0 | 50 | 38 | 110 | 0 | 0 |
| Total | 88 | 338 | 6 | 49 | 862 | 1116 | 1562 | 1068 | 253 |
| pHOS | | | | 0.89 | | | | | 0.19 |

Table 13. Age composition of natural-origin and hatchery-origin spring Chinook salmon spawners in the lower Cowlitz River, 2013.

| Origin | 2-year | 3-year | 4-year | 5-year | 6-year | **Total** |
|---|---|---|---|---|---|---|
| Natural | 7 | 7 | 61 | 31 | 0 | **106** |
| Hatchery | 66 | 44 | 460 | 285 | 0 | **854** |
| **Total** | 73 | 51 | 521 | 315 | 0 | **960** |

Table 14. Age composition of natural-origin and hatchery-origin fall Chinook salmon spawners in the lower Cowlitz River, 2013.

| Origin | 2-year | 3-year | 4-year | 5-year | 6-year | **Total** |
|---|---|---|---|---|---|---|
| Natural | 116 | 739 | 2521 | 203 | 14 | **3593** |
| Hatchery | 0 | 198 | 463 | 182 | 0 | **843** |
| **Total** | 116 | 937 | 2984 | 385 | 14 | **4436** |

*Coho Spawner Abundance, Distribution, and Diversity (pHOS)*

Coho surveys covered 29 miles of habitat, or 6.9% of the modeled coho spawning distribution. A total of 164 new redds were observed. Median redd density per mile was zero and ranged between 0 and 46 redds per mile. Reach occupancy was 34%. The high frequency of empty reaches coupled with high densities of redds in some reaches meant that redd densities could not be easily expanded from the GRTS-based survey reaches to the remainder of the basin.

In comparison to the GRTS based surveys, mark-recapture estimates of coho salmon above tributary weirs (Ostrander, Delameter, Olequa) covered 132.6 miles of habitat or 31.5% of the modeled coho spawning distribution. When expanding the fish per mile above these tributary weirs to the non-monitored tributaries, the total number of adult coho spawners in lower Cowlitz River tributaries for spawn year 2013 is estimated to be 1,694 (1,565 natural-origin and 20 hatchery-origin). This estimate is based on 4.0 coho per mile above weirs (weighted average), 289 miles of spawning habitat modeled outside of the mark-recapture reaches above weirs, and a pHOS of 1.7% for non-weir tributaries.

*Cowlitz River Fishery Encounter and Release Rates of Chinook and Coho Salmon*

Most anglers encountered and most fish caught were observed at the Barrier Dam location (Table 15). Based on interviews with 490 shore anglers, 44 Chinook salmon and 144 coho salmon were retained from 1,416 hours of fishing. Based on interviews with 61 boat anglers, 3 Chinook salmon and 1 coho salmon were retained from 383 hours of fishing.

The total weighted encounter rate for fall Chinook salmon was 0.58 natural-origin fish caught for every one hatchery-origin fish caught (Table 16). For every one hatchery-origin fall Chinook retained, 0.5 hatchery-origin fall Chinook were reported to be released. All natural-origin fall Chinook captured were reported to be released.

The total weighted encounter rate for coho salmon was 0.13 natural-origin fish caught for every one hatchery-origin fish caught. For every one hatchery-origin coho salmon retained, 0.12 hatchery-origin coho were reported to be released. All natural-origin coho salmon captured were reported to be released.

Table 15. Summary of spot creel surveys conducted on the lower Cowlitz River, 2013. Summarized data include number of interviews, total reported fishing effort (hours) and number of jack and adults retained by location and fishing method (shore, boat).

| | Shore | | | | Boat | | | |
|---|---|---|---|---|---|---|---|---|
| Location | Number anglers | Effort (hrs) | CHK | Coho | Number anglers | Effort (hrs) | CHK | Coho |
| Barrier Dam | 385 | 1085 | 43 | 137 | 2 | 4 | 0 | 0 |
| Blue Creek | 29 | 50 | 0 | 0 | 39 | 269 | 2 | 0 |
| Mission Bar | 8 | 32 | 0 | 0 | 0 | 0 | 0 | 0 |
| Toledo | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| I-5 | 0 | 0 | 0 | 0 | 1 | 5 | 0 | 0 |
| Olequa | 17 | 55 | 1 | 6 | 0 | 0 | 0 | 0 |
| Toutle R | 30 | 105 | 0 | 1 | NA | NA | NA | NA |
| Castle Rock | 0 | 0 | 0 | 0 | 19 | 105 | 1 | 1 |
| Camelot | 21 | 89 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | 490 | 1416 | 44 | 144 | 61 | 383 | 3 | 1 |

Table 16. Encounter and release rates estimated from spot creel surveys of adult fall Chinook and coho Salmon in the Cowlitz River, 2013. Summarized data include number of interviews, total reported fishing effort (hours) and number of jack and adults retained by location and fishing method (shore, boat).

| | Fall Chinook Salmon | | | | Coho Salmon | | | |
|---|---|---|---|---|---|---|---|---|
| Location | HOR Kept | Ratio NOR:HOR | Rel. Rate (HOR) | Rel. Rate (NOR) | HOR Kept | NOR:HOR Ratio | Rel. Rate (HOR) | Rel. Rate (NOR) |
| Barrier Dam | 42 | 0.58 | 0.50 | 1.00 | 107 | 0.13 | 0.12 | 1.0 |
| Blue Creek | 2 | 0.50 | 0.00 | 1.00 | 0 | 0 | 0 | 0 |
| Mission Bar | 0 | --- | --- | --- | 0 | --- | --- | --- |
| Toledo | 0 | --- | --- | --- | 0 | --- | --- | --- |
| I-5 | 0 | --- | --- | --- | 0 | --- | --- | --- |
| Olequa | 1 | 0.00 | 0.00 | --- | 0 | | | |
| Toutle R | 0 | --- | --- | --- | 1 | 0.0 | 0.0 | --- |
| Chapman Rd | 0 | --- | --- | --- | 0 | | | |
| Castle Rock | 1 | 1.00 | 0.00 | 1.00 | 1 | 0.0 | 0.0 | --- |
| Camelot | 0 | --- | --- | --- | 0 | | | |
| **Weighted Total** | 46 | 0.58 | 0.50 | 1.00 | 109 | 0.13 | 0.12 | 1.0 |

*Hatchery Broodstock Composition for Chinook and Coho Salmon*

A total of 4,162 spring Chinook salmon (434 jacks, 3728 adults) returned to the Cowlitz Salmon Hatchery separator at Barrier Dam (Table 17). Based on the 57-cm FL partition between jacks and adults, natural-origin returns to the hatchery included 18 jacks, and 381 adults. Hatchery-origin returns to the hatchery included 416 jacks and 3,347 adults. The dominant age classes for spring Chinook were $4_2$ (adult, exit freshwater after one year and return after 2.5 years at sea) and $5_2$ (adult, exit freshwater after one year and return after 3.5 years at sea, Table 20). Additional age classes observed were $3_1$ (adult, exit freshwater in the first year and return after 2.5 years at sea) and $3_2$ (jack, exit freshwater after one year and return after 1.5 years at sea). The $3_1$ age category was likely a scale ageing error as hatchery spring Chinook are released as yearlings. Average length of male spring Chinook used in the segregated broodstock program was 57.5 (± 6.0) cm-FL for jack males (age $3_2$) and 76.0 (± 6.1) cm-FL and 86.3 (± 9.1) cm-FL for adults (ages $4_2$ and $5_2$ respectively). Average length of female spring Chinook used in the segregated broodstock program was 75.5 (± 4.7) cm-FL and 82.0 (± 5.3) cm-FL for ages $4_2$ and $5_2$ respectively.

A total of 9,620 fall Chinook salmon (382 jacks, 9,238 adults) returned to the Cowlitz Salmon Hatchery separator at Barrier Dam (Table 18). Based on the 49-cm FL partition between jacks and adults, natural-origin returns included 92 jacks and 2,785 adults. Hatchery-origin returns included 290 jacks and 6,453 adult fall Chinook salmon. Although summary statistics are provided for the unmarked fish included in the integrated broodstock, sample sizes are too small to be reliable. The 2013 summary statistics for the adipose-clipped or adipose-clipped/coded-wire tagged fall Chinook used in the segregated broodstock are an appropriate surrogate for the integrated broodstock because the integrated broodstock was primarily derived from these fish due to low capture rates of unmarked fall Chinook from the river. The dominant age classes for fall Chinook were $3_1$ (adult, exit freshwater in the first year and return after 2.5 years at sea) and $4_1$ (adult, exit freshwater in the first year and return after 3.5 years at sea, Table 21). Additional age classes observed were $2_1$ (jack, exit freshwater in the first year and return after 18 months at sea), $4_2$ (adult, exit freshwater after one year and return after 2.5 years), and $5_1$ (adult, exit freshwater in the first year and return after 4.5 years at sea). The $4_2$ age category may have been a mis-identified spring Chinook (which are released as yearlings) or a hatchery fall Chinook which reared in freshwater for an additional year prior to outmigration. Average length of male fall Chinook (adipose clip or adipose clip and coded-wire tag) was 48.6 (±5.2) cm FL for jack males (age $2_1$) compared to 68.1 (±4.9) cm FL and 81.2 cm FL (±6.4) for adult males (age $3_1$ and $4_1$respectively, Table 21). Average length of female fall Chinook (adipose clip or adipose clip and coded-wire tag) was 69.1 (±4.2) cm FL, 79.8 (±5.1) cm FL, and 85.5 (±3.8) cm FL for ages $3_1$, $4_1$, and $5_1$ respectively.

A total of 37,363 coho salmon (17,713 jacks, 19,650 adults) returned to the Cowlitz Salmon hatchery (Table 19). Based on the 42-cm FL partition between jacks and adults, natural-origin returns include 273 jacks and 2,962 adult coho salmon. Hatchery-origin returns included 17,440 jacks and 16,688 adult coho salmon. For both natural-origin (UM+CWT) and hatchery-origin coho (AD+CWT, AD only), the dominant age class was $3_2$ (adult, exit freshwater after one year and return after 18 months at sea, Table 22). Additional age classes observed were age $2_2$ (jack, exit freshwater after one year and return after 6 months at sea), age $2_1$ (exit freshwater in the first year and return after 18 months at sea), and age $4_3$ (exit freshwater after two years and return after 18 months at sea), although the latter two age categories were only observed in natural-origin coho (UM+CWT). Average length of male coho used in the integrated broodstock program (unmarked/coded-wire tagged) was 34.9 (±3.5) cm FL for jack males (age = $2_2$) compared to 65.3 (±8.5) cm FL for adult males (age = $3_2$). The average length for adult females (age = $3_2$) was 69.1 (±4.7) cm FL. Average length of male coho used in the segregated broodstock program (adipose clipped) was 41-cm FL for jack males (age = $2_2$) compared to 67.3 (±9.2) cm FL for adult males (age = $3_2$). The average length for adult females (age = $3_2$) was 69.5 (±4.6) cm FL.

Table 17. Disposition of natural (NOR) and hatchery-origin (HOR) spring Chinook salmon returns to Cowlitz Salmon Hatchery in 2013. Mark types include unmarked, adipose-clipped (AD only), adipose-clipped and coded-wire tag (AD + CWT), left pelvic clip (LV-clipped), right pelvic clip (RV-clipped).

| | | Adult (≥ 59 cm FL) | | | Jack | Mini-jacks |
|---|---|---|---|---|---|---|
| | Female | Male | Unknown | Total Adult | (<59 cm FL) | |
| Broodstock – Segregated | | | | | | |
| HOR AD only | 0 | 0 | 1697 | 1697 | 56 | 0 |
| **Sub-total** | **---** | **---** | **1697** | **1697** | **56** | **0** |
| Release to Upper Cowlitz | | | | | | |
| NOR Unmarked | 131 | 158 | 0 | 289 | 15 | 0 |
| NOR LV-clipped | 24 | 25 | 0 | 49 | 2 | 0 |
| NOR RV-clipped | 22 | 21 | 0 | 43 | 1 | 0 |
| HOR AD only | 848 | 724 | 0 | 1572 | 334 | 0 |
| **Sub-total** | **1025** | **928** | **0** | **1953** | **352** | **0** |
| Release to Riffe Lake | | | | | | |
| NOR Unmarked | 0 | 0 | 0 | 0 | 0 | 1 |
| HOR AD only | 0 | 0 | 0 | 0 | 0 | 3289 |
| **Sub-total** | **0** | **0** | **0** | **0** | **0** | **3290** |
| Foodbank/Surplus | | | | | | |
| HOR AD only | 0 | 3 | 0 | 3 | 0 | |
| HOR AD + CWT | 40 | 35 | 0 | 75 | 26 | 144 |
| **Sub-total** | **40** | **38** | **0** | **78** | **26** | **144** |
| Mortalities | 0 | 0 | 0 | 0 | 0 | |
| **NOR Grand Total** | **177** | **204** | **0** | **381** | **18** | **1** |
| **HOR Grand Total** | **888** | **762** | **1697** | **3347** | **416** | **3434** |

Table 18. Disposition of natural (NOR) and hatchery (HOR) fall Chinook salmon returns to Cowlitz Salmon Hatchery in 2013. Mark types include unmarked, adipose-clipped (AD only), adipose-clipped and coded-wire tag (AD + CWT).

| | Adult (≥ 47 cm FL) Female | Male | Total Adult | Jack (< 47 cm FL) | Mini jacks |
|---|---|---|---|---|---|
| Broodstock | | | | | |
| HOR AD only | 968 | 812 | 1780 | 35 | 0 |
| **Sub-total** | **968** | **812** | **1780** | **35** | **0** |
| Released to Tilton | | | | | |
| NOR Unmarked | 1189 | 1590 | 2779 | 92 | 0 |
| HOR AD only | 245 | 677 | 922 | 52 | 0 |
| HOR AD + CWT | 217 | 280 | 497 | 6 | 0 |
| **Sub-total** | **1651** | **2547** | **4198** | **150** | **0** |
| Release to Upper Cowlitz | | | | | |
| NOR Unmarked | 3 | 3 | 6 | 0 | 0 |
| HOR AD only | 942 | 2215 | 3157 | 189 | 1 |
| HOR AD + CWT | 4 | 1 | 5 | 0 | 0 |
| **Sub-total** | **949** | **2219** | **3168** | **189** | **1** |
| Foodbank/Surplus | | | | | |
| HOR AD + CWT | 18 | 74 | 92 | 8 | 0 |
| **Sub-total** | **18** | **74** | **92** | **8** | **0** |
| Mortalities | | | | | |
| NOR Unmarked | 0 | 2 | 0 | 0 | 0 |
| HOR AD only | 1 | 0 | 0 | 0 | 0 |
| **Sub-total** | **1** | **2** | **0** | **0** | **0** |
| **NOR Grand Total** | **1192** | **1595** | **2785** | **92** | **0** |
| **HOR Grand Total** | **2395** | **4059** | **6453** | **290** | **1** |

Table 19. Disposition of natural (NOR) and hatchery-origin (HOR) coho salmon returns to Cowlitz Salmon Hatchery in 2013. Mark types include unmarked, unmarked and blank-wire tagged (Unmarked + BWT), adipose-clipped (AD only), adipose-clipped and coded-wire tag (AD + CWT).

| | Adult (≥ 42 cm FL) | | | Jack (<42) |
|---|---|---|---|---|
| | Female | Male | Total | Total |
| Broodstock | | | | |
| NOR Unmarked | 15 | 13 | 28 | 0 |
| NOR Unmarked + BWT | 84 | 105 | 189 | 13 |
| HOR AD only | 452 | 419 | 871 | 31 |
| HOR AD + CWT* | 295 | 278 | 573 | 1 |
| **Sub-total** | **846** | **815** | **1661** | **45** |
| Released to Tilton | | | | |
| NOR Unmarked | 1149 | 1592 | 2741 | 221 |
| NOR Unmarked + BWT | 2 | 1 | 3 | 9 |
| HOR AD only | 2662 | 2959 | 5621 | 7790 |
| HOR AD + CWT | 0 | 0 | 0 | 1 |
| **Sub-total** | **3813** | **4552** | **8365** | **8021** |
| Released to Upper Cowlitz | | | | |
| NOR Unmarked | 0 | 0 | 0 | 1 |
| NOR Unmarked + BWT | 2 | 2 | 0 | 28 |
| HOR AD only | 0 | 0 | 0 | 3 |
| HOR AD + CWT | 3780 | 4161 | 7941 | 4994 |
| **Sub-total** | **3782** | **4163** | **7941** | **5026** |
| Mortalities | | | | |
| NOR Unmarked | 1 | 0 | 1 | 1 |
| NOR Unmarked + BWT | 0 | 0 | 0 | 0 |
| HOR AD only | 1 | 0 | 1 | 0 |
| HOR AD + CWT | 0 | 4 | 4 | 0 |
| **Sub-total** | **2** | **4** | **6** | **1** |
| Foodbank/Surplus | | | | |
| HOR AD only | 757 | 920 | 1677 | 4620 |
| **Sub-total** | **757** | **920** | **1677** | **4620** |
| **NOR Grand Total** | **1253** | **1713** | **2962** | **273** |
| **HOR Grand Total** | **7947** | **8741** | **16688** | **17440** |

* Contingency if not enough unmarked + coded-wire tagged fish.

Table 20. Age and length summary for spring Chinook broodstock at the Cowlitz Salmon Hatchery. Adipose clip (AD only) and adipose clip/coded wire tagged (AD+CWT) are used for the segregated broodstock program. Data are summarized by age category as total number sampled (*n*) and average, standard deviation (SD), and range (minimum to maximum) of fork length (FL in cm). Gilbert-Rich age notation includes total and freshwater age (e.g., $4_2$ = four years total, exited freshwater as a yearling). *N.D.* indicates that age could not be determined.

| | | Female | | | | Male | | | |
|---|---|---|---|---|---|---|---|---|---|
| Mark Type | Age | *n* | FL_avg | SD FL | Range FL | *n* | FL_avg | SD FL | Range FL |
| AD, AD+CWT | $3_1$ | 0 | --- | --- | --- | 1 | 69.0 | --- | --- |
| | $3_2$ | 0 | --- | --- | --- | 23 | 57.5 | 6.0 | 48-69 |
| | $4_2$ | 176 | 75.5 | 4.7 | 63-89 | 146 | 76.0 | 6.1 | 60-95 |
| | $5_2$ | 84 | 82.0 | 5.3 | 70-100 | 20 | 86.3 | 9.1 | 74-105 |
| | *N.D.* | 32 | 77.1 | 6.0 | 67-90 | 28 | 72.2 | 7.8 | 52-89 |

Table 21. Age and length summary for fall Chinook broodstock at the Cowlitz Salmon Hatchery. Unmarked fish were used for the integrated broodstock program. Adipose-clipped (AD only) fish were used for the integrated broodstock programs. Adipose-clipped/coded-wire tagged fish (AD+CWT) were used in either the segregated or integrated program. Data are summarized by age category as total number sampled (*n*) and average, standard deviation (SD), and range (minimum to maximum) of fork length (FL in cm). Gilbert-Rich age notation includes total and freshwater age (e.g., $4_2$ = four years total, exited freshwater as a yearling). *N.D.* indicates that age could not be determined.

| Mark Type | Age | Female | | | | Male | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | *n* | FL_avg | FL_SD | FL_Range | *n* | FL_avg | FL_SD | FL_Range |
| Unmarked | $2_1$ | 1 | 70.0 | --- | --- | 1 | 43.0 | --- | --- |
| | $3_1$ | 6 | 83.7 | 5.2 | 79-93 | 3 | 66.7 | 4.9 | 61-70 |
| | $4_1$ | 1 | 84.0 | --- | --- | 4 | 86.0 | 7.8 | 77-93 |
| | $4_2$ | 0 | --- | --- | --- | 0 | --- | --- | --- |
| | $5_1$ | 0 | --- | --- | --- | 0 | --- | --- | --- |
| | *N.D.* | 1 | 68.0 | --- | --- | 0 | --- | --- | --- |
| AD only, AD+CWT | $2_1$ | 0 | --- | --- | --- | 6 | 49.0 | 6.0 | 44-60 |
| | $3_1$ | 51 | 69.1 | 4.2 | 61-80 | 152 | 67.8 | 4.9 | 55-81 |
| | $4_1$ | 116 | 79.8 | 5.1 | 70-95 | 48 | 81.5 | 6.5 | 66-94 |
| | $4_2$ | 2 | 80.5 | 2.1 | 79-82 | 0 | --- | --- | --- |
| | $5_1$ | 22 | 85.5 | 3.8 | 76-91 | 1 | 91.0 | --- | --- |
| | *N.D.* | 22 | 77.6 | 7.3 | 63-92 | 14 | 73.4 | 8.7 | 60-91 |

Table 22. Age and length summary for coho salmon broodstock at the Cowlitz Salmon Hatchery. Unmarked/coded-wire tagged (UM+CWT) and adipose-clipped/coded-wire tagged (AD+CWT) were used for the integrated broodstock program. Adipose-clipped only were used for the segregated broodstock program. Data are summarized by age category as total number sampled (*n*) and average, standard deviation (SD), and range (minimum to maximum) of fork length (FL in cm). Gilbert-Rich age notation includes total and freshwater age (e.g., $4_2$ = four years total, exited freshwater as a yearling). *N.D.* indicates that age could not be determined. Table does not include AD+CWT data which were not available at the time of this report.

| Mark Type | Age | Female | | | | Male | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | *n* | FL_avg | FL_SD | FL_Range | *n* | FL_avg | FL_SD | FL_Range |
| UM+CWT, AD+CWT | $2_1$ | 2 | 64.0 | 2.8 | 62-66 | 4 | 63.8 | 9.8 | 51-72 |
| | $2_2$ | 0 | --- | --- | --- | 8 | 34.9 | 3.5 | 31-41 |
| | $3_2$ | 71 | 69.1 | 4.7 | 57-78 | 58 | 65.3 | 8.5 | 35-83 |
| | $4_3$ | 1 | 70.0 | --- | --- | 0 | --- | --- | --- |
| | *N.D.* | 2 | 68.0 | 7.1 | 63-73 | 2 | 67.0 | 4.2 | 64-70 |
| AD only | $2_1$ | 0 | --- | --- | --- | 0 | | | |
| | $2_2$ | 0 | --- | --- | --- | 1 | 41 | --- | --- |
| | $3_2$ | 20 | 69.5 | 4.6 | 61-79 | 19 | 67.3 | 9.2 | 50-80 |
| | $4_3$ | 0 | --- | --- | --- | 0 | --- | --- | --- |
| | *N.D.* | 0 | --- | --- | --- | 0 | --- | --- | --- |

*Juvenile Catches in Mayfield Dam Downstream Migrant Trap*

A total of 154,577 juvenile salmonids (91,251 Chinook, 55,878 coho, 941 cutthroat, and 6507 steelhead) were captured in the downstream migrant trap at Mayfield Dam (Table 23). These fish represented a portion of the total outmigration as some fish pass through the dam directly. Chinook salmon were primarily classified as sub-yearling smolts, with peak outmigration occurring in the month of October. Coho salmon were primarily classified as smolts, with peak outmigration occurring in the months of May and June. Peak outmigration of cutthroat and steelhead smolts also occurred in the months of May and June.

Table 23. Monthly totals of juvenile Chinook, coho, cutthroat, and steelhead captured at the Mayfield Dam downstream migrant trap in 2013. Data were provided by Tacoma Power.

| | Chinook | | | Coho | | | Cutthroat | | Steelhead | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | Fry/Parr | Subyrlg Smolt | Yearling Smolt | Fry | Parr | Smolt | Parr | Smolt | Parr | Smolt |
| April | 136 | 333 | 5 | 55 | 0 | 31 | 4 | 23 | 0 | 137 |
| May | 208 | 537 | 70 | 75 | 13 | 10,963 | 0 | 623 | 0 | 4,031 |
| June | 311 | 5,282 | 298 | 50 | 0 | 31,502 | 0 | 209 | 0 | 2,228 |
| July | 33 | 10,483 | 747 | 9 | 0 | 8,698 | 0 | 16 | 0 | 67 |
| August | 0 | 9,830 | 1,554 | 0 | 0 | 405 | 0 | 1 | 0 | 2 |
| September | 0 | 14,380 | 424 | 0 | 3 | 126 | 1 | 4 | 0 | 2 |
| October | 890 | 35,815 | 512 | 0 | 1,201 | 274 | 19 | 15 | 0 | 5 |
| November | 27 | 6,289 | 61 | 0 | 1,376 | 129 | 8 | 5 | 4 | 15 |
| December | 319 | 2,662 | 35 | 0 | 939 | 22 | 10 | 3 | 10 | 6 |
| January | 0 | 10 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 |
| **Total** | **1,924** | **85,621** | **3,706** | **189** | **3,539** | **52,150** | **42** | **899** | **14** | **6,493** |

## Discussion

The goal for the lower Cowlitz River Monitoring and Evaluation program is to provide metrics of salmon and steelhead abundance, productivity, distribution, and diversity useful for fish management as outlined in Appendix J of the Fisheries and Hatchery Management Plan Update (Tacoma Power 2011). In order for these estimates to provide useful feedback for adaptive management and meet NMFS recommendations for monitoring of ESA-listed populations (Crawford and Rumsey 2011), the estimates must be unbiased and precise (coefficient of variation less than 15%). While many of the methods used to minimize bias and derive precise estimates have been developed in other basins, these methods will need to be refined to the conditions and species of interest in the lower Cowlitz River. Several important steps were taken in 2013 to solidify tools for obtaining unbiased estimates and to combine information from the spawning grounds, hatchery returns, and in-river fisheries as described in the FHMP Update (2011). The most notable advance for monitoring efforts has been the installation and operation of tributary weirs, providing mark-recapture estimates of coho and steelhead spawner abundance for a large portion of their spawning distribution.

This report describes the efforts to implement the first year of the lower Cowlitz River Monitoring and Evaluation Plan. In 2013, methodologies described in the FHMP Update were not yet fully implemented. In addition, coordination and data management for this complex monitoring program was under development. In this discussion, we highlight the most immediate issues and solutions proposed to improve this monitoring program in subsequent years. With respect to estimate quality, our initial focus is to minimize bias of the estimates. A secondary and subsequent effort will be to increase precision (decrease uncertainty) of the estimates.

### *Steelhead Spawner Abundance*

Steelhead spawner abundance was estimated above two tributary weirs in 2013, representing 37% of the modeled tributary spawner habitat. Weir locations were selected to be associated with the major spawning tributaries and therefore do not represent a random selection of spawning habitat. Therefore, the fish per mile expansion to the entire basin is of unknown bias. If spawning habitat quality differs appreciably between monitored and non-monitored tributaries, the fish per mile expansion will be biased. This assumption can be tested by conducting spawner surveys with more complete coverage of habitats above and below weirs. The Monitoring and Evaluation Plan in the FHMP 2011 proposes to use GRTS-based redd surveys in tributaries not included in the weir mark-recapture coupled with census redd surveys above select tributaries to calibrate a redd per female and male:female ratio (both of which are likely to vary on an annual basis). Selection of randomized index reaches below weirs needs to be developed.

The proportion of hatchery-origin steelhead spawners in these tributaries is a subject of management concern due to the large program for hatchery summer steelhead and the relatively small tributary population. No hatchery-origin summer steelhead were observed at the weir sites in a time frame that overlapped with the 2013 spawn year of winter-run steelhead. The tributary estimates of pHOS ranged from 0 to 13.9% with the weirs in place and 2.6% to 15.8% had the weirs not been present. This is a conservative (biased high) estimate of pHOS because this estimate does not account for temporal separation in spawn timing between winter run natural-origin steelhead and early winter run hatchery steelhead. While early winter run hatchery steelhead returned to the river in 2013, this hatchery program has been eliminated which may result in less temporal separation between hatchery and natural winter run steelhead in the future. Genetic tools are needed to truly identify introgression between hatchery and natural-origin steelhead spawners on the spawning grounds.

- **Recommendation: Complete and implement a study design to provide an unbiased estimate of steelhead spawner abundance in lower Cowlitz River tributaries with a coefficient of variation less than 15%.**

*Chinook Spawner Abundance*

The existing method for deriving Chinook spawner abundance is of unknown bias and precision. A major concern with the peak count expansion method is that the origin of the modified expansion factor for helicopter aerial surveys is, to our knowledge, undocumented and therefore cannot be evaluated. Regardless, expansion or calibration factors need to be periodically validated and this type of validation has not occurred in recent history of monitoring for Chinook salmon on the Cowlitz River. Peak counts are also problematic when redd superimposition occurs due to years of high abundance or in high density spawning areas such as the reach between Barrier Dam and Mill Creek. In addition, peak redd count expansions were derived for main stem spawning only. In years such as 2013 when high water events occur in early fall, Chinook are provided access to tributary habitats and unknown proportions of spawners are spawn in tributary as well as main stem areas.

The Monitoring and Evaluation Plan in the FHMP 2011 proposes genetic mark-recapture (GMR) as an appropriate method to derive unbiased estimates of NOR Chinook spawner abundance in the lower Cowlitz River basin. This method has been used in multiple basins in Washington State (Seamons et al. 2012; Rawding et al. 2014). The GMR method uses genetic markers as a “mark” to connect parent spawners (first sample) and juvenile offspring (second sample) in a closed population mark-recapture estimator. This method relies on tissue samples taken from a representative sample of spawners (tributaries and main stem) and juvenile outmigrants. Genetic samples will be collected from spawners in the fall of 2014 and plans are currently underway for a juvenile smolt trap to be deployed in spring of 2015. The sampling design for this study must accommodate for the fall Chinook spawners released into the Tilton and upper Cowlitz basins as natural offspring of these spawners will have similar external appearance (unmarked) to natural offspring of spawners in the lower Cowlitz River basin when captured in the smolt trap. The sampling design must also include representative sampling of juveniles outmigrating from all spawning areas above the smolt trap in order to derive an unbiased estimate of natural-origin Chinook spawners from the lower Cowlitz River basin.

- **Recommendation: Design and implement a genetic-mark recapture study design to provide an unbiased estimate of fall Chinook spawner abundance in the lower Cowlitz River with a coefficient of variation less than 15%.**

*Coho Spawner Abundance*

The GRTS design implemented in 2013 did not produce adequate results to develop an unbiased estimate. The high proportion of reaches with no redds was unusual compared to the other two years (2010, 2011) that this method has been implemented on the Cowlitz River tributaries. While the reach occupancy in 2013 was around 30%, reach occupancy in 2010 and 2011 was above 60%. Hierarchical modeling, which uses redd distributions from other lower Columbia River basins in 2013, may provide an alternate way to analyze the GRTS redd survey data. At the time of this report, coho redd data from other basins have not been summarized in a manner to address this possibility. In addition, the coho results from 2013 highlight the importance of the spawner study design including multiple methods in any given year in order to provide contingencies if one method does not work.

The mark-recapture estimates for coho salmon above three tributary weirs in 2013 were likely biased low because the second sample (carcass recoveries) was not representative of the population. As a result, the expanded fish per mile estimate is also likely to be biased low. The mark-recapture tributary estimates were derived from carcass recoveries that washed up on the weir, but the proportion of recaptures in the weir wash-ups appear to be much higher than those in the spawner surveys. Unfortunately, spawner survey recoveries were too low to use for an estimate in 2013. The difference in recaptures among these samples may occur if the coho salmon that enter the tributary under lower water conditions are more likely to be tagged and more likely to spawn lower in the tributary than coho salmon that enter the tributary under higher water conditions. Coho salmon entering under higher water are more likely to be untagged (swim over submerged panels and are never handled in the weir box) and may spawn higher in the tributary. Under this scenario, carcasses that wash-up on the weir represent those that entered the tributary under low water conditions and were tagged at a higher rate than the overall population entering the tributary.

Unbiased mark-recapture estimates are needed for the GRTS expansion (redd per female) and to apply a fish per mile expansion. Unbiased estimates will rely on representative sampling of carcasses and adequate sample sizes. Census surveys of the entire spawning area above select weir sites are recommended to address these issues.

- **Recommendation: Conduct census surveys of the entire spawning distribution above selected weir sites in order to sample carcasses representative to the spawning population and provide unbiased estimates of coho spawner abundance with a coefficient of variation less than 15%.**

- **Recommendation: Explore the potential for a stratified index-reach study design that models low abundance and high abundance reaches based on habitat characteristics and stratifies survey efforts based on this stratification.**

*Release Mortality of Natural-Origin Fish from Cowlitz River Fisheries*

The objective for creel surveys in the Cowlitz River is to improve catch estimates of (hatchery-origin and natural-origin) in the Cowlitz River fishery, and to determine the ratio of HOR fish kept and NOR fish released. Together this information is needed to estimate fishing mortalities in the Cowlitz River. The spot creel survey methodology implemented on the Cowlitz River provides an estimate of natural-origin fish encounter rates which can then be applied to landed catch of hatchery-origin fish. This report includes the encounter rates in 2013 but not the landed catch, as the source of this information (angler reported catch in WDFW Catch Record Cards) has a two year lag between fishery and reporting. Landed catch of hatchery-origin fish are needed to derive the number of natural-origin fish released based on their encounter rates. A release mortality of 10% is the current standard for tributary fisheries in the Lower Columbia. In the absence of specific Cowlitz River fishery information, this standard will be applied for consistency with other tributary fisheries.

An additional unresolved issue with respect to estimating Cowlitz River hatchery-origin landed catch and natural-origin release mortality is how to incorporate results from fishery monitoring near the confluence of the Cowlitz and the Columbia rivers. Additional creel surveys are conducted at Gearhardt Gardens by WDFW staff from the Vancouver office and a full estimate of mortalities need to include these data as well as those collected elsewhere in the Cowlitz River by the Cowlitz Evaluation staff. Unlike fish encountered above the mouth of the Toutle River, fish encountered in the Cowlitz River near the mouth of the Columbia are of mixed origin and include fish destined for the Coweeman and Toutle rivers as well as fish destined elsewhere in the Columbia River that dip into the cool waters of the Cowlitz River during summer months. Improvements to the mortality estimates of Cowlitz River stocks will require efforts to better address the stock composition of the fishery in the lowest reaches of the Cowlitz River.

In addition, spot creel surveys are of unknown bias without a precision estimator. Landed catch estimates based on self-reporting are also a likely source of bias associated with the expansion of encounter rates derived from spot creel surveys. The Monitoring and Evaluation Plan in the FHMP 2011 proposes a statistical creel survey, which representatively samples fishing efforts, to provide unbiased estimates of hatchery-origin landed catch and natural-origin release mortality. A statistical creel survey would also provide these estimates in a more timely manner because this method does not rely on the WDFW Catch Record Card system.

- **Recommendation: Estimate total mortalities (HOR landed catch and NOR/HOR release mortality) once 2013 Catch Record Card results become available.**

- **Recommendation: Develop a method to incorporate creel survey results from the lowest portions of the Cowlitz River (mixed stock) into the Cowlitz River catch estimates and NOR/HOR encounter ratios. Consider using genetic stock identification to help determine Cowlitz and non-Cowlitz catch in fisheries.**
- **Recommendation: Develop a statistical creel survey design to provide unbiased estimates of catch and NOR/HOR encounter ratios and reduce the time frame required to report these metrics.**
- **Recommendation: Develop a design to evaluate angler self-reporting rates of natural-origin releases.**

*Hatchery Returns and Composition of Hatchery Broodstock*

Unbiased estimates of returning hatchery fish rely on each hatchery stock having a distinct mark type, returning fish being accurately identified and counted at the Cowlitz Salmon Hatchery separator, and data management systems being available to facilitate data exchange and analysis. As described below, data flow and exchange proved to be the most challenging part of summarizing these data in 2013. The data management system associated with Cowlitz River hatchery stocks is admittedly complex and involves multiple databases and coordination among numerous staff. Improvement to the data flow among these databases is the largest improvement needed for analysis of hatchery broodstock age composition (as well as age composition from creel surveys and spawner surveys).

Four different databases are needed for successful data exchange and analysis of the hatchery returns. Total returns and their disposition (where they are released) are documented in the Cowlitz Hatchery Separator database (Tacoma Power). Biological sampling data (including scale ages) are archived in the WDFW Traps-Weirs-Surveys database. Coded-wire tag data are archived in WDFW coded-wire-tag database but the ages from this database need to be translated to the TWS database in order to make a final age assignment for all sampled fish (CWT ages, when available, are needed to validate scale age data). A fourth database, WDFW Fishbooks, is needed to interpret the marking and tagging combinations to hatchery broodstock program.

Although the age composition of hatchery broodstock has historically relied on coded-wire tags, evaluation of contemporary programs will benefit from age information provided by both coded-wire tags and scales for several reasons. Coded-wire tags give the most accurate age for fish reared in the hatchery, but are not useful for natural-origin fish which are increasingly incorporated into integrated broodstock programs. Furthermore, scale age data interpret the age of ocean entry whereas coded-wire tag data assume that ocean entry occurs the year that fish were tagged and released. Given the emphasis on integrated hatchery programs for rebuilding stocks on the Cowlitz River and the higher residualism rates documented for some integrated programs (Hausch and Melnychuk 2012), scale ages are needed in addition to CWT based ages in order to evaluate the success of the hatchery practices.

- **Recommendation: Obtain unbiased and precise estimates of sex, length, and age of NOR fish incorporated into integrated broodstock.**
- **Recommendation: Improve data flow process for fish age data (scale and coded-wire tag) and apply to hatchery broodstock, creel survey, and spawner survey results.**

*Jack-Adult Length Cutoffs*

An anticipated difficulty in combining abundance estimates from spawner surveys, creel surveys, and hatchery returns is the different jack-adult length cutoffs currently used to enumerate fish in these different surveys. This cutoff is important because the jack age class (age = $2_2$ for coho salmon, $3_1$ for fall Chinook) is typically less abundant but also more likely to be biased in both fishery and spawner escapement estimates than the adult age classes for these species.

Currently, the jack-adult length cutoffs differ among surveys for both Chinook and coho salmon. Spawner and creel surveys use a 47-cm FL cutoff for coho salmon, whereas hatchery separator returns are sorted based on a 42-cm FL cutoff. Spawner and creel surveys use a 56-cm FL cutoff for fall Chinook salmon, whereas hatchery separator returns are sorted based on a 47-cm FL cutoff. These differences will make it impossible to provide an unbiased summation of adult returns across these three datasets. Streamlining the data management process for age data (both scale and CWT as discussed above) is needed to further address this issue and identify consistent and appropriate jack-adult cutoffs for Cowlitz River populations.

- **Recommendations: Develop length-by-age summary statistics for coho and Chinook salmon and submit to WDFW managers to facilitate discussion on jack-adult length cutoffs.**

*Proportion of hatchery-origin spawners (pHOS)*

The estimation methods used for pHOS assume that all hatchery fish are adipose clipped prior to release and can thus be identified as hatchery fish upon return. In reality, some hatchery fish are unintentionally released without an adipose clip and will be mis-classified as unmarked natural-origin fish upon return. Consequently, the estimates of pHOS used in this report are biased low. When hatchery releases are large and natural populations are small, this bias is of greater management concern than when hatchery releases are small and natural populations are large. One remedy to this issue will be to use scale growth patterns to interpret hatchery/wild origin of unmarked fish. This method requires validation for Cowlitz River salmonids and may be useful to correct the origin of unmarked returns for species which outmigrate as yearlings (i.e., coho, steelhead, and spring Chinook). Growth patterns of subyearling outmigrants (i.e., fall Chinook) are not sufficiently different to use scales to distinguish between hatchery and natural-origin fish.

- **Recommendation: Validate scale-based assignments of hatchery versus natural origin and use scale-assigned origin to correct the estimate of pHOS by the proportion of hatchery spawners included in the unmarked sample.**

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