Fisheries and Hatchery Management Plan (FHMP)

Draft Final

Cowlitz Hydroelectric Project

FERC No. 2016

Tacoma Power

3628 S 35th Street

Tacoma, WA 98409

October 2019

Contents

CHAPTER 1: INTRODUCTION

CHAPTER 2: COWLITZ BASIN OVERVIEW

CHAPTER 3: FALL CHINOOK SALMON

CHAPTER 5: COHO SALMON

CHAPTER 6: WINTER STEELHEAD

Figures

Chapter 2: Cowlitz Basin Overview

Chapter 3: Fall Chinook Salmon

Chapter 4: Spring Chinook Salmon

Chapter 5: Coho Salmon

Chapter 6: Winter Steelhead

Chapter 7: Cutthroat Trout

Chapter 8: Chum Salmon

Tables

Chapter 1

Chapter 2

Chapter 3: Fall Chinook Salmon

Chapter 4: Spring Chinook Salmon

Chapter 5: Coho Salmon

Chapter 6: Winter Steelhead

Chapter 8: Chum Salmon

Chapter 9: Monitoring and Evaluation

Acronyms and Abbreviations

AOP	Annual Operating Plan
APR	Annual Program Review
BMP	best management practice
BPA	Bonneville Power Administration
BY	brood year
CSFP	Lower Columbia Conservation and Sustainable Fisheries Plan
CSH	Cowlitz Salmon Hatchery
CWT	coded wire tag
DIP	demographically independent population
DPS	distinct population segment
EDT	Ecosystem Diagnosis & Treatment
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FERC	Federal Energy Regulatory Commission
FHMP	Fisheries and Hatchery Management Plan
fpp	fish per pound
FPS	fish passage survival
FTC	Cowlitz River Fisheries Technical Committee
HGMP	Hatchery Genetic Management Plan
HOR	hatchery-origin
HSRG	Hatchery Scientific Review Group
HY	hatch year
IHOT	Integrated Hatchery Operations Team
ISAB	Independent Scientific Advisory Board
ISIT	In-Season Implementation Tool
LCFRB	Lower Columbia Fish Recovery Board
M&E	Monitoring and Evaluation
NMFS	National Marine Fisheries Service
NOAA Fisheries	National Oceanic and Atmospheric Administration, National Marine Fisheries Service
NOR	natural-origin
NPPC	Northwest Power Planning Council
NWFSC	Northwest Fisheries Science Center
pHOS	proportion of hatchery-origin spawners in nature
PNI	proportionate natural influence
pNOB	proportion of natural-origin salmon in the hatchery broodstock
PUD	Public Utility District
R/S	recruits per spawner
rkm	river kilometer
RMIS	Regional Mark Information System
RSI	Remote Site Incubation
SA	Settlement Agreement
SAR	smolt-to-adult return
SASSI	Salmon and Steelhead Stock Inventory
SPS	smolt passage survival
TRT	Technical Recovery Team
TSAR	total smolt-to-adult return

USFWS	U.S. Fish & Wildlife Service
VSP	Viable Salmonid Population
WDF	Washington Department of Fisheries
WDFW	Washington Department of Fish and Wildlife
WDOE	Washington Department of Ecology
WFG	Washington Department of Game
WRIA	Water Resource Inventory Area

CHAPTER 1:
INTRODUCTION

1. Introduction

The Cowlitz River was once highly productive and the major drainages supported many populations of five species of native anadromous salmonids (Chinook Salmon Oncorhynchus tshawytscha, Chum Salmon O. keta, Coho Salmon O. kisutch, winter steelhead O. mykiss, and sea-run Cutthroat Trout O. clarkii; Table 1-1). These runs originally supported subsistence fisheries and later commercial and recreational fisheries but the natural-origin portions of most of these runs have been diminished to a fraction of their former abundance and some have been functionally extirpated. Every endemic population of anadromous salmonid in the Cowlitz River above Mayfield Dam was greatly diminished or extirpated due to the construction of Mayfield and Mossyrock dams (Myers et al. 2006). However, a wide range of factors contributed to population declines, both before and since dam construction, including long periods of overharvest, habitat loss and alteration, introduced species, and hatchery production (LCFRB 2010).

The history of the Cowlitz River salmon populations is similar to those of other Columbia Basin populations, in which the combination of overharvest and habitat degradation caused population abundances to decline through the mid-1900s. Canneries opened in the 1860s and led to chronically unsustainable harvest levels. Intensive logging, including the use of splash dams to transport logs downstream and denuding hillsides, resulted in degradation of spawning and rearing habitats (GAIA Northwest 1994). The construction of Mayfield and Mossyrock dams in the 1960s and further land use development resulted in reduced the abundance of all populations and drove many to extinction (Myers et al. 2006). The dams blocked access to habitat above dams, inundated riverine habitat, and made downstream migration much more difficult. Gravel mining and other poor land use practices destroyed or severely damaged the habitat that remained. Blocked upstream passage also resulted in the aggregation of the formerly distinct populations. Salmon and steelhead from above Mayfield Dam were forced to spawn in the Lower Cowlitz Subbasin or were captured, along with Lower Cowlitz Subbasin salmon, for use in hatchery broodstock. At times, groups of fish not distinguished by population were sometimes captured and transported above Mayfield Dam.

The subsequent intensive hatchery programs were used to mitigate hydroelectric system impacts, but further diminished the remaining natural-origin populations (Lichatowich 2001). The original broodstock for all hatchery programs came from salmon that returned to Mayfield Dam, which resulted in the hatchery populations being an aggregate of all historical populations and likely still contain a portion of the genetic legacy of those populations (Table 1-2). Hatchery production was intended to mitigate for lost natural production and provided (and continues to provide) a positive economic benefit to a broad region, but it came at a cost to the remnant natural populations. After the hydroelectric dams eliminated anadromous salmonid runs in the upper Cowlitz River, the hatcheries became the primary source for the fish to reestablish these runs. But, while these hatchery programs provided a demographic boost to salmon populations, as a whole, they did not result in an increase in natural-origin abundance. The hatcheries supported large fisheries that were not selective for the hatchery-origin salmon, resulting in further reduced abundance of natural-origin salmon, until mass marking of hatchery salmon allowed for mark-selective fisheries. Also, large numbers of hatchery-origin salmon escaped the fisheries and spawned in nature, which reduced the reproductive fitness of the natural-origin salmon by up to 50% for Cowlitz Basin salmon and steelhead populations (HSRG 2009; LCFRB 2010).

Table 1-1. Baseline viability status, viability and abundance objectives, and productivity improvement targets for Cowlitz River Chinook Salmon, Chum Salmon, Coho Salmon, and steelhead populations (from Table 6-1; LCFRB 2010).

	Baseline Viability[2]					Productivity	Natural-origin Abundance		
Run, Population, Recovery Priority[1]	Abundance & Productivity	Spatial Structure	Diversity	Net Status[3]	Viability Objective[4]	Improvement[5]	Historic[6]	Baseline[7]	Target[8]
Chinook Salmon									
Fall									
Lower Cowlitz River									
Contributing	VL	H	M	VL	M+	50%	24,000	500	3,000
Upper Cowlitz Subbasin (includes the Cispus, upper Cowlitz, and Tilton rivers)									
Stabilizing	VL	VL	M	VL	VL	--	28,000	0	--
Spring									
Upper Cowlitz River									
Primary	VL	L	M	VL	H+	>500%	22,000	300	1,800
Cispus River									
Primary	VL	L	M	VL	H+	>500%	7,800	150	1,800
Tilton River									
Stabilizing	VL	VL	VL	VL	VL	0%[9]	5,400	100	--
Chum Salmon									
Fall									
Cowlitz River									
Contributing	VL	H	L	VL	M	>500%	195,000	<300	900
Summer									
Cowlitz River									
Contributing	VL	L	L	VL	M	>500%	na	na	900
Coho Salmon									
Lower Cowlitz River									
Primary	VL	M	M	VL	H	100%	18,000	500	3,700
Upper Cowlitz River									
Primary	VL	M	L	VL	H	>500%	18,000	<50	2,000
Cispus River									
Primary	VL	M	L	VL	H	>500%	8,000	<50	2,000
Tilton River									
Stabilizing	VL	M	L	VL	VL	0%[9]	5,600	<50	--
Steelhead									
Winter									
Lower Cowlitz River									

Run, Population, Recovery Priority[1]	Baseline Viability[2]				Viability Objec-tive[4]	Produc-tivity Im-prove-ment[5]	Natural-origin Abundance		
	Abund-ance & Produc-tivity	Spatial Struc-ture	Diver-sity	Net Status[3]			Histo-ric[6]	Base-line[7]	Target[8]
Contributing	L	M	M	L	M	5%	1,400	350	400
Upper Cowlitz River									
Primary	VL	M	M	VL	H	>500%	1,400	<50	500
Cispus River									
Primary	VL	M	M	VL	H	>500%	1,500	<50	500
Tilton River									
Contributing	VL	M	M	VL	L	>500%	1,700	<50	200

1. Primary, Contributing, and Stabilizing designations reflect the relative contribution of the population to Major Population Group recovery goals.
2. Viability status is based on Technical Recovery Team viability rating approach. VL = Very Low (>60% chance of extinction over the next 100 years); L = Low (26-60% chance of extinction).
3. The net baseline status is equal to the lowest of the attribute ratings.
4. Viability objective is based on the scenario contribution. VL = Very Low (>60% chance of extinction); L = Low (26-60% chance of extinction); M = Medium (6-25% chance of extinction); H = High (1-5% chance of extinction); VH = Very High (<1% chance of extinction).
5. Improvement is the relative increase in population production required to reach the prescribed viability goal.
6. Historical population size was mean number, inferred from presumed habitat conditions using EDT Model and NMFS back-of-envelope calculations.
7. Approximate mean annual number of naturally-produced fish returning to the watershed in the 1990s.
8. Abundance targets were estimated by population viability simulations based on viability goals. No recovery target was set for Stabilizing populations.
9. Improvement increments are based on abundance and productivity; however, this population will require improvements in spatial structure or diversity to meet recovery objectives.

As a result, all endemic populations of Cowlitz River Chinook Salmon, Chum Salmon, Coho Salmon, and steelhead were listed as threatened under the Endangered Species Act (ESA) between 1998 and 2005. Since then, efforts have been made to protect and bolster the Cowlitz Basin populations and to reintroduce the populations above the hydropower system, but recovery targets have not been reached. For anadromous salmonid populations in the Cowlitz River, the hydropower system, habitat, harvest, and hatcheries are the key limiting factors (LCFRB 2010). All populations remaining in the lower Cowlitz River are still considered to be at high or very high risk of extinction (NMFS 2013).

The decline of these populations has caused negative ecological, sociological, and economic impacts, and a variety of actions are being taken to reverse those detrimental impacts. Mitigation hatcheries were developed to replace the lost production of areas that were flooded by reservoirs or became inaccessible, and to mitigate for the inevitable ecological impacts of hydroelectric development to the lower Cowlitz River ecosystem. These hatcheries now supplement the remaining extant populations and hatchery salmon of native stock have been used in an effort to reintroduce salmon to their historic habitat in reaches above the dams. To meet recovery goals, Cowlitz River salmon and steelhead must be restored to Medium or High levels of population viability (<25% risk of extinction over the next 100 years). At this point, the population would be productive and abundant, would have colonized substantial portions of the available habitat, would exhibit multiple life history strategies, and would support sustainable harvest opportunities.

Table 1-2. Historical populations of anadromous salmonids in the Cowlitz River and potential remaining genetic legacy (Table 4-1 from 2004 FHMP).

Species, Run, Historical Population	Potential Genetic Legacy
Chinook Salmon	
Fall: Lower Cowlitz River; Upper Cowlitz River	Lower Cowlitz River and Cowlitz Salmon Hatchery fall Chinook Salmon populations are believed to be a mixture of all historical Cowlitz River fall Chinook Salmon populations. Between 1953 and 1993, 92% of all fall Chinook Salmon released into the Cowlitz River were from Cowlitz Salmon Hatchery.
Spring: Cispus River; Upper Cowlitz River; Tilton River	Cowlitz Salmon Hatchery spring Chinook Salmon population is believed to be a mixture of all historical Cowlitz River spring Chinook Salmon populations. Between 1948 and 1993, 96% of all spring Chinook Salmon released into the Cowlitz River were from Cowlitz Salmon Hatchery.
Chum Salmon	
Summer: Cowlitz River; Fall: Cowlitz River	Wild salmon only, no hatchery program.
Coho Salmon	
Lower Cowlitz River; Cispus River; Upper Cowlitz River; Tilton River	Lower Cowlitz River and Cowlitz Salmon Hatchery Coho Salmon populations are believed to be a mixture of all historical Cowlitz River populations.
Pink Salmon	
Cowlitz River	Wild salmon only, no hatchery program.
Sockeye Salmon	
Cowlitz River	Wild salmon only, no hatchery program.
Steelhead	
Winter: Lower Cowlitz River; Cispus River; Upper Cowlitz River; Tilton River	Lower Cowlitz River and Cowlitz Trout Hatchery late winter steelhead populations are assumed to be a mixture of all historical Cowlitz River winter steelhead populations.
Cutthroat Trout	
Coastal: Cowlitz River	Population present. Cowlitz Trout Hatchery has developed an anadromous population from returns to the hatchery.

Moving forward, the goal of this Fisheries and Hatchery Management Plan (FHMP) is to continue our progress in developing a rigorous management program for Cowlitz River anadromous salmonids. We begin by recognizing the shared interests and goals of all interested parties, as well as their differences, in an effort to embrace collaboration and cooperation. We fully embrace adaptive management with the understanding that it can only be accomplished when we have sufficient information, both in quantity and in quality, to make informed decisions. Improvements to the existing monitoring program and best management practices (in the hatchery, at collection facilities, and in nature) will be the result of the information collected through monitoring and evaluation in an effort to reduce constraints and improve our ability to effectively manage these populations. These activities will be conducted with the collaboration of state and federal agencies, under the umbrella of the Federal Energy Regulatory Commission (FERC) license to operate the Cowlitz River Hydroelectric Project (FERC 2002; 2004) and the Biological Opinion (NOAA Fisheries 2004), and with the recommendations of the Cowlitz River Fisheries Technical Committee (FTC).

1.1 Federal Energy Regulatory Commission License

FERC issued the original license for the Cowlitz River Hydroelectric Project in 1951. This license expired in 2001, at which point the Project operated pursuant to an annual license until the Project was relicensed in 2002 for a period of 35 years (FERC 2002, 2004).

1.1.1. Settlement Agreement

The Cowlitz River Hydroelectric Project Settlement Agreement (Settlement Agreement; SA) was published in 2000 (Tacoma Power et al. 2000) and incorporated into the new license (FERC 2002, 2004). Parties to the SA included the following: Tacoma Power, Washington Department of Fish and Wildlife (WDFW), Washington Department of Ecology (WDOE), Washington State Parks and Recreation Commission, United States Fish and Wildlife Service (USFWS), NOAA Fisheries, United States Forest Service - Gifford Pinchot National Forest, Recreation and Conservation Office (formerly the Interagency Committee for Outdoor Recreation), Lewis County, Confederated Tribes and Bands of the Yakama Nation, and three Conservation Groups (Washington Council of Trout Unlimited, Sport Fishing Guides of Washington, and American Rivers). The purpose of the Cowlitz River Hydroelectric Project Settlement Agreement (Section 5.1; Tacoma Power 2000) is to:

> *“resolve, to the satisfaction of the Parties, all issues associated with issuance of a new license for the Project regarding fish passage, fish production, fish habitat, water quality, instream flows, wildlife, recreation and cultural and historic resources. This Agreement establishes Tacoma's obligations for the protection, mitigation and enhancement of natural resources affected by the Project under a new license issued by FERC. It also specifies procedures to be used among the Parties to ensure the implementation of those license articles consistent with this Agreement, and with other legal and regulatory mandates, including but not limited to those described in Sections 4.2 and 4.3 above. It is the intent of the Parties to establish a framework for future collaborative efforts for the protection, mitigation and enhancement of the natural resources of the Cowlitz River basin.”*

Section 6.1.1 of the SA, titled Guidance for Future Interpretation and Decision Making, states:

> *“The emphasis of this agreement is ecosystem integrity and the restoration and recovery of wild indigenous salmon runs, including ESA- listed indigenous and unlisted stocks to harvestable levels.”*

It is the first and most important priority of the Settlement Agreement. The SA recognizes the importance of harvest, stating in Section 6.1.2 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 program to compensate for unavoidable impacts at levels consistent with ESA recovery, and providing fish production for sustainable fisheries."*

Section 6.15 further accentuates the hatchery production as it relates to recovery directing that:

> "*Fisheries management and hatchery production will be consistent with the overall goal of restoring and recovering wild stocks in the Cowlitz River basin. The hatchery complex will be designed with flexibility so managers can employ innovative rearing practices, low densities, and replication of historic fish out-migration size and timing."*

Section 6.1.6 reiterates the importance of the recreational fishery but emphasizes that recovery of indigenous stocks is the priority:

> *"Maintenance of a recreational fishery is important. Implementation of the wild salmonid recovery measures shall allow for the continued support of a recreational fishery on the Cowlitz River, including the production of non-indigenous stock, provided this is consistent with the priority objective to maximize the recovery of wild, indigenous salmon stocks."*

By signing the SA, the signatories committed to the continued advancement of the goals listed above.

1.1.2. Applicable License Articles

The Settlement Agreement (SA) (2000) contains an appendix with 25 proposed license articles addressing specific issues, such as water quality, quantity, flow, and ramping requirements; fish and wildlife, including species listed under the ESA; habitat; Tacoma Power's comprehensive operations and development plans and capabilities; recreation; cultural resources; and compliance with the Federal Power Act.

- Article 1: Downstream Fish Passage: Riffe Lake and Cowlitz Falls Collection and Passage
- Article 2: Downstream Fish Passage: Mayfield
- Article 3: Upstream Fish Passage: Barrier, Mayfield, and Mossyrock
- Article 4: Juvenile Tagging and Monitoring
- Article 5: Fish Production and Hatcheries
- Article 6: Fisheries and Hatchery Management Plan
- Article 7: Hatchery Complex Remodel and Phase-In Plan
- Article 8: Disease Management Plan
- Article 9: Large Woody Debris
- Article 10: Gravel Augmentation
- Article 11: Fish Habitat Fund
- Article 12: Coordination with Wildlife Settlement Wetlands Acquisition Fund
- Article 13: Instream Flows
- Article 14: Ramping Rate Conditions

- Article 15: Fish Monitoring Plan
- Article 16: Instream Flow Implementation
- Article 17: Recreation Facilities
- Article 18: Recreation Operation, Maintenance, and Safety
- Article 19: Water Access Facilities
- Article 20: Recreation Reporting
- Article 21: Forest Service Facilities
- Article 22: Forest Service Report
- Article 23: Cultural and Historic Resources
- Article 24: Wildlife
- Article 25: Reservation of Commission Authority

Eight of the articles pertain directly to fish and/or their management (Articles 1-8) and an additional four articles address fish habitat (9-11 and 13-15).

License Articles 1, 2, and 3 address fish passage, both upstream and downstream, for anadromous salmonids. Juvenile migrants (smolts) are captured at facilities at Cowlitz Falls and Mayfield dams for bypass around the dams and release into the Cowlitz River to continue their migration to the ocean. Mature salmon are collected at Cowlitz Salmon Hatchery and transported above Mayfield Dam to the Tilton River and above Cowlitz Falls Dam to the Cispus and upper Cowlitz rivers in the Upper Cowlitz Subbasin. License Article 8 addresses *Ceratonova (Ceratomyxa) shasta* and other diseases related to hatchery conditions and the transport of fish upstream of Mayfield Dam.

License Article 5 identifies fish production and hatchery obligations in the near and long term. Tacoma Power is to fund the operation and maintenance of the Cowlitz Hatchery Complex, consisting of the Cowlitz Salmon Hatchery, Cowlitz Trout Hatchery, and three satellite rearing facilities (yet to be developed). Indigenous populations to be supplemented by hatchery production are: fall Chinook Salmon, spring Chinook Salmon, Coho Salmon, late winter steelhead, and sea-run Cutthroat Trout. Non-indigenous stocks of steelhead (e.g., summer and early winter steelhead) and Rainbow Trout *O. mykiss* that are important to the angling community may also be produced, provided that production shall emphasize the recovery of indigenous stocks. License Article 5 also defines various factors influencing production levels and directs Tacoma Power to fund any monitoring required for adaptive management at the hatcheries, as included in the Fisheries and Hatchery Management Plan required by License Article 6 (see below).

Pursuant to License Article 11, Tacoma Power established a fish habitat fund for the purpose of fisheries habitat protection, restoration, and enhancement in the lower Cowlitz River through acquisition, easements, or restoration projects. Tacoma Power established this fund in 2004 and submits annual reports detailing the use of funds to FERC. As of 30 June 2015, over 625 acres within the Lower Cowlitz Subbasin have been acquired.

Tacoma Power's habitat restoration activities in the lower Cowlitz River include large woody debris placement (required by License Article 9) and gravel augmentation (License Article 10). A total of 183 linear meters of large woody debris and 382 m^3 of gravel are intended to be placed in the lower Cowlitz River annually. Tacoma Power has identified river reaches suitable for restoration and protection in the Upper Cowlitz Subbasin (Article 3), but no actions have been taken to date.

License Article 15 mandated that a plan be developed to monitor the effects of the instream flow requirements of the new license on the Cowlitz River fishes. The plan then became a license requirement.

The 25 SA articles were incorporated into the 2002 FERC license, which was stayed by FERC action and not made effective until 2003. In addition, the license contained 4(e) Conditions (License Appendix B), Water Quality Certification Conditions (License Appendix C), and Section 18 Prescriptions (License Appendix D). In addition to those from the SA, the 2002 license added 13 new license articles:

- Article 201: Annual Payments
- Article 202: Drawings and Exhibits
- Article 203: Headwater Benefits
- Article 301: Revised Exhibits After Construction
- Article 302: Construction Notification to FERC for Articles 1,2,3
- Article 303: Pool Elevations and Flood Regulation
- Article 401: Plan to Abandon Volitional Upstream Fish Passage
- Article 402: Annual Instream Flow Monitoring Report
- Article 403: Historic Preservation
- Article 404: Archaeology Monitoring Plan
- Article 405: Public Information Management Plan
- Article 406: Fish Passage Facilities
- Article 407: Use of Project Lands

On 18 July 2003 (license effective date) the license stay was lifted and one additional license article (408) was added:

- Article 408: Implementing Future Biological Opinion

In 2004, an amendment of the new license (FERC 2004) was issued by FERC. It included a new Appendix E (Construction Practices Near Water and Pollution and Erosion Control Plan), modified two previous articles (401 and 402), and added several additional license articles (409-417):

- Article 409: Lower Cowlitz River Side Channel Habitat
- Article 410: Water Quality Monitoring
- Article 411: Fisheries and Hatchery Management Plan - modified Settlement Article 6 in 2004 to include a “Chum Salmon analysis.”
- Article 412: Agency-Specified Stream Flows
- Article 413: Trap and Haul Plan
- Article 414: Adaptive Management
- Article 415: Final Fish Passage Plan
- Article 416: Control Sediment During Construction in or Near Waterways
- Article 417: Minimize Impact to Listed Fish while Addressing Articles 9 and 10

1.2 Fisheries and Hatchery Management Plan (FHMP)

License Article 6 of the Cowlitz River Hydroelectric Project Settlement Agreement (Tacoma Power et al. 2000) and the FERC license order (FERC No. 2016; FERC 2002) directed Tacoma Power to develop a Fisheries and Hatchery Management Plan (FHMP) for managing supplemented Cowlitz River salmonid populations. The text of Settlement Agreement and License Article 6 is as follows:

“Within 9 months of license issuance, the Licensee shall submit a Fisheries and

Hatchery Management Plan. The plan shall be updated every 6 years, starting in year 7, of the license. The plan shall identify: a) the quantity and size of fish to be produced at the Cowlitz Hatchery Complex; b) rearing and release strategies for each stock, including upward and downward production adjustments to accommodate recovery of indigenous stocks; c) credit mechanisms for production of high quality natural stocks; d) plans for Licensee-funded on-going monitoring and evaluation; and e) a fisheries management strategy consistent with the priority objective of maximizing the natural production of wild indigenous fish stocks and species in the basin. The Licensee shall prepare the plan in collaboration with the Fisheries Technical Committee provided for in the August 2000 Settlement Agreement, or if the Settlement Agreement has become void, with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, Washington Department of Fish and Wildlife and Washington Department of Ecology (referred to as "the FTC or agencies"). When a draft plan has been prepared, it shall be provided to all affected agencies and Tribes for 30-day review and comment. The Licensee shall include with the final plan documentation of consultation and copies of comments and recommendations, and specific descriptions of how the final plan accommodates all comments and recommendations. If the Licensee does not adopt a recommendation, the filing shall include the Licensee's reasons, based on Project-specific information. The Commission reserves the right to make changes to the plan. Upon Commission approval, the Licensee shall implement the plan, including any changes required by the Commission. Following Commission approval, the plan becomes a requirement of the license, enforceable by the Commission."

License Article 6 also directed the creation of the Cowlitz River Fisheries Technical Committee (FTC), which is comprised of seven representatives - one from each of Tacoma Power, NOAA Fisheries, USFWS, WDFW, WDOE, the Yakama Nation, and one representative from the Parties included in the Conservation Groups. The FTC assists Tacoma Power with implementation of the terms of the SA by advising Tacoma Power in the review of plans (such as the FHMP), monitoring plans and studies, reviewing and evaluating resulting data, and decisions on adaptive management measures associated with the fisheries measures.

In its 2004 Order Amending New License, FERC (2004) added the requirement that the FHMP "shall include a Chum Salmon analysis and be updated at 6-year intervals." The initial FHMP was submitted in 2004 and approved by FERC in 2006 (115 FERC ¶ 62,029). A second FHMP was updated in 2011 and approved by FERC in 2014 (149 FERC ¶ 62,032). As the previous two plans have, this FHMP addresses fall and spring Chinook Salmon, Chum Salmon, Coho Salmon, winter steelhead, and Cutthroat Trout populations and guide Cowlitz River fisheries and hatchery management. This FHMP will replace the 2004 and 2011 update.

Each FHMP is to be developed in collaboration with the FTC. This FHMP represents an extensive revision of the two previous FHMPs. The data contained herein have been updated to be the most recent available. Additionally, we have revised the strategies for each species, based on the best available science, strategies to make steps toward recovery goals, and maintain angler opportunity. This has been done through extensive consultation with the FTC, including six separate Monitoring and Evaluation, and Management Workshops to address areas of disagreement and information gaps for each species and population. These workshops were successful in developing agreed-upon management themes for each species and population, which are presented in the appropriate species and population sections below (Chapters 3-8). Lastly, we have developed a "Big Table" for each species, which provides metrics to be monitored for each species and population; goals, where appropriate, for those metrics; and documentation of the most recent 5-year means for those metrics and FHMP and recovery goals for those metrics, where appropriate. The Big Tables (Appendix A) will be accessible to all FTC members and will be linked to one or more databases so that they can be continually updated with the most recently available data. As such, this extensively revised FHMP supersedes the two previous versions and addresses fall and spring Chinook Salmon, Chum Salmon, Coho Salmon, winter steelhead, and Cutthroat Trout populations, and guides Cowlitz River fisheries and hatchery management.

1.2.1. Purpose of the Fisheries and Hatchery Management Plan

The FHMP is used for managing the Cowlitz Salmon Hatchery, Cowlitz Trout Hatchery, and the endemic anadromous salmonid populations in the Cowlitz Basin. FERC License No. 2016 (FERC 2002; 2004) directs Tacoma Power to implement measures to restore and recover natural-origin populations of indigenous anadromous salmonids in the Cowlitz Basin (primary objective), while continuing to support important recreational fisheries. This dual (restoration and harvest) mandate is a consideration in all of the recommended actions in this FHMP.

To effectively restore and manage these populations, a greater amount of information is needed and at a greater level of detail. Therefore, we have added additional performance standards and metrics to be monitored and evaluated so that we can better assess the program and how well it is achieving its goals.

Population recovery is the ultimate goal of all involved with managing depleted, threatened, or endangered species. While population recovery is an integral component of every aspect of this FHMP, it is designed to be a flexible document that provides attainable goals for the FHMP period, while allowing that recovery may require more time to achieve. It is a guide that provides clear direction for achieving those goals, which are steps toward achieving the long-term recovery goals and population recovery. Each FHMP is a stepping stone on the path to recovery of these populations. In this FHMP, we provide two sets of goals:

- **Long-term Goals**: The long-term goal for all of these populations is full recovery to a viable salmonid population (McElhany et al. 2000) that returns at healthy and harvestable levels (LCFRB 2010). The directional goals and specific targets for each population come from the Washington Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan (LCFRB 2010) and the ESA Recovery Plan (NMFS 2013) and have the ultimate goal of ending hatchery supplementation of each population.
- **FHMP Goals:** Goals that we plan to achieve during the period of this FHMP. These are intended to serve as stepping stones toward recovery by addressing specific factors inhibiting our understanding of each population and its progress toward recovery. FHMP goals may be directional (increase or decrease) or specific targets (e.g., numbers of natural-origin salmon spawning in nature, pNOB, pHOS, or smolt production) and may include targets for metrics that are not listed as triggers for transitioning among recovery phases. FHMP goals may also be programmatic (e.g., develop plans for specific segments of the program).

The conclusions and recommendations in this revised FHMP are consistent with the SA and represent adjustments and clarifications of the 2011 FHMP. It is intended to improve implementation of the adaptive management process and the effectiveness of these supplementation programs by incorporating the most recent science to effectively meet resource priorities identified in the SA. It employs rigorous monitoring and evaluation protocols, using the results of studies and baseline monitoring conducted in the Cowlitz Basin, as well as incorporating the most current fisheries science and new knowledge that has been developed by the broader scientific community, in an adaptive management process that includes feedback from key stakeholders. To a large degree, the scientific foundation for the FHMP rests upon the work of the Independent Scientific Advisory Board (ISAB) as presented in NPPC (2001), and of the Hatchery Scientific Review Group (HSRG 2009). Feedback from affected agencies, Tribes, and the public has also provided guidance in the preparation of this document.

Each version of the FHMP reflects maturation of the program and of the document as a management tool. Revising the FHMP is important for adaptive management, as it provides an excellent opportunity to evaluate our success at moving toward population recovery. Each FHMP is an opportunity to make appropriate programmatic changes to refocus our trajectory toward our shared ultimate goal or recovered populations. Organizational changes have been incorporated to make the 2018 plan a more useful document for the implementing parties. The plan provides overarching guidance for decisions for the period covered by this FHMP; however, species- and population-specific information changes annually, which renders portions of chapters of even the most recent FHMPs obsolete. Therefore, species-specific annual action plans will be developed outside of this FHMP and will guide each year's management activities, such as hatchery smolt production goals, disposition of trapped salmon, broodstock collection and spawning, rearing, marking, and release strategies, transport of smolts and mature salmon, data collection, and pHOS, pNOB, and PNI goals.

Additional factors/changes taken into consideration in the preparation of this FHMP include, but are not limited to: legal requirements under the ESA, new knowledge and information from sources outside the Cowlitz River program, changes in fisheries and hatchery operations outside the Project area that affect fish populations in the Project area, lessons learned from the experience of the FTC during its tenure, advice and recommendations from interested parties, and the public record of implementation of actions called for in the 2004 and 2011 FHMPs. Additionally, this FHMP was written in alignment with the Hatchery Genetic Management Plan (HGMP) that is currently being written for each of the six hatchery populations to ensure agreement between the FHMP and HGMPs.

1.3 Endangered Species Act Regulatory Framework

All actions conducted in association with the Cowlitz Hydroelectric Project are governed by their effects on species listed under the Endangered Species Act (ESA). NOAA Fisheries published a Biological Opinion (NOAA Fisheries 2004) and published an ESA Recovery Plan for lower Columbia River Coho Salmon, lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and lower Columbia River steelhead Evolutionarily Significant Units (ESUs)/Distinct Population Segments (DPSs) (NMFS 2013).

In the Cowlitz Basin, excluding the Toutle and Coweeman subbasins, historical populations of each species have been characterized. Distinct populations of fall Chinook Salmon, Coho Salmon, and winter steelhead were identified in the Lower Cowlitz Subbasin - the lower Cowlitz River and tributaries below Mayfield Dam, excluding the Toutle and Coweeman subbasins. Above Mayfield Dam, distinct populations of spring Chinook Salmon, Coho Salmon and winter steelhead were identified in each of the Cispus, upper Cowlitz, and Tilton rivers. For fall Chinook Salmon above Mayfield Dam, a single "Upper Cowlitz Subbasin" population has been identified, which comprises all three of the Cispus, upper Cowlitz, and Tilton drainages. Because there is currently no means to differentiate salmon or steelhead originating from the Cispus and upper Cowlitz rivers, we have pooled them into an "Upper Cowlitz Subbasin" population for each species. Additionally, for current management purposes, population recovery efforts for spring Chinook Salmon are limited to and focused on the Upper Cowlitz Subbasin (Cispus and upper Cowlitz drainages), so no spring Chinook Salmon are being transported to the Tilton Subbasin. Conversely, current restoration efforts for fall Chinook

Salmon above Mayfield Dam are focused solely on the Tilton River drainage and no fall Chinook Salmon are transported to the Cispus or upper Cowlitz rivers. The separate populations are described further in the species and populations sections, below (see Chapters 3 through 8).

1.3.1. NOAA Fisheries Biological Opinion

In conjunction with Cowlitz Project relicensing, NOAA Fisheries issued a Biological Opinion (NOAA Fisheries 2004), establishing conditions for the Project's continued operation. The Biological Opinion found that the continuing the Project's operations would adversely affect essential fish habitat for Chinook Salmon and Coho Salmon and recommended essential fish habitat conservation measures. These measures, including passage performance standards, instream flows, ramping rate restrictions, fish monitoring plan, side channel habitat monitoring, water quality monitoring plan, and others, were subsequently included in the amended license as modified license articles and settlement agreement articles.

1.3.2. Cowlitz River Subbasin Plans

The Lower Columbia Fish Recovery Board (LCFRB 2010) published the Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan, which describes a vision and framework for rebuilding ESA-listed Chinook Salmon, Chum Salmon, Coho Salmon, and steelhead populations in the Lower Columbia Basin, including the Cowlitz Basin. Specific priority actions to improve population viability for Cowlitz Basin anadromous salmonids include:

- Restoring access above dams to the upper portion of the basin;
- Protecting intact forests in headwaters;
- Managing forest land pursuant to Forest and Fish Rules to protect and restore watershed processes;
- Managing growth and development to protect watershed processes and habitat conditions;
- Restoring passage at culverts and other artificial barriers;
- Restoring lowland floodplain function, riparian conditions, and stream habitat diversity;
- Addressing immediate risks with short-term habitat fixes;
- Aligning hatchery priorities with conservation objectives; and
- Reducing out-of-subbasin impacts.

A more specific plan, with recommendations and recovery goals, was provided for each species and population in separate chapters for each subbasin, including the Lower Cowlitz Subbasin and Upper Cowlitz Subbasin.

1.3.2.1 Lower Cowlitz Subbasin Plan

The Lower Cowlitz Subbasin Plan identifies habitat connectivity, habitat diversity, channel stability, riparian function, floodplain function, streamflow, water quality, and substrate and sediment as limiting factors in the Lower Cowlitz Subbasin, and prioritizes a number of habitat and hatchery implementation measures. Hatchery measures include developing a conservation management strategy for natural- and hatchery-origin fall Chinook Salmon production; precluding release of out-of-basin fall Chinook Salmon, spring Chinook Salmon, or Coho Salmon eggs or juveniles into the Cowlitz Basin; adipose fin-clipping 100% of hatchery-origin fall Chinook Salmon, Coho Salmon, spring Chinook Salmon, steelhead, and sea-run Cutthroat Trout; using Cowlitz Basin hatcheries to supplement and enhance natural Coho Salmon and Chum Salmon populations; adopting juvenile release strategies to minimize impacts on natural populations; evaluating facility operations; and monitoring, evaluating, and implementing adaptive management.

Upper Cowlitz Subbasin Plan

Similar to the Lower Cowlitz Subbasin Plan, objectives are identified in the Upper Cowlitz Subbasin Plan for improving fishery resources upstream of Mayfield Dam, including the Cispus, upper Cowlitz, and Tilton rivers. The hydropower system is the primary factor for salmonid population decline in the Upper Cowlitz Subbasin, as it has flooded riverine habitat and impeded volitional access to upstream habitats. Habitat limiting factors in the Upper Cowlitz Subbasin include habitat connectivity (due to dams), habitat diversity, channel stability, riparian function, floodplain function, water quality, substrate and sediment, and streamflow. Hatchery program actions are the same as those for the Lower Cowlitz Subbasin, with the addition of marking/tagging of smolts collected at Mayfield Dam and Cowlitz Falls Dam so that they can be uniquely identified for broodstock collection or transport and release into their natal streams upon their return at maturity.

1.3.3. National Marine Fisheries Service Recovery Plan

The National Marine Fisheries Service (NMFS 2013) published a Recovery Plan for each of the four species of anadromous salmonids in the Lower Columbia Basin that are listed under the ESA. It incorporated the Subbasin Plan and provides overarching guidance for this FHMP. Listed populations in the Cowlitz River are defined by Evolutionarily Significant Units (ESUs). There are four ESA-listed populations in the Cowlitz Basin, all of which are listed as threatened: lower Columbia River Chinook Salmon, lower Columbia River Chum Salmon, lower Columbia River Coho Salmon, and lower Columbia River steelhead.

The Recovery Plan uses recovery scenarios developed by the Willamette/Lower Columbia Technical Recovery Team (TRT; McElhaney et al. 2003) that identify viability objectives for each population that meet TRT recovery criteria for a viable ESU. The viability objectives are based on Viable Salmonid Population (VSP) attributes:

- **Abundance**: The numerical size of the population, typically based on annual numbers of smolts leaving the system; mature salmon returning to the basin, hatchery, and spawning grounds; and spawners in nature.
- **Productivity**: A population’s ability to replace itself and rebound to the equilibrium population level from a low level. It is measured by the number of progeny that survive to spawn (recruits) for each parental spawner (recruits / spawner).
- **Spatial structure**: The amount of habitat available, the organization and connectivity of habitat patches, and the relatedness and exchange rates among adjacent populations.
- **Diversity**: The genetic variability in life history, behavioral, and physiological traits within a population.

The Recovery Plan established a target viability status for each population, taking into consideration:

1) Each population’s potential for improvement, considering available habitat and historical production;
2) The degree of improvement needed in each stratum to meet Willamette/Lower Columbia TRT guidelines for a viable ESU; and
3) For some ESUs, the desire to maintain opportunities to harvest hatchery-origin fish.

These targets are considered the minimum contribution by each individual population toward the recovery of the ESU as a whole.

The viability (= inverse of extinction risk) of each population over the next 100 years was then rated (Very Low to Very High) for each viability attribute and was then given a net baseline viability rating and an objective rating (Table 1-1). The objective rating is the viability goal for that population and that rating determined its recovery designation:

- **Primary**: Populations that are targeted for restoration to High or greater level of viability - High or Very High viability (≥95% persistence probability = ≤5% extinction risk). These populations are the foundation of salmon recovery and at least two populations per strata must be at High or better viability to meet recommended TRT criteria for a viable ESU. Primary populations are typically those with the best prospects for protection or restoration and typically include populations at High or Medium viability during the listing baseline. In some cases, populations with Low or Very Low baseline viability were also designated as Primary populations in order to achieve viable strata and ESU conditions.
- **Contributing**: Populations for which some improvement in viability is needed to achieve the TRT recommended strata-wide average of Medium viability (40-94% persistence probability = 6-60% extinction risk). As such, most Contributing populations are targeted for a medium viability level and might include those of Low to Medium significance and viability but where improvements can be expected to contribute to recovery. Varying levels of improvement are identified for Contributing populations, with some being targeted for substantial improvements whereas more limited increases are identified for others.
- **Stabilizing**: These are typically populations that are currently at Very Low viability (<40% persistence probability = >60% extinction risk) and are expected to be maintained at their current viability level. Stabilizing populations might include those where significance is low, feasibility is low, and uncertainty is high. While Stabilizing populations are not targeted for significant improvement, substantive recovery actions will typically be required to avoid further degradation.

Cowlitz River anadromous salmonid populations were all given a net baseline viability rating of Very Low (Table 1-1). Objective ratings ranged from Very Low for Stabilizing populations (upper Cowlitz River fall Chinook Salmon and Tilton River spring Chinook Salmon and Coho Salmon) to High+ (Cispus and Upper Cowlitz rivers spring Chinook Salmon). Populations were also given natural-origin productivity and abundance targets for achieving recovery. The approach described in the species chapters and sections (3-9) is consistent in taking steps to achieve the NOAA Fisheries recovery strategies. The approaches are consistent in working to achieve natural self-sustaining ESUs by protecting and improving populations through fish management actions that reduce the influence of hatchery-origin spawners in nature over time; build abundance, quality, and distribution; and implement fish management strategies that consider impacts from harvest on productivity and natural-origin abundance.

1.3.4. Hatchery Genetics Management Plans (HGMPs)

Draft HGMPs were prepared by WDFW and submitted jointly by WDFW and Tacoma Power in 2014 for the six hatchery programs at Cowlitz Salmon Hatchery and Cowlitz Trout Hatchery. These documents are currently in draft to ensure alignment with the FHMP:

<u>Cowlitz Salmon Hatchery</u>

- Chinook Salmon

    - Cowlitz River fall Chinook Salmon
    - Cowlitz River spring Chinook Salmon
- Coho Salmon
    - Cowlitz Type N Coho Salmon

<u>Cowlitz Trout Hatchery</u>

- Steelhead
    - Cowlitz River winter steelhead
    - Cowlitz River summer steelhead
- Cutthroat Trout
    - Cowlitz River sea-run Cutthroat Trout

To date, NOAA Fisheries has not consulted on these HGMPs and Tacoma Power will update them, in collaboration with WDFW and NOAA Fisheries, to ensure that they are in agreement with this FHMP before they are submitted.

1.3.5. Conservation and Sustainable Fisheries Plan

As part of the recovery approach in the Lower Columbia Region, the LCFRB collaborated with WDFW to develop the Lower Columbia Conservation and Sustainable Fisheries Plan (CSFP; WDFW and LCFRB 2016). The CSFP provides the framework for addressing hatchery and harvest implementation actions and threat reduction targets identified in the Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan (LCFRB 2010). The overall goal of the CSFP is to address hatchery and harvest threat reduction targets in a manner that returns natural-origin salmon and steelhead to healthy and harvestable levels, while sustaining important tribal, commercial, and recreational fisheries. The CSFP sets forth specific strategies, actions, and management practices for operating hatcheries and in managing related fisheries. The targets relating to population productivity and performance in the CSFP are grounded in the HSRG standards and guidelines.

1.4 Population Restoration and Recovery

All entities involved in managing depleted, threatened, or endangered species, such as these programs, have the ultimate goal of recovering these populations to self-sufficiency and at abundance levels that will allow them to be harvested. Tacoma Power is amongst those entities and will use this FHMP as a guide for progressing toward that ultimate goal. This FHMP is a plan with specific interim targets, and a guide for achieving those targets, which are steps forward in our path to population recovery. Population recovery is an integral component of every aspect of this FHMP and we want to keep the ultimate goal of population recovery in sight, while achieving the nearer goals of this document.

The Hatchery Scientific Review Group (HSRG 2014) defined four phases (biological/recovery) of population restoration: Preservation, Recolonization, Local Adaptation, and Full Restoration (Table 1-3). These phases inform management decisions by providing a framework to monitor and evaluate progress toward the recovery of natural populations.

Table 1-3. Biological phases of restoration and objectives for different ecosystem conditions (HSRG 2014).

Biological Phase	Ecosystem Conditions	Objectives
Preservation	Low population abundance; habitat unable to support self-sustaining population; ecosystem changes pose immediate threat of extinction	Prevent extinction; retain genetic diversity and identity of existing population
Recolonization	Underutilized habitat available through restoration and improved access	Re-populate suitable habitat from pre-spawning to smolt outmigration (all life stages)
Local Adaptation	Habitat capable of supporting abundances that minimize risk of extinction as well as tribal harvest needs; prevent loss of genetic diversity; and promote life history diversity	Meet and exceed minimum viable spawner abundance for natural-origin spawners; increase fitness, reproductive success and life history diversity through Local Adaptation
Full Restoration	Habitat restored and protected to allow full expression of abundance, productivity, life history diversity, and spatial distribution	Maintain viable population based on all VSP attributes using long-term adaptive management

Each natural population is monitored and its progress toward recovery is evaluated using specific indicators, metrics, and triggers:

- **Indicator:** Information on population performance used to evaluate whether the goals for a given restoration phase have been met.
- **Metric:** Actual measures selected to represent each performance indicator.
- **Trigger:** Threshold values for a given metric that indicate the goal of the restoration phase has been met. All triggers associated with one restoration phase must be met for the population to progress to the next restoration phase. However, not all triggers must be met in order to shift management strategies for that indicator. Triggers are identified for each population in subsequent sections of the FHMP describing each population (Chapters 3-8) and in Chapter 11 (Adaptive Management: Annual Program Review and Annual Operating Plan).

We use five performance indicators, each with a set of metrics (Table 1-4):

- **Abundance**: These are the numbers (by origin, sex, and age) of salmon at specific life stages and locations that many of the other indicators rely on. Important metrics include the numbers of mature salmon returning to the Cowlitz River, spawning (in the hatchery and in nature), and smolts produced and leaving the Cowlitz River.
- **Distribution**: This information tells us how broadly the salmon are using the available habitat. Distributions may be spatial or temporal and may address factors such as spawning, rearing, and migrations of hatchery- and natural-origin salmon.
- **Productivity**: This performance indicator gives us an additional indication of whether a population is increasing or decreasing and is the primary monitoring metric for natural-

origin populations. Productivity metrics include recruits-per-spawner (R/S), which is calculated as the number of F_1 generation recruits for each F_0 generation spawner. Recruits can be either spawners ("spawner-to-spawner" R/S) or smolts (smolts/spawner). Spawner-to-spawner R/S provides an overall view of population viability, where:

  - If productivity >1, the population is increasing.
  - If productivity <1, the population is declining.

Therefore, spawner-to-spawner R/S also indicates the trajectory of a population - whether it is self-sufficient and growing or it is failing.

- **Survival**: Survival indicators show us where a population (hatchery- and natural-origin) may be limited. Important metrics include juvenile hydropower system passage survival, smolt-to-adult return (the percentage of smolts that survive to return to their natal spawning grounds - hatchery or nature), and total smolt-to-adult survival (the percentage of smolts that survive to be harvested in fisheries, return to the hatchery, or spawn in nature).
- **Diversity**: A population is unlikely to persist without a sufficient amount of diversity to allow it to withstand perturbations that decrease survival. Life history diversity, age composition, proportion of hatchery-origin salmon spawning in nature (pHOS), proportion of natural-origin salmon in the hatchery broodstock (pNOB), proportionate natural influence (PNI) growth rate, health, and smolt size of hatchery- and natural-origin salmon are important metrics. Also, spawning matrices (the number of individuals of the opposite sex that each individual spawned in the hatchery is crossed with) are important for maintaining diversity in hatchery populations.

These performance indicators and their metrics provide the information needed to address the five topics required of the FHMP. They also expand upon the five topics to provide the greater amount of information that is needed, and at a greater level of detail, to adequately monitor and evaluate each program and assess its progress toward achieving its goals. We apply these indicators, as appropriate, to both hatchery and natural populations because hatchery salmon may affect natural populations at many stages in the life cycle, and it is critical to manage the effects of hatchery salmon on the viability of natural populations at all possible phases in the life cycle of each group of salmon.

Specific metrics and their trigger values may vary among species and populations, in accordance with their recovery priority and viability status and objective. Trigger values are set by HSRG criteria, VSP standards, and recovery goals, when those guidelines are available, or by managers. When data show that a trigger has been met, the population may shift to a higher or lower recovery phase. All triggers associated with one restoration phase must be met for the population to progress to the next higher/lower recovery phase. However, management actions may be taken to achieve the trigger for the next (higher or lower) recovery phase as soon as a specific trigger for the current phase has been met. Additionally, trigger values may need to be updated and adaptively managed as restoration of a population continues through time. Data gaps result in uncertainty about the status of a population relative to an indicator and indicate a need for improved monitoring efforts. This uncertainty can only be resolved by the collection of the appropriate data through an expanded rigorous monitoring effort.

Table 1-4. Important baseline monitoring indicators and metrics for hatchery- and natural-origin salmon for advancement through the recovery phases. Note: 'X' indicates that data should be collected, usually by origin, age, and sex.

	Origin	
Indicators and Metrics	Hatchery	Natural
<u>Abundance</u>		
Harvest	X	X
Jack and Adult Salmon		
Returned to Hatchery/Spawning Grounds	X	X
Transported above dams	X	X
Spawners		
In Hatchery	X	X
In Nature	X	X
Pre-smolt life history stages		
Green eggs	X	
Eyed eggs	X	
Fry	X	X
Parr	X	X
Smolts		
Released/Produced	X	X
Leaving the Cowlitz River	X	X
<u>Distribution</u>		
Space		
Spawning		
Range		X
Density		X
Rearing		
Range		X
Density		X
Time (timing)		
Returning (run timing)		
Range	X	X
Frequency	X	X
Spawning (spawn timing)		
Range	X	X
Frequency	X	X
Rearing		
Range		X
Frequency		X
Smoltification (smolt migration)		
Range	X	X

Indicators and Metrics	Origin: Hatchery	Origin: Natural
Frequency	X	X
<u>Productivity (recruits-per-spawner)</u>		
Fecundity (data collected at hatchery)	X	X
Smolts	X	X
Adults	X	X
Jacks + Adults	X	X
Females	X	X
<u>Survival</u>		
Smolt-to-adult return	X	X
Total smolt-to-adult survival	X	X
Collection Efficiency		X
Smolt passage survival (SPS)		X
<u>Diversity</u>		
Spawning matrices	X	
Life history		X
Smolt Size	X	X
Size at maturity (by age and sex)	X	X
Age composition	X	X
Proportionate Natural Influence		
pHOS	X	X
pNOB	X	X
PNI	X	X

1.4.1. Preservation to Recolonization

Preservation programs are developed for natural populations that are threatened by imminent extinction and are in dire need of support. These populations are usually threatened by habitat loss, so the primary goal of the program is to maintain the existing genetic identity and diversity of the population until the habitat can be sufficiently restored so that it can support all life stages of the population. Efforts to increase abundance are also underway through hatchery supplementation. At this stage, natural abundance and productivity metrics are monitored, and the influence of hatchery salmon on the natural population (while of importance) is secondary to increasing abundance while maintaining genetic diversity. Following best management practices for well-managed hatchery programs is critical (Piper et al. 1982; IHOT 1995; Flagg and Nash 1999; Wedemeyer 2002; Williams et al. 2003; Campton 2004; Galbreath et al. 2008; HSRG 2004, 2009, 2017).

1.4.2. Recolonization to Local Adaptation

During the Recolonization phase, the emphasis is on increasing population size to further reduce the threat of extinction. As such, the performance indicators associated with movement between the Recolonization and Local Adaptation phases are based on abundance, productivity, and survival. As a result, HSRG criteria do not guide the selection of trigger values associated with advancement between the Recolonization and Local Adaptation phases. Instead, the trigger values have been developed by managers and are intended to guide the population toward the triggers for advancement to Local Adaptation.

Metrics of the abundance indicator that should be evaluated during the Recolonization phase are the numbers of mature salmon returning to the system (or transported above dams), actually spawning in nature, and of smolts that they produce. Including smolts as a trigger in the Recolonization phase ensures that adults released into the upper watershed are successfully producing juveniles before advancing to the Local Adaptation phase.

Population productivity is the primary monitoring metric for any population, especially natural populations (HSRG 2017). Measuring spawner-to-spawner R/S is critical, and smolts/spawner will be useful if spawner-to-spawner R/S is below replacement.

Survival metrics, such as smolt-to-adult return and total smolt-to-adult survival rates can be informative, as well, and are the primary metric for evaluating hatchery programs. Survival at additional juvenile life stages may also be monitored, particularly if there is a concern for survival during a specific period. For populations in the Upper Cowlitz and Tilton subbasins, collection efficiency and smolt passage survival are critical metrics.

However, we want to be cognizant of the potential of the population to become domesticated and the risk that this will pose when we try to get it to adapt to spawning and rearing in the natural environment. Some distribution and diversity metrics, such as age composition and run and spawn timing, are more readily affected by hatchery rearing. These metrics should be evaluated at early stages in the process of recovery, and management efforts should be taken to limit the effect of hatchery rearing to improve the potential for adaptation to spawning and rearing in the natural environment. Spawning matrices help maintain genetic diversity and pHOS, pNOB, and PNI triggers are useful for monitoring and reducing the potential for domestication and its deleterious effect on natural populations. Best management practices for well-managed hatchery programs remain critical.

1.4.3. Local Adaptation to Full Restoration

The emphasis of the Local Adaptation phase is the development of self-sustaining natural populations that are capable of supporting directed harvest of natural-origin salmon upon advancement to the Full Restoration phase. Additionally, the distribution and diversity of the population become important. During this phase, triggers must be set to meet or exceed the appropriate HSRG criteria and minimum viability goals from the Recovery Plan.

Abundance metrics to be monitored and evaluated during the Local Adaptation phase are similar to those for the Recolonization phase. However, because we are expecting the population to withstand some level of harvest, abundance triggers for both spawners and smolts will increase, and the trigger for returned mature salmon may shift to an emphasis on natural production.

Productivity metrics to be evaluated during the Local Adaptation phase may include recruits-per-spawner (both spawner-to-spawner and smolts/spawner). The survival metrics (e.g., smolt passage survival, smolt-to-adult return rate, total smolt-to-adult survival rate) become more important for highlighting sources of low survival, and triggers for these metrics may be included or increased.

Distribution indicators for this phase focus on spawning and rearing of critical life stages. Metrics to be evaluated may include the range in both space (lowest to uppermost) and time (earliest to latest) and density of specific life stages, overall and within index reaches of historical importance.

Diversity indicators for the Local Adaptation phase will focus on whether all appropriate life stages are present in the system. Presence and abundance of all life stages will indicate whether the habitat is capable of supporting the desired population size. Additionally, hatchery-oriented metrics, such as matrix spawning, age composition, run and spawn timing, and pHOS, pNOB, and PNI criteria become important as we are actively encouraging the natural population to become completely independent of hatchery supplementation and traits that may be beneficial to salmon in the hatchery but detrimental to salmon in nature. Triggers for these values are rigorous to ensure that the populations are meeting the HSRG criteria and best management practices for well-managed hatchery programs.

1.4.4. Full Restoration

The goal of the Full Restoration phase is a self-sustaining natural population that supports a managed harvest. The performance indicators associated with the Full Restoration phase include abundance, distribution, productivity, and diversity. Metrics that need to be evaluated are the same as those that were monitored during the Local Adaptation phase. Trigger values are changed to reflect natural populations that continue to be self-sustaining and increased adaptation to local watershed conditions while supporting fisheries. Hatchery supplementation is no longer needed, but a hatchery program may be maintained for harvest purposes. If so, hatchery indicators must still be monitored and evaluated, including restrictive pNOB, pHOS, and PNI triggers, and best management practices remain a critical metric.

1.4.5. Recovery Plan Productivity Targets

The Washington Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan (LCFRB 2010) set productivity improvement targets for each population. These targets are the relative increase in population production required to reach its prescribed viability goal. Meeting the Recovery Plan goals is necessary to achieve minimum viability for the population, which correspond to the Local Adaption phase of a restoration program. Moving these populations to the Full Restoration phase would require additional productivity improvements for all H’s (Hatchery, Harvest, Hydro, and Habitat), as well as Ecological Interactions, beyond those called for in the Recovery Plan.

Separate historical populations of spring Chinook Salmon, Coho Salmon, and steelhead have been described in the upper Cowlitz and Cispus rivers (Myers et al. 2006), and each population has its own recovery goals (LCFRB 2010). However, current management is for a single Upper Cowlitz Subbasin population, comprised of the Cispus River and the upper Cowlitz River and their tributaries above Lake Scanewa. The Cowlitz Falls Fish Facility captures smolts from these streams and marks them as coming from the Upper Cowlitz Subbasin but the two rivers merge in Lake Scanewa, just upstream of the Cowlitz Falls Fish Facility. There are no weirs or other structures on these rivers that permit managers to capture and mark smolts migrating downstream from each river, so the river of origin of these smolts cannot be determined. Subsequently, when mature salmon return, managers can only identify them as having originated in the Upper Cowlitz Subbasin, where they are transported to spawn naturally, after being released into one of the two rivers or into Lake Scanewa, from which they can select their preferred stream. In the future, facilities or genetic tools may become available for segregating the two populations. Until then, managers combine the recovery abundance goals and other viability metrics for these two populations into a single goal/target for the Upper Cowlitz Subbasin population.

CHAPTER 2:
COWLITZ BASIN OVERVIEW

2. Cowlitz Basin Overview

The Cowlitz Basin encompasses approximately 6,586 square kilometers and lies within Water Resource Inventory Area (WRIA) 26 (Figure 2-1). The Cowlitz River is an important tributary to the lower Columba River, joining the Columbia River at river kilometer (rkm) 109, approximately 5.6 km southeast of Longview, WA. For fisheries management purposes, the basin is separated into the Lower and Upper Cowlitz subbasins, demarcated by Mayfield Dam at rkm 84, which blocks all natural passage of anadromous fish to the Upper Cowlitz Subbasin. Hydropower operation is the dominant influence in the Cowlitz River from Lake Scanewa to the Toutle River, which is sufficiently large to give the Cowlitz River a natural seasonal discharge regime. This FHMP addresses anadromous fish populations in the Cowlitz Basin, except those in the Coweeman and Toutle rivers.

The Cowlitz River Hydroelectric Project consists of two dams and is Tacoma Power's largest hydroelectric project. Mayfield Dam is located at rkm 84 and Mossyrock Dam is located at rkm 105. Tacoma Power owns and funds operation of the Cowlitz Salmon Hatchery, with its associated Barrier Dam (rkm 80), and the Cowlitz Trout Hatchery (rkm 68). Cowlitz Falls Dam, owned by Lewis County Public Utility District (PUD), is located at rkm 142 in the Upper Cowlitz Subbasin. This hydroelectric project includes the Cowlitz Falls Fish Facility for collection and downstream passage of naturally produced smolts that was constructed and is operated by Tacoma Power under an agreement with Lewis County PUD.

The Lower Cowlitz Subbasin encompasses approximately 2,986 square kilometers within Lewis and Cowlitz counties (Figure 2-1). Significant tributaries within the basin are Salmon, Lacamas, Olequa, Delameter, and Ostrander creeks; the Coweeman and Toutle rivers also flow into the Lower Cowlitz Subbasin but are not considered part of the basin for the purposes of this FHMP. Land uses in this portion of the watershed are largely rural mixed use. The lower 27 km of the mainstem Cowlitz River is tidally influenced and contains pool habitat of low quality due to channelization. Diking, the placement of dredge spoils, and transportation corridors have eliminated most side-channel habitat on the lower Cowlitz River and the lower reaches of tributaries (Wade 2000). Gravel mining also has eliminated historical side channel habitat at various sites along the mainstem from rkm 32-80.

The Upper Cowlitz Subbasin includes approximately 3,600 square kilometers in portions of Lewis, Skamania, Pierce, and Yakima counties. Major tributaries to the upper Cowlitz River are the Cispus, Clear Fork, Ohanapecosh, and Tilton rivers. Land management in the Upper Cowlitz Subbasin is largely comprised of areas of rural mixed use and natural resource areas, including patches of state-owned land and a large portion of the watershed upstream of Cowlitz Falls Dam, which is managed by the U.S. Forest Service for multiple uses.

In the Upper Cowlitz Subbasin, the Cispus and mainstem upper Cowlitz rivers and their tributaries above Cowlitz Falls, the mainstem Tilton River, and lower reaches of Tilton River tributaries provide the most abundant spawning and rearing habitats for anadromous salmonids. Aquatic and floodplain habitat in these reaches has been affected by timber harvest, road building, channelization, and rural development. Natural barriers occur on many tributaries within a few miles of their confluences with the Upper Cowlitz River (Wade 2000), restricting access to low-gradient habitat. Channel alterations, combined with increased sediment inputs, have created low-flow passage problems and reduced habitat quality within these important reaches. In addition, large woody debris is generally lacking, resulting in limited pool habitat, cover, and habitat diversity in the mainstem and lower reaches of most tributaries (Wade 2000).

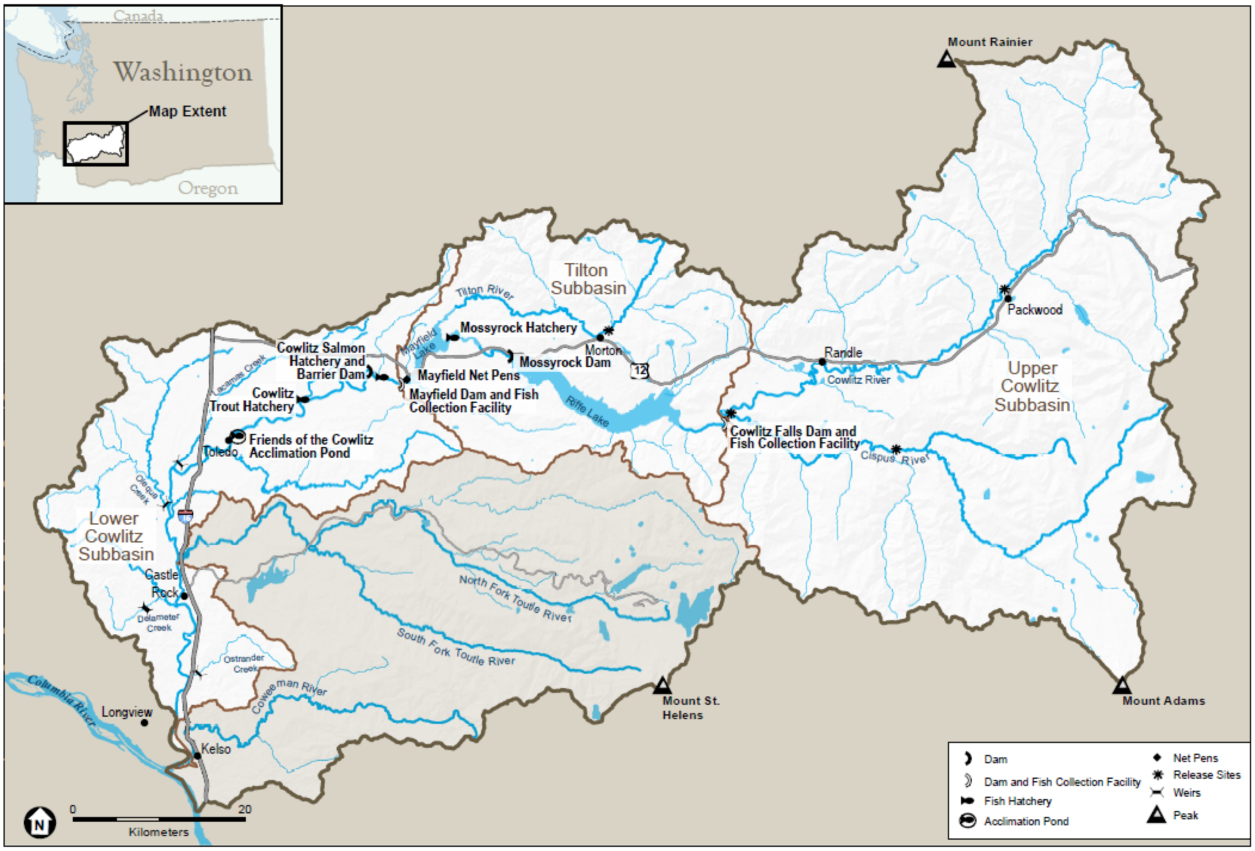


Figure 2-1. Cowlitz Basin, Washington, with the Lower Cowlitz, Cispus, Upper Cowlitz, and Tilton subbasins and important fisheries management sites.

For our purposes, there are three subbasins of importance in the Cowlitz Basin, which are defined as:

1. **Lower Cowlitz Subbasin**: The mainstem Cowlitz River and tributaries below the Barrier Dam at rkm 81, excluding the Toutle and Coweeman rivers.
2. **Tilton Subbasin**: The Tilton River and all of its tributaries.
3. **Upper Cowlitz Subbasin**: The Cispus and upper Cowlitz rivers, above Cowlitz Falls Dam, and all of their tributaries.

Distributions of each species vary by population (Table 1-1). The Cispus River is considered to have contained demographically independent populations (DIPs) of spring Chinook Salmon, Coho Salmon, and winter steelhead (Myers et al. 2006). However, it is currently logistically infeasible to distinguish the Cispus River DIP migrants from those originating from the upper Cowlitz River DIP. To mitigate for this uncertainty, many adults transported to the Upper Cowlitz Subbasin are released into Lake Scanewa so they can seek out their river of origin (upper Cowlitz or Cispus). Data collected on adults and juveniles in the Upper Cowlitz Subbasin have been combined into a single Upper Cowlitz Subbasin population. In the future, however, we may be able to distinguish smolts and mature salmon from each of these rivers. At that time, we may move toward developing separated datasets for each river.

2.1 Hydroelectric Facilities

There are three major hydropower facilities on the Cowlitz River (Figure 2-1). The Mayfield and Mossyrock hydroelectric facilities are operated by Tacoma Power, and Cowlitz Falls Dam is operated by Lewis County PUD.

Cowlitz Falls Dam, located at rkm 142, is owned and operated by Lewis County PUD and generates 70 megawatts (Figure 2-1). Completed in 1994, it is 43 m high and creates the 247-hectare Lake Scanewa that extends about 18 km upstream into the Cispus and upper Cowlitz rivers. The land in the Upper Cowlitz Subbasin is largely managed by the U.S. Forest Service and National Park Service (Mt. Rainier National Park).

The Mossyrock Hydroelectric Project is a 300 megawatt facility that was completed in 1968 and impounds the Cowlitz River below Cowlitz Falls Dam (Figure 2-1). Mossyrock Dam is a 185-m high concrete arch dam that forms the 37 km long Riffe Lake, covering 4,787 hectares and with 84 km of shoreline.

The Mayfield Hydroelectric Project is a 162 megawatt facility that was completed in 1963 (Figure 2-1). It includes a 76-m high dam that impounds the lower reaches of the Tilton River, as well as the Cowlitz River below Mossyrock Dam to form 911-hectare Mayfield Lake. Mayfield Dam is operated to reregulate flows from Mossyrock Dam to reduce fluctuations in the Cowlitz River downstream.

2.2 Cowlitz River Management Time Line

Table 2-1. Time line of important dates and events in fisheries and river management in the Cowlitz Basin.

Year	Event
1915-1921	Coho Salmon released by Tilton River Hatchery.
1933	Washington Hydraulics Division issues permit to construct Mayfield Dam.
? - 1949	A salmon hatchery operated in the upper Cowlitz River near the mouth of the Clear Fork River.
circa1946	Construction of Mayfield and Mossyrock dams was proposed.
1946	Tacoma bought water rights on the Cowlitz River.
1948	License application submitted to FERC for construction of Mayfield and Mossyrock dams.
1948	The Washington Department of Fisheries (WDF) and the Washington Department of Game (WDG) estimated spawning escapement and total production (harvest plus spawning escapement) of salmon, steelhead, and Cutthroat Trout in the Cowlitz River above the Mayfield Dam site to be:

Species	Total Harvest	Spawning Escapement	Total Production
Spring Chinook Salmon	23,490	9,000	32,490
Fall Chinook Salmon	49,612	14,000	63,612
Coho Salmon	53,000	24,000	77,000
Steelhead	11,000	11,000	22,000

Year	Event			
	Cutthroat Trout	24,861	24,861	49,722
	Totals	161,963	82,861	244,824
1948	Moore (1948) estimated that the fishing "industry" in the Cowlitz River was worth $1,000,000 (~$10,600,000 in 2019).			
1949	Columbia River Fish Sanctuary law enacted by Washington State, requiring approval of WDFW to build any dam over 25 feet in the designated lower Columbia River area. WDF did not approve the construction of Mayfield Dam.			
Late 1940s - Late 1950s	• Fish passage was identified as the key issue and necessary for run continuance by Tacoma Power, its consultants, and the fishery resource agencies. • Salmonid hatchery technology was not advanced, so relying on hatchery production to compensate for fish losses was not seriously considered.			
1950s	Many fish passage designs were developed and hydraulic studies conducted.			
1950	Strunk and Hubbs (1950) noted the dramatically depressed populations rather than habitat limitations in the Cowlitz Basin.			
1951	Tacoma was issued a license by FERC to construct, operate and maintain the Mayfield and Mossyrock Hydroelectric Project.			
1957	USFWS approved the installation of the skimmer and other fish facilities for Mayfield Dam to collect downstream migrants (Richey 1956).			
1961	Mayfield Dam adult collection and transfer facility began operations. Adult salmonids were collected at the base of Mayfield Dam, and a tram took them 100 m up the hillside to a transfer house, where they were released into a 3-foot diameter pipe that routed them directly into Mayfield Lake.			
1962	After many studies and much coordination, an upstream fish passage system was constructed at Mayfield Dam, which consisted of a fish ladder, an elevator system, and an adult passage flume.			
1963	Mayfield Dam was completed, with volitional salmon migration blocked at rkm 84.			
1963	Juvenile fish collection system at Mayfield Dam began operating. It included a surface collection system consisting of louver panels and a fish bypass system. However, it was not completed before dam closure, so smolts from the Upper Cowlitz Subbasin were initially passed over the spillway.			
1965	Fisheries agencies confirmed the poor performance of floating Merwin traps at upper end of Mayfield reservoir and proposed a series of traps in the future Mossyrock reservoir to trap and transport juveniles downstream by truck, to trap-and-haul upstream migrants at the future Mossyrock Dam, and to build hatcheries to supplement fish production.			
1966	A plan for managing anadromous fishes above Mayfield Dam was developed, which included the elimination of upstream facilities at Mossyrock Dam, the construction of hatcheries and a barrier dam downstream of Mayfield Dam on the Cowlitz River, the transportation of adults from Mayfield Dam to above Mossyrock reservoir, floating smolt collection traps in Mossyrock reservoir, and the continuation of downstream migrant collection facilities at Mayfield Dam.			
1967	Tacoma Power and WDF signed an agreement in which Tacoma would pay for the construction, operation, and maintenance of the Cowlitz Salmon Hatchery and existing fish collection facilities already in place on the Cowlitz River at the level necessary to maintain the existing runs of Chinook Salmon and Coho Salmon at the following annual return levels:			

Year	Event
	• Coho Salmon: 25,500 • Spring Chinook Salmon: 17,300 • Fall Chinook Salmon: 8,300
1967	Cowlitz Salmon Hatchery and Cowlitz Trout Hatchery opened.
1968	Mossyrock Dam completed.
1968	Cowlitz River was diverted over the Barrier Dam adjacent to the hatchery, with volitional salmon migration blocked at rkm 81.
1968	Operation of upstream fish facilities at Mayfield Dam terminated because no fish had entered the facilities since 3 July 1968.
1971	Federal Power Commission formally approved abandonment of Mayfield upstream fish transport facilities.
1974	Last field season for the Riffe Lake downstream migrant collectors.
1974-Present	Mayfield Dam downstream fish collection facilities opened. They have been operational year round with the attraction pumps for the fish louver system being operational from April through July, annually.
1980	Mt. Saint Helens eruption.
Early 1980s	Management of the Upper Cowlitz Subbasin shifted from anadromous fish production to recreational harvest opportunities upon stocked anadromous salmonids and resident trout.
1994	Completion of Cowlitz Falls Dam.
1994	Trap-and-haul program restored to transport adult salmon to the Upper Cowlitz Subbasin.
1995	Mass marking of smolts at Cowlitz Salmon Hatchery begins; smolts are adipose fin-clipped since brood year 1995, and some groups are also 100% coded-wire tagged.
1996	Cowlitz Falls Fish Facility completed; downstream migrant trapping begins at Cowlitz Falls Dam.
2000	Settlement Agreement was signed by 12 parties resolving, to the satisfaction of the Parties, all issues associated with issuance of a new license for the Project.
2002	FERC issues “Order Approving Settlement and Issuing New License” for the Cowlitz River Hydroelectric Project No. 2016.
2004	NOAA Fisheries issues the Cowlitz River Hydroelectric Project Biological Opinion.
2004	An amendment to the license was issued adding an additional eight license articles.
2011	Weirs installed in lower Cowlitz River tributaries, allowing control of hatchery-origin salmon into those streams.
2014	Tacoma Power takes over operation of Cowlitz Falls Fish Facility and begins planning North Shore Collector.
2017	New smolt collection facility at Cowlitz Falls Dam begins operation.

2.3 Cowlitz River Fishes

Historically, the Cowlitz River supported large populations of Chinook Salmon, Coho Salmon, steelhead, and sea-run Cutthroat Trout throughout much of the watershed, with Chum Salmon generally in the lower river. Today, anadromous fish populations are largely confined to the lower reaches downstream of Mayfield Dam and are supplemented by hatchery production. Natural production in the Upper Cowlitz Subbasin is gradually increasing as a result of supplementation with hatchery-origin salmon for reintroduction programs for spring Chinook Salmon, Coho Salmon, and winter steelhead. Anadromous sea-run Cutthroat Trout, sturgeon *Acipenser* sp., Eulachon *Thaleichthys pacificus*, and Pacific Lamprey *Entosphenus tridentatus* are also present in the lower reaches of the Cowlitz River.

Resident fishes include Cutthroat and Rainbow Trout; Largescale *Catostomus macrocheilus*, Bridgelip *Catostomus columbianus*, and Mountain suckers *C. platyrhynchus*; Mountain Whitefish *Prosopium williamsoni*; sculpin *Cottus* sp.; Longnose Dace *Rhinichthys cataractae*; Speckled Dace *R. osculus*; Western Brook Lamprey *Lampetra richardsoni*; and Northern Pikeminnow *Ptychocheilus oregonensis*. Introduced fishes in the basin include Largemouth *Micropterus salmoides* and Smallmouth *M. dolomieu* bass, Brook Trout *Salvelinus fontinalis*, Crappie *Pomoxis* sp., Bluegill *Lepomis macrochirus*, and Brown Bullhead *Ameiurus nebulosus*. Mayfield Lake is stocked with tiger muskellunge *Esox lucius* x *E. masquinongy* as sport fish and for Northern Pikeminnow control.

The Cowlitz River is fished intensively by sport anglers. It has been a top winter steelhead river in Washington and is also a popular summer steelhead river. The Cowlitz River also attracts intense angler effort for spring Chinook Salmon, fall Chinook Salmon, and Coho Salmon. Additionally, sea-run Cutthroat Trout are an important indigenous species that are produced in the Cowlitz River hatcheries to provide recreational opportunities for anglers.

As is the case with most watersheds in the region, salmon runs dramatically declined in the Cowlitz Basin due to overharvest and habitat loss, and the construction of Mayfield and Mossyrock dams further contributed to the decline of these populations. Construction of Cowlitz Falls Dam was another impetus for reintroduction of anadromous salmonids into the Upper Cowlitz Subbasin. Since the license renewal in 2002 (Tacoma Power 2002), anadromous fishes in the basin have been managed for both harvest and recovery.

Myers et al. (2006) examined the historical records to identify and characterize DIPs of listed Chinook Salmon, Coho Salmon, and Chum Salmon and steelhead within the Columbia River ESU for each species (Table 2-2). Good information on historical abundance, life history characteristics, and genetics was scarce for most populations (particularly for Upper Cowlitz Subbasin winter steelhead), while information on historical presence and geographic distribution was more plentiful and of higher quality (except for summer Chum Salmon).

2.4 Fish Facilities

To meet production requirements, Tacoma Power developed and funds the operation of the Cowlitz Hatchery Complex, as stipulated in the Settlement Agreement. The complex is comprised of two hatcheries for the collection of mature salmon, transport of mature salmon from the lower Cowlitz River to rivers above the dams, spawning, and juvenile production, at Cowlitz Falls and Mayfield dams, for downstream transport to the lower Cowlitz River. During the period covered by this FHMP, Tacoma Power will initiate the planning for the satellite rearing facilities, including inception (what they will be used for), location, and design phases.

2.4.1. Hatchery Facilities

Tacoma Power's Cowlitz Hatchery Complex includes Cowlitz Salmon Hatchery, located about 4 km downstream of Mayfield Dam, and Cowlitz Trout Hatchery, about 12 km downstream of Cowlitz Salmon Hatchery (Figure 2-1).

Table 2-2. Ratings of the quantity and quality of historical information available for ESA-listed salmonid species and populations in the Cowlitz River (from Myers et al. 2006).

Information scale:
0 No information is available.
1 Some information is but of limited quality or quantity.
2 Information is available but of limited use because of quality issues (i.e., hatchery, nonnative stock influences, environmental degradation, etc.).
3 Good information available that directly pertains to historical populations or to present populations that are representative of historical populations.

Species / Population	Historical Presence	Historical Abundance	Life History Character-istics	Genetics	Geography
Fall Chinook Salmon					
Lower Cowlitz River	3	2	2	2	3
Upper Cowlitz River	3	1	2	1	3
Spring Chinook Salmon					
Cispus River	3	2	1	0	3
Upper Cowlitz River	3	2	1	2	3
Tilton River	3	2	1	0	3
Winter Steelhead					
Lower Cowlitz River	3	1	1	1	2
Cispus River	3	1	0	0	3
Upper Cowlitz River	3	2	0	0	2
Tilton River	3	1	0	0	3
Coho Salmon					
Lower Cowlitz River	3	2	1	2	3
Cispus River	3	1	1	0	3
Upper Cowlitz River	3	2	1	2	3
Tilton River	3	1	1	0	3
Chum Salmon					
Cowlitz River Summer	1	1	1	2	2
Cowlitz River Fall	3	2	2	0	3

The hatcheries were constructed by Tacoma Power and began operation in 1967 and 1968, respectively, after Mossyrock Dam was completed. Both hatcheries are operated by WDFW with funding provided by Tacoma Power. Cowlitz Salmon Hatchery was fully remodeled in 2010, and a major remodel of Cowlitz Trout Hatchery is currently in the design phase. On-site housing and back-up generators provide emergency response capabilities at both hatcheries.

In its 2006 "Order Modifying and Approving Fisheries and Hatchery Management Plan, Article 6," FERC (2006) dictates that the "principal stocks of fish to be produced are the indigenous stocks" (fall and spring Chinook Salmon and Coho Salmon, produced at Cowlitz Salmon Hatchery, and sea-run Cutthroat Trout and late winter steelhead, raised at Cowlitz Trout Hatchery). It further states that "non-indigenous stocks, such as early winter and summer steelhead, may be produced, provided that production shall emphasize the recovery of indigenous stocks, and production and management of all stocks shall be consistent with that goal." Specific production details have changed since FERC (2006), but total hatchery production has not (Table 2-3).

As described above, Barrier Dam directs migrating adult salmon and steelhead into Cowlitz Salmon Hatchery. The adult fish ladder is operated year-round, with an auxiliary water source to provide additional attraction flow to reduce the inclination of fish to try to jump over the Barrier Dam. At the top of the ladder, fish enter a holding pond, which has a capacity for 2,540 kg of fish or approximately 350 adult Chinook Salmon or 700 Coho Salmon. During sorting, the fish are crowded into the sorting facility, where the salmon are sorted and directed for release to on-site holding ponds or for transport upstream to designated release sites on the Tilton, Cowlitz, and Cispus rivers.

Broodstock are held in nine adult raceways at Cowlitz Salmon Hatchery, with two crowders that can crowd any of the holding ponds into the common crowding channel. A channel crowder directs the adults to an uplift crowder and into the spawning room, which is equipped with an electro-anesthesia basket. Eggs are collected and fertilized inside the hatchery building and then placed in one of three incubation rooms. Incubation facilities are supplied by five wells and include vertical stack and kitoi-style incubators with recirculation capability. Fry are ponded into either six starter troughs or routed directly to the 36 California-style raceways, which are supplied by 4.7 m^3/s of water pumped from the river and where they are raised to smoltification. Smolts are volitionally released through the pond drain system and into the Cowlitz River just downstream of the Barrier Dam. Fish waste is vacuumed via a venturi system and routed to offline settling ponds. Total production capacity is 294,835 kg, approximately 7.5 million smolts pursuant to the Settlement Agreement.

Cowlitz Trout Hatchery produces and releases about 1.5 million steelhead each year. Although it is equipped with a fish ladder and adult ponds, collection and spawning of broodstock occurs at Cowlitz Salmon Hatchery. Green eggs and sperm are collected at Cowlitz Salmon Hatchery and transported to the trout hatchery incubation facility, where they are combined and the fertilized eggs are incubated in 88 shallow troughs, two deep troughs, and two heated tanks supplied by nine wells, which provide a total of approximately 91 L/s. Fry are ponded into 30 raceways and held until marking, after which the steelhead parr are transported to four rearing lakes, equipped with rotating outlet screens, and held until volitional release into Blue Creek. Fish waste within the raceways is pumped to an offline settling pond. The hatchery pumps approximately 1.42 m^3/s of river water, of which 0.57 m^3/s is treated via an ozone plant strategically operated to avoid *Ceratonova shasta* outbreaks throughout the year.

Table 2-3. Artificial production goals at Cowlitz Salmon Hatchery (Chinook and Coho Salmon) and Cowlitz Trout Hatchery (steelhead and Cutthroat Trout) in 2006 (based on the WDFW 2004 Future Brood Document), after the hatchery rebuild in 2008, and current production levels (updated from FERC 2006).

	2004 Future Brood Document			Current Program				
	Total Production			Total Production			Mean Weight	
Species/ Run / Population	Number	Kg	Pounds	Number	Kg	Pounds	g	fpp
Chinook Salmon								
Fall	5,000,000	28,409	62,500	3,500,000	19,950	43,750	5.7	80
Spring	1,267,000	28,409	62,500	1,738,529	99,458	218,956		
				438,529	39,818	87,706	90.8	5
				800,000	45,440	100,000	56.8	8
				500,000	14,200	31,250	28.4	16
Coho Salmon	3,210,000	96,974	213,343	2,178,000	65,993	145,200	30.3	15
Integrated				978,000	29,633	65,200	30.3	15
Segregated				1,200,000	36,360	80,000	30.3	15
Steelhead	1,440,000	112,122	246,667	1,297,000	95,617	210,610		
Late Winter	590,000	36,364	80,000	647,000	41,963	92,429	64.9	7
Lower Cowlitz Subbasin				481,000	31,196	68,714	64.9	7
Upper Cowlitz Subbasin				118,000	7,653	16,857	64.9	7
Tilton Subbasin				48,000	3,113	6,857	64.9	7
Early Winter	300,000	27,273	60,000					
Summer	550,000	48,485	106,667	650,000	53,655	118,182	82.5	5.5
Sea-run Cutthroat Trout	160,000	17,045	37,500	100,500	11,097	24,443		
Cowlitz Trout Hatchery				90,500	10,272	22,625	114	4
To Friends of the Cowlitz				10,000	825	1,818	82.5	5.5
Totals	11,077,000	282,959	622,509	8,814,029	292,116	642,959		

2.4.2. Upstream Passage

There are no upstream passage or collection facilities at any of the three major dams. All upstream-migrating salmon are stopped at the Barrier Dam and diverted into Cowlitz Salmon Hatchery by a velocity/electric barrier. The salmon are separated by species, sex, and disposition. A trap-and-haul strategy is used to transport all natural- and some hatchery-origin salmon and steelhead that are not retained for hatchery broodstock past the Cowlitz River dams and reservoirs to the Tilton and Upper Cowlitz subbasins for recovery and harvest purposes (Figure 2-1).

2.4.3. Downstream Passage

Salmon and steelhead smolts migrating downstream from the upper Cowlitz and Cispus rivers are collected at the Cowlitz Falls Fish Facility, located at Cowlitz Falls Dam. These smolts are transported by truck to one of eight stress relief ponds at Cowlitz Salmon Hatchery, where they are held for an acclimation period and then volitionally released to the lower Cowlitz River immediately below the Barrier Dam to continue their journey to the ocean. Downstream migrating salmon and steelhead entering Mayfield Lake from the Tilton Subbasin are diverted by a screen to a fish passage channel at Mayfield Dam so they can reach the lower Cowlitz River without passing through the powerhouse turbines and stress relief ponds.

Since 2014, WDFW has operated net pens to rear an additional 2 million juvenile fall Chinook Salmon in the forebay of Mayfield Dam (Figure 2-1). The resulting smolts are trucked to Cowlitz Salmon Hatchery for release. Net pens are currently owned and operated by WDFW; discussions about their future use for final rearing of fall Chinook Salmon and other species in Mayfield Lake are ongoing.

2.4.4. Satellite Rearing Facilities

Article 5 of the Settlement Agreement requires that Tacoma Power "shall be responsible for funding the operation and maintenance of the Cowlitz Hatchery Complex consisting of the remodeled Cowlitz Salmon Hatchery, the remodeled Cowlitz Trout Hatchery, and three satellite rearing facilities, for the duration of this license." During the period covered by this FHMP, Tacoma Power will initiate the planning for the satellite rearing facilities, including inception (what they will be used for), location, and design phases.

2.5 Hatchery Production

Hatchery production begins with the collection of broodstock, which are held until they are ready to spawn, at which time gametes are collected and combined to form fertilized eggs. The eggs are incubated until they hatch and the resulting offspring are reared until release, usually at the smolt stage. For conservation/recovery programs, the goal is to produce salmon that resemble and perform like natural-origin salmon as best as possible. Best management practices (Piper et al. 1982; IHOT 1995; Flagg and Nash 1999; Wedemeyer 2002; Williams et al. 2003; Campton 2004; Galbreath et al. 2008; HSRG 2004, 2009, 2017) should be employed at all stages and include the collection of broodstock that are representative of the natural population in all aspects (and are predominantly natural-origin for a high pNOB and PNI), spawning within matrices to incorporate as much genetic diversity as possible in the resulting F_1 generation, and rearing conditions and growth rates that produce offspring that will survive and mature at similar rates as natural-origin salmon and have similar reproductive success.

We will continue evaluating our hatchery practices and look for ways to improve these programs. The Settlement Agreement (Section 6.1.5), states that, "The hatchery complex will be designed with flexibility so managers can employ innovative rearing practices, low densities, and replication of historic fish out-migration size and timing." The intent of the SA is to rear the salmon so that they are as similar, in both appearance and performance, to natural-origin salmon as possible. Programs will be evaluated with the goal to rear fish to the size and release strategy that provides the best returns for population recovery and harvest.

The 2011 FHMP states that "in the future, consideration could be given to converting to an integrated hatchery program to further improve fitness of the natural population," the WDFW Hatchery Action Implementation Plans (2009) lists "modify programs to achieve goals for PNI, pHOS, and pNOB" as a needed improvement action for Cowlitz River hatchery programs, and the Lower Columbia Basin Conservation and Sustainable Fisheries Plan (WDFW and LCFRB 2016) recommends that programs "convert from segregated programs to integrated or local brood source." To improve pNOB and PNI for the Cowlitz River Coho Salmon hatchery programs and improve the fitness of the natural populations that they supplement, we will shift production from segregated hatchery programs to integrated hatchery programs, using 100% natural-origin salmon for broodstock, wherever possible.

We will follow best management practices for managing our hatchery programs (Piper et al. 1982; IHOT 1995; Flagg and Nash 1999; Wedemeyer 2002; Williams et al. 2003; Campton 2004; Galbreath et al. 2008; HSRG 2004, 2009, 2017). The HSRG (2017) guidelines for implementing hatchery reform in the context of recovery planning and determined that an integrated hatchery program may be appropriate when: (1) the hatchery program has a conservation goal, or (2) the proportion of hatchery salmon on the spawning grounds cannot be reduced sufficiently to meet guidelines for a segregated program. Integrated hatchery programs are intended to artificially increase the demographic abundance of a naturally spawning population and have a goal that natural selection in the natural environment drives the fitness of the population as a whole. To accomplish this, pNOB should exceed pHOS, (HSRG guidelines for Primary populations are that pNOB >2 * pHOS). This means that integrated programs require a natural population that is self-sustaining (or nearly so) in order to provide fish for broodstock (Paquet et al. 2011).

A segregated hatchery program may be appropriate: (1) when there is a very low probability of hatchery salmon spawning with natural populations, (2) for mitigation programs where spawning habitat no longer exists, or (3) where smolt release and adult recollection facilities are physically separated from natural spawning areas. Segregated hatchery programs created a new, hatchery-adapted population that is genetically distinct from the natural population (Paquet et al. 2011). As such, these hatchery salmon may pose significant genetic and ecological risks to naturally spawning populations.

Stepping stone hatchery programs may provide a transition to a fully integrated program. They have the goal of increasing hatchery production while maintaining genetic continuity with the natural population. As such, they retain some genetic continuity between the hatchery- and natural-origin populations, particularly when natural-origin broodstock is in short supply. Stepping stone programs may be appropriate for supplementing harvest when the small size of an integrated program does not meet harvest objectives. Salmon from the integrated and segregated portions of the stepping stone program must be able to be non-lethally identified by separate marks.

Best management practices will be developed from state, federal, tribal, and private hatcheries, as well as the scientific literature (e.g., Piper et al. 1982; IHOT 1995; Flagg and

Nash 1999; Wedemeyer 2002; Williams et al. 2003; Campton 2004; Galbreath et al. 2008; HSRG 2004, 2009, 2017) and will include protocols for:

- Broodstock collection - to ensure that the broodstock are representative of the entire run and fit with the management goals of the program.
- **Spawning**: To ensure that the spawners are representative of the population that they will supplement and fit with the management goals of the program.
- **Egg incubation:** To ensure maximum survival and that the hatch timing fits with the planned growth profile.
- **Rearing**: To ensure that the juveniles grow at the expected rate and remain healthy.
- **Release**: To maximize survival to maturity.
- **Marking**: So that we can identify the hatchery salmon, by release group.

Best management practices will change as technology and knowledge improve. Specific strategies will include:

- The use of spawning matrices to maximize the genetic diversity of our hatchery populations and the natural populations that they supplement;
- Evaluation of raising hatchery salmon to a more natural size and at a more natural rate so that they mature at a more natural (older) age; and
- Developing new protocols and a database to better monitor hatchery production at all stages.

Additionally, procurement of new technology and infrastructure may also be utilized to achieve best management practices. Examples might be:

- Automated fish and egg counters,
- Smaller innovative (nature-mimicking) rearing vessels, or
- Artificial spawning channels.

2.6 Fish Management

Management of Cowlitz River anadromous fish populations has evolved over time, as managers have learned more about how the populations respond to anthropogenic and natural perturbations, as human societal desires and demands have changed, and as recovery goals have been set. Effective management relies on the best available data. Increased monitoring efforts have provided improved data, which allow for better-informed decision-making.

The low abundance of natural populations, fractured habitat, and a myriad of competing interests, among other issues, make managing these populations difficult. Reintroduction efforts into the Tilton and Upper Cowlitz subbasins are progressing. The Lower Cowlitz Subbasin and hatchery populations are being used as the parent stocks for all of the restoration programs, with the assumption that these populations still carry at least some of the genes that were present in the original populations that inhabited the streams above Mayfield Dam.

The goal of population restoration is self-sustaining natural populations. We will continue to improve the rigor of the monitoring programs so as to estimate, with greater confidence, the abundance of these populations and when they have become self-sufficient, as well as to identify areas where we can improve survival. Additionally, the monitoring program will allow for evaluation of activities facilitated by Tacoma Power to protect and enhance habitat in the Cowlitz Basin and the impacts of this work on smolt production and the subsequent return of adult salmon.

Management priorities will be defined when interests, such as recovery and harvest, conflict. These conflicts must be clearly identified and understood so that a plan to resolve the conflict can be developed and subsequently followed. Development of a successful management strategy will involve creative thinking to identify new alternatives, allow flexibility to adapt to changes, and take advantage of new opportunities when they arise. It will also incorporate opportunities to explore and evaluate new alternatives in order to advance our knowledge, thereby being better able to manage the populations.

2.7 Adaptive Management

Adaptive management is and will continue to be an integral part of the management of these populations as a whole, and of the fisheries that benefit from them, the hatcheries that support the populations, all of the management activities, and, hence, this FHMP. We will adaptively manage these populations and programs, as directed by the Settlement Agreement and license and as recommended (HSRG 2009; NMFS 2013; WDFW and LCFRB 2016). The adaptive management program is described in more detail in Chapter 11 and in each species and population section (below).

Adaptive management is a resource management policy that seeks to improve the management of biological resources by using a process where management actions and strategies are adjusted based on new information, which comes from monitoring data that are rigorously collected and evaluated. It is a structured, iterative process of robust decision making where management actions are designed, implemented, and monitored as experiments, and uses data to adjust specific parts of programs (e.g., hatchery production or broodstock collection). There are five steps in this process and each is conducted, in order, and documented during each decision-making cycle:

1) Conduct Program & Collect Data
2) Data Analysis (Annual Report)
3) Reporting Results (Annual Report)
4) Decision-making (Annual Program Review [APR])
5) Planning (Annual Operating Plan [AOP])

Because new information is brought into each cycle, monitoring and evaluation are emphasized to provide the new information in order to make better management decisions. Three important documents are used in adaptive management:

1) Annual Production Review (APR)

As stated in the Annual Project Review Procedures Manual (Tacoma Power 2013), *"the APR adaptive management process asserts that the key to achieving resource goals over time is to:*

a) Assemble the most recent and relevant information and
b) Use this information to operate fisheries, hatcheries, and the monitoring program in a manner that is consistent with the established guidelines each year."

The most relevant information is a set of "key metrics," which include measures of hatchery- and natural-origin production, survival, and productivity, harvest, and age composition, as well as proportionate natural influence. Managers examine the status of those metrics and for trends, and apply Decision Rules to decide on the specific management and M&E strategies and activities that will be used for the coming year. These are then incorporated into the Annual Operating Plan.

2) Annual Operating Plan (AOP)

The AOP is an annual, scientifically defensible, and mutually agreed-upon work plan that documents the management and M&E activities and goals for those activities for each cycle (year) that were developed during the APR, such as:

- Harvest rates in all fisheries
- Disposition of salmon captured at weirs and traps
- Numbers of broodstock to be collected, by origin, sex, and age; and the expected pre-spawn survival rate
- Numbers of salmon to be spawned, by origin, sex, and age; and the expected fecundity and fertility rates
- Green eggs to be collected
- Numbers of fry hatched, parr (at marking), and smolts released; and the expected survival rates to each stage
- Growth rate and expected (target) size at release
- Types of marks/tags
- Release details (e.g., date and location)
- Information on evaluations being conducted

However, not all of the activities and goals documented in the AOP are decided upon during the APR process (e.g., harvest rates are set for various fisheries outside of the APR process). The AOP simply documents all of these decisions and goals and the entity responsible for them so that managers can evaluate whether the target was achieved or not and, especially if not, examine, evaluate, and propose appropriate changes to improve program success.

3) Annual Reports

Annual reports document the success of the program in achieving the goals set in the AOP and provide status reports on the five FHMP topics identified in Section 6 of the SA. Annual reports are the source of the information used in the APR process and fuel adaptive management. The Annual Operating Plan is the blueprint for actions related to the FHMP for the coming year. All work products produced as part of the annual review process, including the AOP, will be included in a comprehensive annual report.

2.8 Monitoring and Evaluation

Monitoring (data collection) and evaluation of those data are critical to effective adaptive management (IHOT 1995; HSRG 2009). We introduce some important concepts here but describe the Monitoring and Evaluation Program in detail in Chapter 9.

Rigorous monitoring and collection of the necessary data are the key to effectively monitoring a population (Table 1-4). Effective adaptive management requires monitoring data for the most recent year, as well as past years, so that the appropriate questions can be considered and decisions made. This information tells managers whether the populations are meeting trigger values for each metric associated with a recovery phase and, if not, these data may provide clues to potential explanations. The recent year's data tell us the current condition of the population, and the historical data (as much as are available) provide context and trend information.

Ideally, we would continuously monitor a population, but anadromous salmon may spend over half of their lives in the Pacific Ocean. While monitoring their growth and survival during this period is important for understanding each population, it is impractical. Tacoma Power has no influence over this part of their life cycle, and WDFW has only minimal influence, through setting harvest levels in ocean and Columbia River fisheries, which cannot target or avoid specific populations, such as natural-origin fall Chinook Salmon from the Cowlitz Basin. Further, little is known about the natural mortality of outmigration juveniles or returning salmon, including avian (e.g., kingfishers, cormorants, mergansers, and terns) and mammalian predators (e.g., orcas, harbor seals, and California and Steller sea lions).

There are many points at which a population can be monitored and data and samples (from which additional data are obtained) can be collected. All of these data are important for providing insight into the status and condition of the population. Monitoring focuses on key, diagnostic points in the life cycle of a population, when we can handle and/or count individual salmon to collect data that will allow us to monitor abundance, growth, condition, and survival (Figure 2-2). Some of those monitoring points provide key metrics that are critical to understanding a population and for managing it effectively. Additional management metrics are calculated from the collected data that further describe the status of the population and are important for adaptive management. Without adequate monitoring data, a population cannot be effectively managed.

Current monitoring efforts (since 2010) have mainly focused on the Cowlitz River but also include the ocean and Columbia River fisheries. Once a salmon enters the Cowlitz River, it may either survive to spawn (in a hatchery or in nature), be removed at a weir or hatchery (hatchery-origin salmon) or die prior to spawning either from harvest in a fishery or from natural causes (predation or disease). While we cannot individually count the salmon as they approach the Columbia River or enter the Cowlitz River, we can estimate the numbers of salmon at major locations (e.g., fisheries, weirs/traps, and spawning grounds) and the sum of these is our estimate of the total number that returned.

The most critical management metrics concern abundance, so this is the most common type of data collected and include total run size, number harvested, number captured at the hatchery or remain in nature, number of spawners in nature and the hatchery, and numbers of smolts produced in nature and the hatchery. These metrics are also used to calculate additional monitoring and management metrics, such as survival and population productivity, and can identify where a population may be limited and management actions can be taken to alleviate that limitation, thereby improving survival and increasing abundance. Whenever data are collected, they must be collected by origin, age, and sex, in order to sufficiently understand the population.

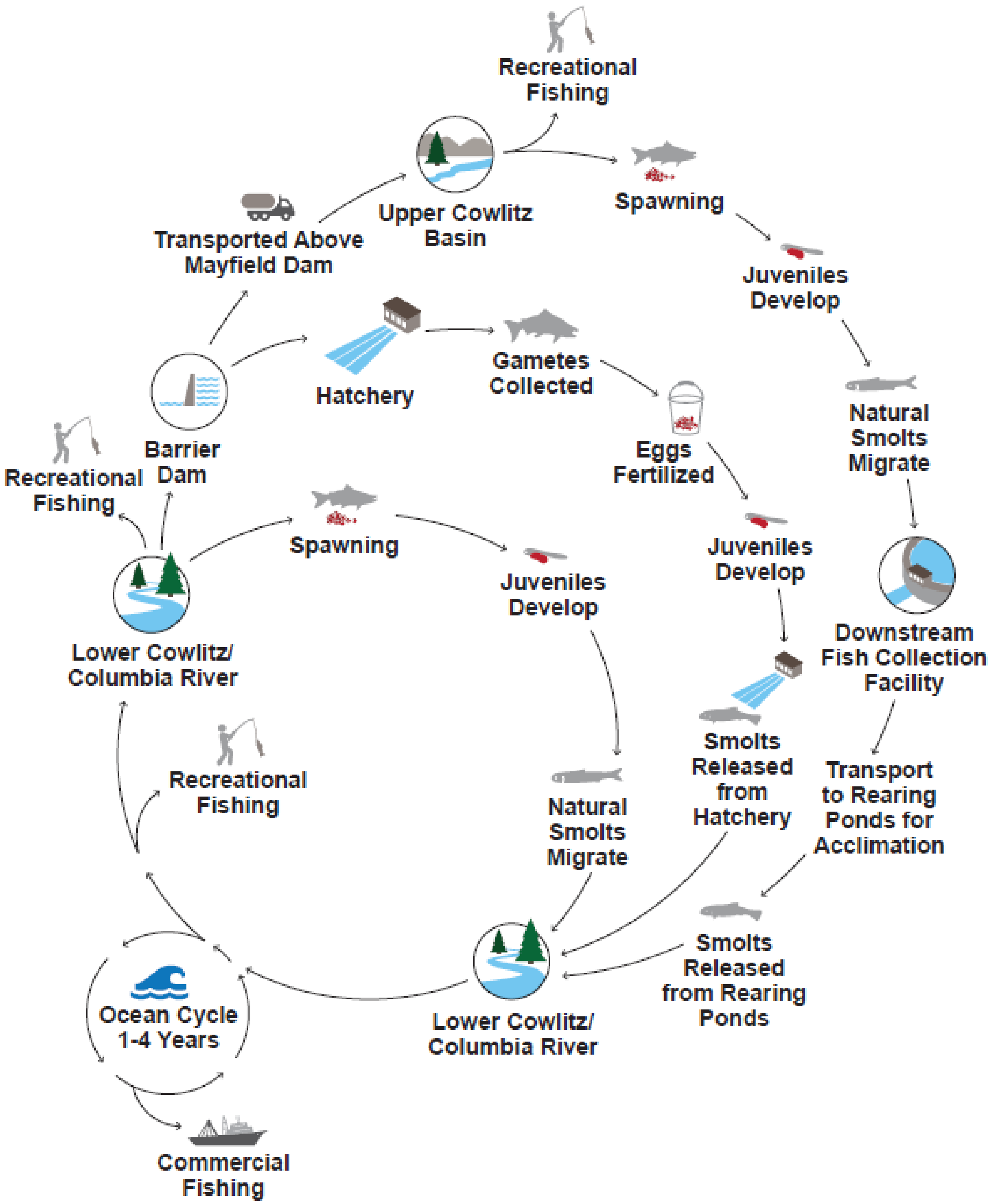


Figure 2-2. The general life cycle and handling points of Cowlitz River salmon and steelhead.

CHAPTER 3:
FALL CHINOOK SALMON

Fall Chinook Salmon *Oncorhynchus tshawytscha*

ESA Listing

Status:	Threatened Listed in 2005, reaffirmed in 2011 and 2016
Evolutionarily Significant Unit:	Lower Columbia River Chinook Salmon
Major Population Group:	Cascade Chinook Salmon
Recovery Region:	Lower Columbia River Salmon
Populations, Recovery Designations, and Abundance Targets (natural-origin adults spawning in nature):	Lower Cowlitz Subbasin - Contributing, 3,000 Upper Cowlitz Subbasin (includes Cispus, upper Cowlitz, and Tilton drainages) - Stabilizing, not established
Current Hatchery Program(s):	Lower Cowlitz Subbasin - Integrated; 1.1 million age-1 (sub-yearling) smolts Lower Cowlitz Subbasin - Segregated; 2.4 million age-1 (sub-yearling) smolts
Proposed Hatchery Programs(s):	Tilton River (Upper Cowlitz Subbasin) - Integrated; 3.5 million age-1 (sub-yearling) smolts

3.0. Fall Chinook Salmon: Overview

3.0.1. Program Focus

The focus for fall Chinook Salmon is on population recovery in both the Lower Cowlitz and Upper Cowlitz subbasins. The Recovery Plan (LCFRB 2010) identifies a Contributing fall Chinook Salmon population in the Lower Cowlitz Subbasin and a single Stabilizing fall Chinook Salmon population, encompassing the Cispus, upper Cowlitz, and Tilton river basins, upstream of Mayfield Dam. However, the current effort for recovering the Upper Cowlitz Subbasin fall Chinook Salmon population is focused on the Tilton Subbasin, in in order to prevent interference with the recovery of spring Chinook Salmon in the Upper Cowlitz Subbasin. Therefore, fall Chinook Salmon will not be transported and released into the Cispus or upper Cowlitz rivers, upstream of Cowlitz Falls Dam and spring Chinook Salmon will not be released into the Tilton Subbasin during the period covered by this FHMP. Because we cannot discern fall Chinook Salmon smolts from spring Chinook Salmon smolts, mixing the runs would greatly reduce the certainty of monitoring data for managers so that we would not be able to determine whether any potential problem in adult recruitment was due to poor freshwater survival or poor saltwater survival. A framework will be developed for the eventual release of fall Chinook Salmon above Cowlitz Falls Dam by the Cowlitz FTC. Such a framework requires an understanding of the key population parameters, referred to as Viable Salmonid Population (VSP) parameters (which include population abundance, productivity, spatial structure, and diversity) for both fall and spring Chinook Salmon in the affected basins, which will be amongst the parameters and considerations for releasing fall Chinook Salmon above Cowlitz Falls Dam (McElhany et al. 2000).

Due to blocking of upstream migration following dam construction in the 1960s, the subsequent aggregation of the populations, and continued genetic exchange since that time, the two fall Chinook Salmon populations (Lower Cowlitz and Upper Cowlitz subbasins) identified within the ESA framework have functionally become a single Lower Cowlitz Subbasin population. Recovery of the Upper Cowlitz Subbasin population will rely on the extant Lower Cowlitz Subbasin population, which has increased and is now nearing its recovery abundance goal of 3,000 natural-origin adults spawning in nature, with pHOS <0.3 in the lower Cowlitz River. Restoration of fall Chinook Salmon in the Upper Cowlitz Subbasin will be accomplished by converting the current Lower Cowlitz Subbasin Segregated and Integrated Hatchery Programs into a single Tilton Subbasin Integrated Hatchery Program, with a production goal of 3.5 million sub-yearling (age-1) smolts, which will support supplementation of both natural spawning in the Tilton Subbasin and fisheries below Mayfield Dam and in the Tilton River. If needed, a Segregated Hatchery Program will be used to ensure that the annual hatchery production goal is met. Additionally, during this period of focus on the Lower Cowlitz and Tilton subbasins, we will continue to evaluate the appropriate program structure to manage for individual populations and Local Adaptation.

3.0.2. Population Structure

Historically, Cowlitz River fall Chinook Salmon spawned and reared in mainstem and lower reaches of major tributaries from the mouth of the Cowlitz River, upstream into the Cispus, upper Cowlitz, and Tilton basins. Excluding the Coweeman and Toutle rivers (lower tributaries that are unaffected by the Tacoma Power hydroelectric dams), two historical independent populations have been recognized in the Cowlitz Basin: the Lower Cowlitz Subbasin (below Mayfield Dam) and the Upper Cowlitz Subbasin (comprised of the Cispus, upper Cowlitz, and Tilton drainages (LCFRB 2010; Figure 3.0-1; Table 3.0-1). In the Recovery Plan, the Lower Cowlitz Subbasin fall Chinook Salmon population is classified as a Contributing population toward recovery of the lower Columbia River fall Chinook Salmon ESU, with a minimum recovery target of 3,000 natural-origin adults spawning in nature in the Lower Cowlitz Subbasin (LCFRB 2010). The Upper Cowlitz Subbasin fall Chinook Salmon population was assigned the lower classification of Stabilizing and does not have a recovery target. However, all potential management options will include strategies for recovery and persistence of both populations. The population-level sections that follow provide performance indicators for each of these populations and a strategy for achieving their recovery.

The genetic composition of the extant fall Chinook Salmon population has been heavily influenced by past overharvest, habitat degradation throughout the basin, loss of access to habitat above Mayfield Dam, and hatchery supplementation. Any population differentiation that previously existed was eliminated when upstream access was blocked by the dams and the subsequent failure of the adult passage systems. At that time, salmon from the Upper Cowlitz Subbasin population were forced to spawn in the Lower Cowlitz Subbasin or were incorporated into the Cowlitz Salmon Hatchery broodstock.

Although little evidence suggests that two distinct populations remain, the Lower Cowlitz Subbasin population currently occupies the mainstem and the lower reaches of some tributaries of the lower Cowlitz River, while the nascent Upper Cowlitz Subbasin population is found only in the Tilton River. Recovery actions have been undertaken over the past three decades, but delisting cannot occur until all populations that historically existed have been restored with a probability of persistence that is consistent with Recovery Plan objectives. The current mixed Lower Cowlitz Subbasin population is believed to still contain genes from the Upper Cowlitz Subbasin population, so recovery of fall Chinook Salmon in the Cispus, upper Cowlitz, and Tilton rivers will rely on this genetic diversity existing in the Lower Cowlitz Subbasin fall Chinook Salmon population as the founding population.

Table 3.0-1. Recovery priority, baseline viability status, viability and abundance objectives, and productivity improvement targets for Cowlitz River fall Chinook Salmon populations (from LCFRB 2010).

	Demographically Independent Population	
	Lower Cowlitz River	Upper Cowlitz Subbasin
Recovery Priority Designation[1]	Contributing	Stabilizing
Abundance		
Historic[2]	24,000	28,000
Current (last 5 years)[3]	3,134	2,716[4]
Target[5]	3,000	3,000 (1,000 / basin)[6]
Baseline Viability[7]		
Abundance & Productivity	Very Low	Very Low
Spatial Structure	High	Very Low
Diversity	Medium	Medium
Net Viability Status	Very Low	Very Low
Viability Improvement[8]	+50%	Medium[6]
Recovery Viability Objective[7]	Medium +	Very Low
Proportionate Natural Influence		
pHOS	<0.3	<0.3[6]
pNOB	>0.3	>0.3[6]
PNI	>0.5	>0.5[6]

1 Primary, Contributing, and Stabilizing designations reflect the relative contribution of the population to Major Population Group recovery goals.
2 Historical population size was mean number, inferred from presumed habitat conditions using EDT Model and NMFS back-of-envelope calculations.
3 Approximate current mean annual number of naturally produced salmon returning to the watershed. Note that these values are 5-year means and are not necessarily consistent with mean values over various intervals that are presented elsewhere in the FHMP.
4 Currently, only released into the Tilton River.
5 Abundance targets were estimated by population viability simulations based on viability goals.
6 For Stabilizing populations, the current operating conditions were considered adequate to meet conservation goals (LCFRB 2010). No criteria were developed for proportion of effective hatchery-origin spawners, pNOB, pHOS, or PNI, so we propose the values indicated.
7 Viability status is based on Technical Recovery Team viability rating approach. Viability objective is based on the scenario contribution. Very Low (>60% chance of extinction); Low (26-60% chance of extinction); Medium (6-25% chance of extinction); High (1-5% chance of extinction); Very High (<1% chance of extinction).
8 Improvement is the relative increase in population abundance and productivity required to reach the prescribed viability goal.

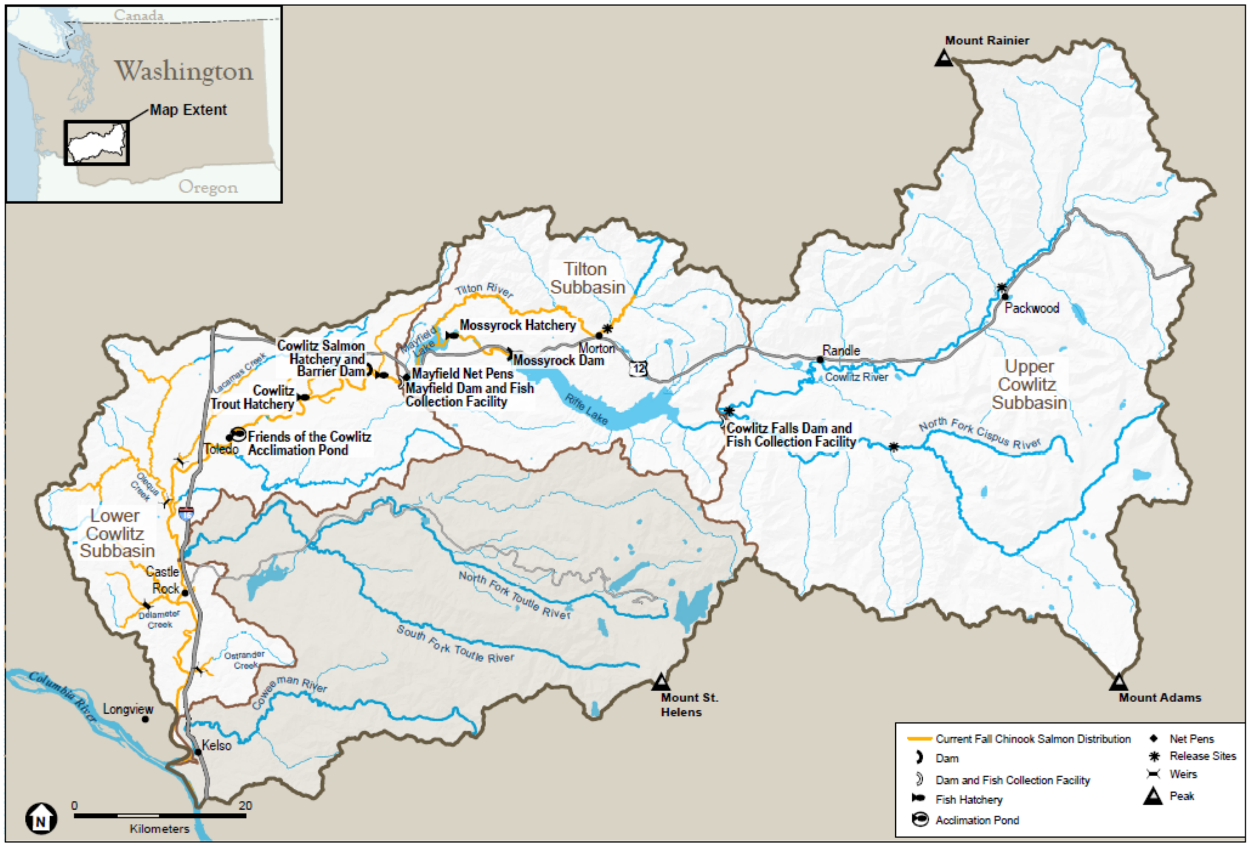


Figure 3.0-1. Distribution of fall Chinook Salmon and locations of important fish management sites in the Cowlitz Basin (not including the Coweeman and Toutle basins).

3.0.3. Life History Diversity

In the Cowlitz Basin, maturing fall Chinook Salmon return to Cowlitz Salmon Hatchery beginning in late August, with some temporal separation between return spawn timing of fall Chinook Salmon and spring Chinook Salmon. Spatial separation of spawning areas also occurs; generally, fall Chinook Salmon spawn in the larger mainstem reaches and lower river tributaries, whereas spring Chinook Salmon typically spawn higher in the system. Spawning of fall Chinook Salmon in the Cowlitz River is protracted, compared to most fall Chinook Salmon populations in the Columbia River ESU, and primarily occurs between late September and late December, with peak activity usually around the first week of November.

In the Lower Cowlitz Subbasin, fry emerge in March/April and rear downstream of spawning areas for several months prior to migration to the Columbia River in spring and summer as sub-yearlings (LCFRB 2010). LCFRB (2010) reports that age of maturation of natural-origin Cowlitz River fall Chinook Salmon ranges from age-2 to age-6, with most maturing at age-3 (16.5%), age-4 (58.1%), and age-5 (19%), although the source of this information is unclear. In contrast, for brood years 1977-2011 fall Chinook Salmon smolts released from Cowlitz Salmon Hatchery with coded wire tags (CWTs), a mean of 9% matured at age-2, 35% at age-3, 49% at age-4, 8% at age-5, and 0.2% at age-6 [data from Regional Mark Information System (RMIS), www.rmpc.org on 9 October 2018].

3.0.4. History

The history of fall Chinook Salmon in the Cowlitz Basin is similar to those of other Columbia Basin populations. Historically, fall Chinook Salmon populations in the Lower and Upper Cowlitz subbasins ranged from 30,000-40,000 and 24,000-28,000 adults, respectively (LCFRB 2010). However, the combination of overharvest in the early to mid-1900s, hydropower development in the 1960s, and the consistent, continuing, and pervasive effects of habitat loss and hatchery supplementation took their toll on these populations (see Table 3.0-2; WDF et al. 1993; Myers et al. 2006). Current population estimates represent a small fraction of historic returns, despite continued recovery efforts. Early efforts to mitigate for the problems caused by habitat loss and overharvest included poorly managed hatchery supplementation programs, which did not provide the desired increase in natural-origin abundance and further degraded the populations.

More recently, natural-origin abundance in the Lower Cowlitz Subbasin has increased and may be nearing minimum recovery targets. Changes to fishery and hatchery practices, as well as improved monitoring, have played a large role in making this improvement possible. However, habitat in the Lower Cowlitz Subbasin has continued to suffer major degradations of the massive hydrological changes associated with hydroelectric development. Land development and increasing human population pressures will likely contribute to further habitat degradation, especially in lowland areas along the mainstem Cowlitz River that are important to fall Chinook Salmon. Additionally, although returns have improved, poor ocean conditions can cause rapid population declines, and most populations in the lower Columbia River ESU are still considered to be at High Risk, including the Cowlitz Basin populations (NWFSC 2015).

In 1948, the Washington Department of Fisheries (WDF) and Washington Department of Game (WDG) estimated that the Cowlitz River above the current Mayfield Dam site produced 63,612 fall Chinook Salmon, of which 46,000 were harvested outside the Cowlitz River, 3,552 were harvested in the lower Cowlitz River, and 16,500 spawned or were harvested above the site of Mayfield Dam (WDF and WDG 1948). In 1951, WDF estimated that 19,500 fall Chinook Salmon spawned in the Cowlitz Basin (excluding the Toutle and Coweeman rivers; WDF 1951) but declined to about 18,000 spawners in the 1950s and only 12,000 in the 1960s (LCFRB 2010).

Prior to the early 1950s, fall Chinook Salmon returning to the Cowlitz River would have been nearly all natural-origin due to very few hatchery releases (Table 3.0-2). From 1952-1960, fall Chinook Salmon redd counts in the Cowlitz Basin ranged from 494-1,759, with 43% above the Mayfield Dam site (Thompson and Rothfus 1969). Run size decreased further and dramatically when Mayfield Dam blocked access to the Cowlitz Basin above rkm 84 in 1961. From 1961-1966, redd counts dropped to a range of 280 to 794, but 37% were still located above the Mayfield Dam site (Thompson and Rothfus 1969). From 1961-1966, a mean of 4,992 adult fall Chinook were transported above Mayfield Dam but declined precipitously afterward (Thompson and Rothfus 1969). Although a trap was initially operated at Mayfield Dam to collect returning salmon for upstream transport, trap operation was terminated in 1968, replaced by a trap-and-haul system that operated in 1969, 1970, 1973-1975, 1978, and 1980, transporting mainly jacks (Seidel and Hopley 1978; Stober 1986). Collection of both spring and fall Chinook Salmon juveniles at Mayfield Dam averaged 397,346 from 1964-1966 (Thompson and Rothfus 1969). Hatchery releases of fall Chinook in the Cowlitz River increased somewhat in the 1950s and 1960s (Table 3.0-2), but the majority of returns were still likely natural-origin prior to the late 1960s.

Table 3.0-2. Hatchery releases of fall Chinook Salmon into the Cowlitz Basin, excluding the Coweeman and Toutle rivers (updated from Myers et al. 2006).

Release Location	Release Years	Years[1]	Broodstock Origin	Total Released[2]
Cowlitz River	1952	1	Carson NFH	24,506
	1953, 1955	2	Spring Creek NFH	586,673
	1953-1981	3	Lower Kalama Hatchery	2,830,087
	1961-2017	49	Cowlitz Hatchery	403,440,663
	1968, 1979	2	Toutle Hatchery	1,008,357
	1978, 1990	2	Washougal Hatchery	2,606,330
	1981	1	Big Creek Hatchery (OR)	807,000
	1981	1	Bonneville Hatchery	4,217,937
Total				**415,521,553**

[1] Total number of years that salmon were actually released within the time frame.
[2] Releases indicated herein were all classified by Myers et al. (2006) as derived from within the lower Columbia River Chinook Salmon ESU.

Completion of Cowlitz Salmon Hatchery in 1968 also incorporated a Barrier Dam at rkm 81, which further restricted distribution in the lower Cowlitz River. When Mossyrock Dam was completed in 1968, it created an additional seasonally warm reservoir that the smolts had to traverse, which greatly reduced the survival of natural-origin smolts to the mouth of the Cowlitz River. From 1964-2001, total (hatchery- and natural-origin) annual escapement estimates for Cowlitz River fall Chinook Salmon ranged from 1,045 to 23,345 (mean = 5,522; LCFRB 2010). Thompson and Rothfus (1969) estimated that 28% of the fall Chinook Salmon spawning habitat above Mayfield Dam was lost by inundating Mayfield and Riffe reservoirs by Mayfield and Mossyrock dams, respectively.

Fish hatcheries have operated on the Cowlitz River for over 100 years, with releases of fall Chinook Salmon beginning in 1952 (Table 3.0-2). Annual hatchery releases of Chinook Salmon were minor before the construction of the Cowlitz River hydroelectric dams but have exceeded 5 million smolts since then. The broodstock has largely been from within the Cowlitz Basin and almost solely from within the ESU, so there appears to be little influence from out-of-basin populations (Myers et al. 2006). Estimates of fall Chinook Salmon returns beginning in the late 1960s contain a large percentage of hatchery-origin fish; however, this percentage was unknown prior to mass marking of returning fall Chinook Salmon.

Some adults were transported around Mayfield Dam to the Tilton River and/or Cispus/upper Cowlitz rivers from 1961 until 1976, after which only jacks were sporadically released until 1996. This resulted in the hybridized, composite population of fall Chinook Salmon that is currently found in the Lower Cowlitz Subbasin and has been transported to the Tilton River nearly continuously since 1996. Downstream migrating juveniles have been and still are collected at Mayfield Dam and transported downstream.

Following the construction of Mayfield and Mossyrock dams, WDFW and Tacoma Power reached a Settlement Agreement with an annual mitigation goal of 8,300 adult fall Chinook Salmon returning to the Cowlitz Salmon Hatchery, much lower than the annual fall Chinook Salmon returns of 52,000 prior to dam construction (Table 3.0-1). To accomplish this, Cowlitz Salmon Hatchery opened in 1968 and was designed to release 5 million fall Chinook Salmon smolts annually.

Following completion of Cowlitz Falls Dam, upstream of Riffe Lake in 1994 by Lewis County PUD, and a reintroduction effort in the Upper Cowlitz Subbasin by Bonneville Power Administration, a new Settlement Agreement was reached in 2000 that required Tacoma Power to prioritize the recovery of wild, indigenous salmonid runs, including fall Chinook Salmon, to harvestable levels. With the listing of these populations under the ESA in 2005, the management focus turned to recovery of the two original populations and conservation was elevated to a higher management priority, resulting in changes in hatchery, harvest, and habitat actions. The recovery goal for the Lower Cowlitz Subbasin was set at 3,000 natural-origin spawners in nature (LCFRB 2010). At the same time, an upstream trap-and-haul program was reinstated. Excess hatchery-origin fall Chinook Salmon from the Lower Cowlitz Subbasin population began to be transported to the Tilton River and above Cowlitz Falls Dam in an effort to reintroduce the historical populations in the Tilton, Cispus, and upper Cowlitz rivers.

As soon as the natural-origin offspring of these salmon began returning, a combination of hatchery- and natural-origin fall Chinook Salmon adults were transported and released, with the intent to produce as many natural smolts as possible and, ultimately, to produce a self-sustaining natural population above the Cowlitz River hydroelectric complex. While this is expected to benefit the restoration effort, transport and release of fall Chinook Salmon upstream of Mayfield Dam is currently limited to the Tilton River until the FTC decides to reinitiate transportation upstream of Cowlitz Falls Dam. The spring Chinook Salmon populations in the Cispus River and upper Cowlitz River are both Primary populations and are critical for recovery of the ESU, making them a higher priority than fall Chinook Salmon.

Natural-origin fall Chinook Salmon abundance has varied widely but has been improving. Based on spawning ground surveys in the Lower Cowlitz Subbasin and standard survival rates for adults transported above Mayfield Dam, we estimate that the total number of natural-origin spawners in the Cowlitz Basin (excluding the Coweeman and Toutle rivers) has ranged from 3,566-6,629 from 2011-2017 (Figure 3.0-2; Table 3.0-3). Since 1964, juvenile fall Chinook Salmon have been collected at Mayfield Dam and released downstream to complete their migration. Returns of natural-origin fall Chinook Salmon to the Cowlitz River from 2007-2017 have ranged from 4,272-8,255, with 1,876-5,689 of them returning to Cowlitz Salmon Hatchery; these return rates indicate that both upstream and downstream salmon passage programs are now allowing for the return of relatively large numbers of naturally produced salmon to areas where populations had been extirpated. However, managers are unable to identify the origin (above vs. below Mayfield Dam) of natural-origin fall Chinook Salmon returning to the Cowlitz River, so the observed increase in natural-origin abundance at Cowlitz Salmon Hatchery may be due, at least in part, to increased production by the Lower Cowlitz Subbasin population. Likewise, it is likely that some Tilton Subbasin salmon remain below Cowlitz Salmon Hatchery and have contributed to the observed increase in the Lower Cowlitz Subbasin natural population, where natural-origin escapement has increased from 1,276 in 2007 to 2,979 in 2017 and has had a mean of 3,317 from 2013-2017. It is assumed that improvements at the Mayfield Dam downstream juvenile collection facility will further increase the abundance of smolts leaving the Cowlitz River, further increasing adult returns, and improving the status of the Tilton Subbasin population.

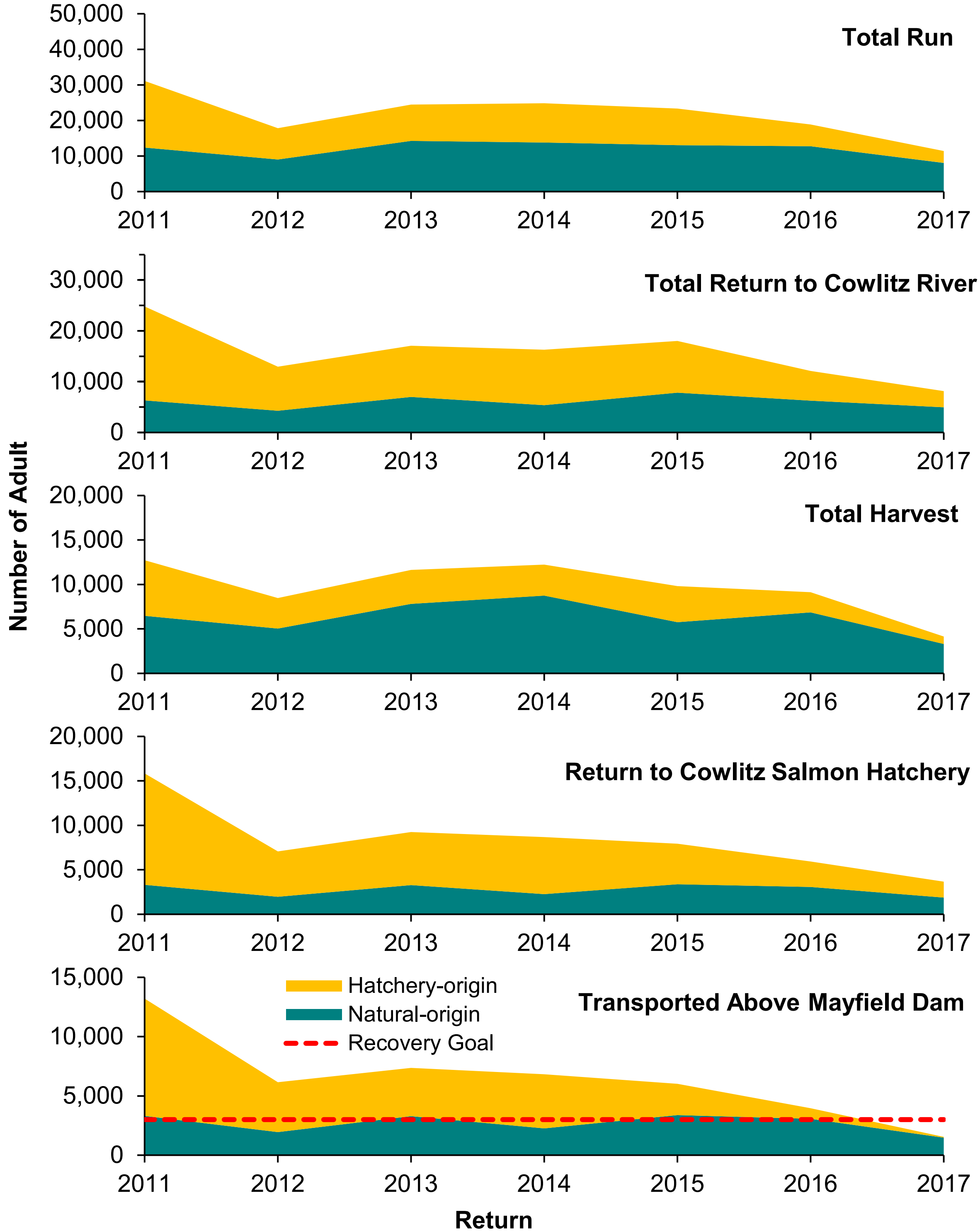


Figure 3.0-2. Estimated total run size for adult natural- and hatchery-origin fall Chinook Salmon and the numbers that returned to the Cowlitz River, were harvested, returned to Cowlitz Salmon Hatchery, and were transported above Cowlitz Falls Dam, 2011-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Table 3.0-3. Mean, minimum, and maximum numbers of all adult hatchery- and natural-origin fall Chinook Salmon from the Cowlitz Basin, excluding the Coweeman and Toutle rivers, that could be accounted for at recovery locations, 2011-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Origin, Recovery Location	Mean	Minimum	Maximum
Hatchery-origin			
Total Run (unique to or below hatchery)[1]	9,804	3,360	18,773
Harvest (total for harvest rate)[2]	3,451	839	6,244
Total Return to Cowlitz River[3]	9,624	3,182	18,464
Return to Hatchery	5,607	1,805	12,527
Collected for Broodstock	1,739	803	2,264
Survived to Spawn [4]	3,760	694	8,877
Natural-origin			
Total Run (unique to or below hatchery)[1]	11,900	8,078	14,262
Harvest (total for harvest rate)[2]	6,291	3,302	8,749
Total Return to Cowlitz River[3]	6,003	4,272	7,841
Return to Hatchery	2,735	1,876	3,380
Collected for Broodstock	57	0	396
Survived to Spawn in Nature[4]	5,015	3,566	6,629
Total			
Total Run (unique to or below hatchery)[1]	21,704	11,438	31,117
Harvest (total for harvest rate)[2]	9,742	4,141	12,726
Total Return to Cowlitz River[3]	15,628	8,137	24,806
Return to Hatchery	1,796	803	2,264
Collected for Broodstock	5,619	3,288	10,372
Survived to Spawn[4]	9,233	5,789	15,396

[1] Sum of all harvest below Mayfield Dam, returns to hatchery, and spawning in nature in Lower Cowlitz Subbasin.
[2] Total of harvest in ocean, Columbia River, lower Cowlitz River, and Upper Cowlitz Subbasin fisheries.
[3] Sum of Lower Cowlitz Subbasin harvest, returns to hatchery, and spawning in nature in Lower Cowlitz Subbasin.
[4] Calculated as number transported to the Upper Cowlitz Subbasin minus harvest in the Upper Cowlitz Subbasin, 12% fallback, and 10% pre-spawn mortality.

3.0.5. Distribution

Historically, Cowlitz River fall Chinook Salmon were distributed from the mouth of the Cowlitz River upstream in mainstem Cowlitz River and larger tributaries (WDF and WDG 1948, WDF 1951, Thompson and Rothfus 1969). Construction of Mayfield Dam (rkm 83.7) in 1961-1963 and subsequent cessation of upstream transport of adults in 1976 blocked access to the spawning grounds above Mayfield Dam, when fall Chinook Salmon to continue above Mayfield Dam until 1981, when the Upper Cowlitz Subbasin fall Chinook Salmon population became functionally extinct. Fall Chinook Salmon transport above Mayfield Dam (mostly, but not exclusively, to the Tilton River) resumed in 1996 and the current spawning distribution of the

Lower Cowlitz Subbasin population includes the Cowlitz River mainstem from its mouth upstream to Barrier Dam (rkm 81) and the Tilton Subbasin. In the mainstem lower Cowlitz River, spawning is concentrated between Toledo Bridge and Cowlitz Salmon Hatchery Barrier Dam (rkm 55-81; Figure 3.0-1; Klett et al. 2013). Small numbers of fall Chinook Salmon have also been observed spawning below the weirs in the lower reaches of Delameter and Olequa creeks (Gleizes et al. 2014). In 1998, 2001, and from 2010-2016, fall Chinook Salmon were also released upstream of Cowlitz Falls Dam in Lake Scanewa, the upper Cowlitz River, and the Cispus River. However, transport of fall Chinook Salmon upstream of Cowlitz Falls Dam has been suspended since 2017 and will remain so for the period of this FHMP.

3.0.6. Abundance

Prior to mass marking of the hatchery salmon in 2011, estimates of natural production from the Lower Cowlitz Subbasin were unreliable because only a small fraction of the hatchery-origin salmon were marked, so we have presented data only since 2011. Since the implementation of mass marking, the estimate of total natural-origin salmon for this population has improved but is still subject to error associated with: (1) spawning or harvest observations in the Lower Cowlitz Subbasin of unmarked fall Chinook Salmon that originated from upstream of Mayfield Dam; (2) collection of unmarked fall Chinook Salmon at Cowlitz Salmon Hatchery that originated from the Lower Cowlitz Subbasin (all natural-origin salmon captured at Cowlitz Salmon Hatchery are assumed to have originated from above Mayfield Dam); and (3) spawning or harvest observations in the Lower Cowlitz Subbasin of unmarked fall Chinook Salmon that originated from outside the Cowlitz Basin.

From 2011-2017, mean total run size (all hatchery- and natural-origin salmon that can be accounted for from ocean and freshwater fisheries, captured at weirs, returns to the hatchery, and remaining in rivers and tributaries) of Lower and Upper Cowlitz fall Chinook Salmon populations, was 21,704 (ranging from 11,438-31,117), of which 55% were natural-origin and 45% were hatchery-origin (Figure 3.0-2; Table 3.0-3). An annual total mean of 15,628 fall Chinook Salmon returned to the Cowlitz Basin from 2011-2017. A mean of 42% of the total run was harvested in the ocean, lower Columbia River, and lower Cowlitz River fisheries, combined. The remaining 58% escaped those fisheries, and about 38% (of the total run) returned to Cowlitz Salmon Hatchery, with 19% remaining to spawn in the Lower Cowlitz Subbasin. A mean of 30% of the total run was transported and released above Mayfield Dam, and we estimate that 23% of the total run survived to spawn there.

Productive spawning and rearing habitats still exist above the Cowlitz Hydroelectric Complex, but reintroduction efforts have been hindered by poor survival of smolts through the dams and associated reservoirs. Downstream migrant traps are operated for juvenile salmon at Mayfield and Cowlitz Falls dams and help to assess the reproductive success of the adult releases, but their collection efficiency has been lower than desired. Additionally, smolt traps operated in the lower Cowlitz River are largely successful in collecting downstream migrating fry but catches very few smolts. As part of its work plan, the M&E Team will evaluate the appropriate methods for estimating the abundance of smolts produced in the Lower Cowlitz Subbasin. As a result, even though mass marking of hatchery fall Chinook Salmon returns was complete in 2011, there is still uncertainty regarding the annual production of natural-origin fall Chinook Salmon smolts in the Cowlitz Basin.

3.0.7. Harvest

One of the main purposes of the fall Chinook Salmon hatchery program is mitigation for the impacts from dam construction in the Cowlitz River. Maintaining a fishery is an important objective of the Cowlitz River Project Settlement Agreement and the management of Cowlitz Basin fall Chinook Salmon. Fisheries can affect population recovery and therefore require careful management. These fisheries are managed by WDFW. Cowlitz River fall Chinook Salmon are an important component of commercial, sport, and tribal harvest and are harvested in ocean, lower Columbia River, and lower and upper Cowlitz River fisheries. CWT recoveries of hatchery-origin Cowlitz River fall Chinook Salmon (1989-1994 brood years) from ocean fisheries indicate that harvest is greatest off the Washington coast, followed by British Columbia and Alaska (LCFRB 2010).

Managing for recovery would support high harvest rates for hatchery-origin salmon while keeping harvest of the natural-origin salmon as low as possible until the population can support harvest (Paquet et al. 2011). Until 2011, when mass marking of all age classes of returning adults became complete, naturally-produced fall Chinook Salmon were managed the same as hatchery salmon and were subjected to similar harvest rates. Since that time, fisheries for fall Chinook Salmon have been mark-selective in the Cowlitz River (i.e., only hatchery-origin Chinook Salmon may be harvested). Therefore, impacts on natural-origin salmon from the Cowlitz River fishery are limited to mortality after release (i.e., hooking mortality). However, natural-origin fall Chinook Salmon may still be legally caught in the ocean and a portion of Columbia River fisheries, which reduces the number that return to the Cowlitz River by some unknown amount, as the method for allocating their harvest to specific populations is imprecise.

Increasing the harvest of hatchery-origin fall Chinook Salmon is a means of reducing the number hatchery-origin salmon spawning in nature. While the potentially adverse effects of hatchery-origin salmon remaining to spawn in nature should diminish as integration of the hatchery program progresses, relatively large numbers of hatchery-origin salmon escaping the ocean, lower Columbia River, and lower Cowlitz River fisheries may result in a large number of excess hatchery-origin salmon reaching Cowlitz Salmon Hatchery. Returning hatchery fall Chinook Salmon that are not needed for the hatchery programs or for Upper Cowlitz Subbasin reintroduction will be utilized in the future for nutrient enhancement or donated to local or statewide foodbanks, if suitable.

Currently, the main overall fishery goal is to maximize harvest of hatchery-origin fall Chinook Salmon while not exceeding impact limits on natural-origin fall Chinook Salmon set by NOAA Fisheries. WDFW established long-term goals for harvest of Cowlitz Basin fall Chinook Salmon in terms of catch numbers, harvest rates, and seasons, by fishery (Tacoma Power 2011). These are not necessarily the goals associated with the Settlement Agreement (which calls for mitigation to be met by a combination of hatchery production, effective passage, and recovery of populations) but rather long-term goals that may require implementation of measures beyond the scope of the Settlement Agreement.

From 2011-2017, 85% of the harvest of hatchery-origin salmon occurred in the lower Cowlitz River, while 65% and 29% of the natural-origin harvest occurred in the ocean and lower Columbia River, where intentional harvest of natural-origin fall Chinook Salmon is allowed (Figure 3.0-3). Only 2% and 3%, respectively, of the natural-origin harvest-related mortality occurred in the lower Cowlitz River and above Mayfield Dam, where intentional harvest of natural-origin fall Chinook Salmon is not allowed, and most of this harvest-related mortality (exploitation) is thought to be post-release hooking mortality. Means of 4%, 1%, and 10% of the hatchery-origin harvest occurred in the ocean, Columbia River, and above Mayfield Dam, respectively.

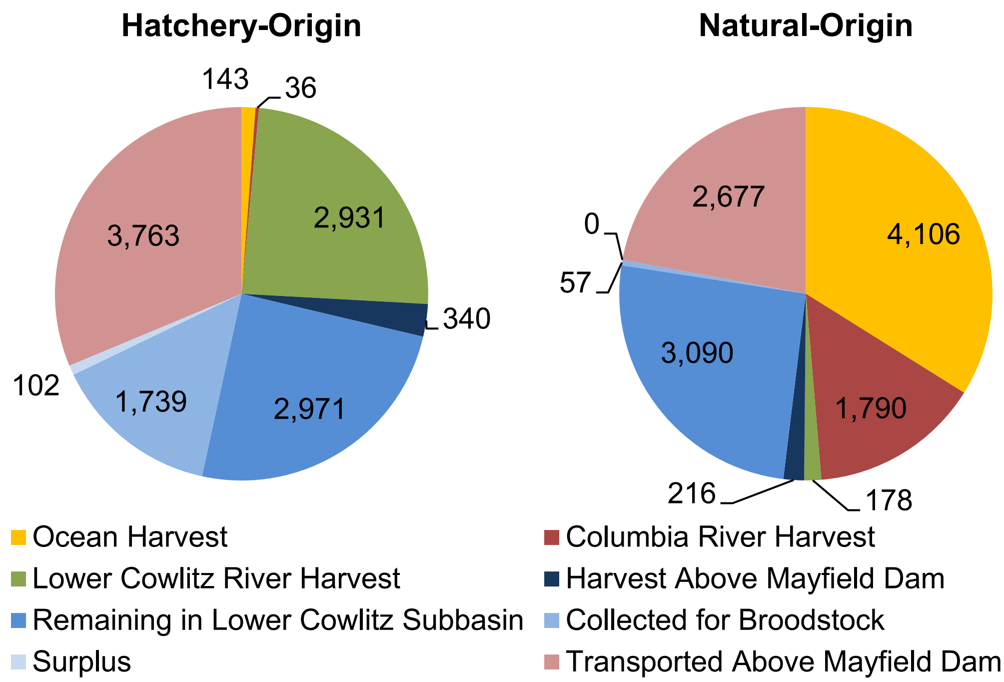


Figure 3.0-3. Percentages and mean numbers of hatchery-origin and natural-origin Cowlitz Basin fall Chinook Salmon harvested, by fishery location, 2011-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

3.0.8. Natural Production

To recover a salmon population, we must develop a self-sustaining natural population. For management toward population recovery, it is also important to know the abundance of the population at intermediate points in their life history. Therefore, we need to know (by origin, sex, and age) how many salmon are spawning in each habitat component (F_0 generation) and how many of their offspring (F_1 generation) survive to produce the subsequent (F_2) generation. Spawning ground surveys (aerial red counts and carcass surveys) are routinely conducted in the mainstem lower Cowlitz River to estimate spawner abundance and composition of fall Chinook Salmon (e.g., Gleizes et al. 2014). However, there are few other current monitoring points for natural-origin Lower Cowlitz Subbasin fall Chinook Salmon from which metrics for earlier life history stages can be estimated. For the population above Mayfield Dam, we collect adults at Cowlitz Salmon Hatchery and transport them upstream, but no spawning ground surveys are conducted. Therefore, we can only roughly estimate spawners by simply using the numbers of hatchery- and natural-origin adults transported multiplied by a standard survival rate, which does not reflect inter-annual variability. Abundance at intermediate points in the life history of the salmon (e.g., number of smolts) allows us to identify critical periods and take appropriate action to ameliorate any problems.

The minimum recovery abundance goal for fall Chinook Salmon in the Cowlitz River is 3,000 adult natural-origin spawners in nature; this target reflects only the Lower Cowlitz Subbasin population (Table 3.0-1; LCFRB 2010). No recovery abundance target was established in the Recovery Plan for the Upper Cowlitz Subbasin population because it is only a Stabilizing population but we propose a target of 3,000; 1,000 in each of the Cispus, upper Cowlitz, and Tilton rivers. Because the ultimate fate (i.e., spawning, harvest, or pre-spawn mortality) of fall Chinook Salmon transported above Mayfield Dam is not reported in ISIT, these salmon cannot be included in estimates of natural production and the status of fall Chinook Salmon recovery in the Cowlitz Basin is currently based exclusively on estimates of natural-origin spawners from the Lower Cowlitz Subbasin population.

3.0.8.1. Adult Transport/Natural Spawning

No effort is currently conducted to identify the true origin of natural-origin salmon returning to Cowlitz Salmon Hatchery, so all natural-origin returns to the hatchery are assumed to have originated from the Tilton Subbasin and are transported upstream of Mayfield Dam. Implementing marking of Chinook Salmon juveniles captured at the Mayfield Downstream Collection Facility and assessment of collection efficiencies should be the first step to understanding fall Chinook Salmon production from the Tilton River. Along with adult return data, we will then be able to estimate SAR and productivity and estimate the proportion of salmon returning to Cowlitz Salmon Hatchery that originate from the Tilton River.

For the 2011-2017 run years, a mean of 2,677 natural-origin fall Chinook Salmon were transported and released upstream of Mayfield Dam. A mean of 73% went to the Tilton Subbasin, but from 2010-2016, an annual mean of 3,747 adult fall Chinook Salmon (42% of those transported) were released above Cowlitz Falls Dam. Spawning ground surveys have not been regularly conducted in the Tilton Subbasin, so the number of transported fall Chinook Salmon that actually spawn in nature above Mayfield Dam can only be roughly estimated. Using the harvest estimate and standard fallback (12%) and pre-spawn mortality (10%) rates, we estimate that from 1,100-2,447 (mean = 1,925) natural-origin fall Chinook Salmon spawned in nature above Mayfield Dam from 2011-2017.

Based on spawning ground surveys in the mainstem lower Cowlitz River, the mean estimated natural-origin adult abundance on the Lower Cowlitz Subbasin spawning grounds (3,090) from 2011-2017 was greater than the minimum recovery goal of 3,000 spawning natural-origin salmon, and the goal was exceeded in both 2013 (3,477) and 2015 (4,182), as well as the mean for the last 5 years (3,317). The Lower Cowlitz Subbasin fall Chinook Salmon population appears to be close to the recovery target for natural-origin adult abundance, and this improved viability will be the foundation for recovery of the population above Mayfield Dam, as well.

3.0.8.2. Smolt Production/Transport

Most of the fall Chinook Salmon smolts are captured and counted at Mayfield Dam, where an annual mean of 74,721 juvenile fall Chinook Salmon were captured from 2007-2017. However, because fish passage survival studies have not been completed on the Mayfield Dam downstream collection facility, the juvenile Chinook Salmon counts at Mayfield Dam do not account for those that survive passing through the dam, so they allow only a vague understanding of fall Chinook Salmon production in the Tilton Subbasin.

Based on the proportion of adult Chinook Salmon transported to the Upper Cowlitz Subbasin that were fall Chinook Salmon, a rough estimate of 6,446 sub-yearling fall Chinook Salmon smolts were caught at Cowlitz Falls Dam from 2011-2016 (2010-2015 brood years, when adults were released in the Cispus and upper Cowlitz rivers).

Smolt monitoring in the Lower Cowlitz Subbasin is conducted using a screw trap in the mainstem Cowlitz River and is difficult due to the large size of the river. However, the smolt trap is effective in capturing fry but not smolts, so the M&E Team will evaluate the appropriate methods for estimating the abundance of smolts produced in the Lower Cowlitz Subbasin.

Further confounding these estimates is the presence of fall Chinook Salmon smolts from the Tilton Subbasin and spring Chinook Salmon smolts from the Upper Cowlitz Subbasin, which cannot be discerned from those from the Lower Cowlitz Subbasin.

3.0.9. Artificial Production

The overall goals of the current hatchery programs for fall Chinook Salmon within Cowlitz Basin are to:

1) Promote recovery of populations inhabiting the Cowlitz Basin.
2) Mitigate for harvest opportunities reduced by construction and operation of the Cowlitz River Project, for commercial, and recreational, and tribal fisheries.
3) Support educational and research opportunities.

Specific and quantifiable objectives of the hatchery program to achieve these goals are described in detail within the respective sections for each of the fall Chinook Salmon populations.

The fall Chinook Salmon hatchery program at Cowlitz Salmon Hatchery began in 1967 (WDFW 2014). The program was integrated by default because the hatchery-origin fall Chinook Salmon were not 100% marked until return year 2011. Prior to that, managers could not be certain about the origin of the salmon collected for broodstock. The Segregated Hatchery Program for Lower Cowlitz Subbasin fall Chinook Salmon began in 2011 and currently has a production goal of 2,400,000 age-1 (sub-yearling) smolts. The Integrated Hatchery Program began in 2013 (albeit with low rates of natural-origin integration), with an annual production goal of 1.1 million age-1 smolts and a target of 30% of the broodstock being of natural-origin. However, because all natural-origin salmon returning to Cowlitz Salmon Hatchery were assumed to have come from above Mayfield Dam and are transported upstream, the Integrated Hatchery Program has had difficulty collecting natural-origin salmon for broodstock, and mean pNOB = 0.077. Additionally, the natural-origin contribution came solely from salmon that WDFW captured on the spawning grounds by netting, hook and line, or snagging.

Sperm was collected from most males, after which they were released, and their sperm was transported to Cowlitz Salmon Hatchery, where it was used to fertilize the eggs of hatchery-origin females. Some males and all females were taken to Cowlitz Salmon Hatchery for spawning. A mean of 87% of these natural-origin adults were males. Relying so heavily on males for the natural-origin contribution is a poor practice for integrating a hatchery population and is discouraged by geneticists because any alleles that were linked to females were less likely to be included in the hatchery population (R. Waples, J. Hard, and P. Moran, NOAA Fisheries, personal communication). However, because of low abundance in recent years (i.e., 2017 and 2018), natural-origin broodstock have been collected from those captured at the hatchery. Prior efforts for broodstock collection resulted in poor PNI values, so this change is a positive one. All hatchery-origin salmon have been visually identifiable since 2011, and we have developed and will implement a plan to mark natural-origin smolts captured at Mayfield Dam. In addition, with the transition to the single Upper Cowlitz Subbasin Integrated Hatchery Program, all future broodstock (both hatchery- and natural-origin) will be collected solely from returns to Cowlitz Salmon Hatchery.

From 2007–2017, an annual mean of 5,098 adult hatchery-origin fall Chinook Salmon returned to Cowlitz Salmon Hatchery, of which 2,066 were collected for broodstock and 1,903 were spawned. The Segregated Hatchery Program spawned 2,162 adults in 2011 and 748 adults in 2012. From 2013-2017, a mean of 1,795 adults were spawned for the combined

Integrated and Segregated Hatchery Programs, 93% (1,662) of which were hatchery-origin and 7% (133) were natural-origin. From 2007–2017, a combined total mean of 3,969,970 sub-yearling smolts were released from the Integrated and Segregated Hatchery Programs.

All hatchery-reared salmon are released into the Cowlitz River directly from Cowlitz Salmon Hatchery and, upon their return, they support fisheries both below and above Mayfield Dam. Those transported to the Tilton Subbasin that escape harvest will spawn naturally and support the restoration of the natural fall Chinook Salmon population there. Returns of natural-origin adults to Cowlitz Salmon Hatchery have ranged from 1,876-3,380 from 2011-2017. We will be transitioning all hatchery production to the Integrated Hatchery Program for supplementing natural spawning in the Tilton Subbasin and harvest both below and above Mayfield Dam. This new, larger Integrated Hatchery Program will continue to produce up to 3.5 million smolts, using both hatchery- and natural-origin salmon that return to Cowlitz Salmon Hatchery for broodstock and with pNOB >0.5 so that all hatchery-origin offspring have at least one natural-origin parent. If natural-origin returns cannot support the program, a Segregated Hatchery Program component (pNOB = 0) will be used to make up the difference.

Hatchery production metrics must be monitored to ensure that production goals are met, and also to understand the magnitude of hatchery influence on the natural population that it is supplementing (e.g., pNOB). Key monitoring metrics are the numbers of salmon collected and spawned (by origin, age, and sex), green eggs, eyed eggs, fry, parr, smolts released, and salmon returning to the Cowlitz River and Cowlitz Salmon Hatchery (by age and sex). Using these data, we also calculate and monitor hatchery effectiveness metrics and smolt-to-adult survival and return rates.

3.0.10. Survival and Productivity

Mean SAR (which includes all mature salmon that could be accounted for) of hatchery-origin fall Chinook Salmon with CWTs for the 1977-2012 brood years was 0.30% (0.02-1.95%). SAR of natural-origin salmon is unknown because necessary data are unavailable, but is expected to be greater than that of the hatchery-origin salmon. Because the numbers of returns by brood year are unavailable, productivity (spawner-to-spawner) also cannot be calculated.

3.0.11. Proportionate Natural Influence and Age Composition

Proportionate natural influence (PNI) is an index of the potential influence that hatcheries may have on salmon populations, as a whole. PNI is calculated using two proportions: the proportion of spawners in nature that are hatchery-origin (pHOS) and the proportion of the hatchery broodstock that is comprised of natural-origin salmon (pNOB). The Hatchery Scientific Review Group (HSRG; 2009) recommended that Contributing populations with segregated hatchery programs should have pHOS <0.1. For those with integrated hatchery programs, pHOS should be <0.3 and pNOB should exceed pHOS so that PNI >0.5.

Prior to 2011, the Cowlitz River fall Chinook Salmon population was supplemented by a single hatchery program with limited marking, so we could identify only a small proportion of the hatchery-origin salmon. Therefore, any estimation of pNOB, pHOS, or PNI would be wildly inaccurate. In 2011 and 2012, hatchery production came from only the Segregated Hatchery Program, so pNOB = 0 and PNI = 0. We estimate that pHOS for the combined Lower Cowlitz, Upper Cowlitz, and Tilton subbasins was 0.606 in 2011 and 0.506 in 2012. During the 2013-2017 spawn years, we operated both the Integrated and Segregated Hatchery Programs and mean pNOB was 0.077. Mean pHOS = 0.334 for the combined Lower Cowlitz, Upper Cowlitz, and Tilton subbasins, and the resulting mean PNI = 0.184. We achieved the HSRG recommendation for pHOS in 2016 (0.245) and 2017 (0.157). However, mean pHOS did not achieve the HSRG recommendations, and the program did not achieve the HSRG recommendation for pNOB or PNI for any individual year or the mean.

For brood years 1977-2012 fall Chinook Salmon with CWTs, mean age at maturity was 3.62 years (3.00-4.24). An annual mean of 6% of these salmon matured at age-2, 36% at age-3, 50% at age-4, 9% at age-5, and 0.2% at age-6. The ages of natural-origin salmon at maturity are currently not available but it is assumed that natural-origin salmon will be older than hatchery-origin salmon.

3.0.12. Marking and Tagging

Currently, all hatchery-origin fall Chinook Salmon are marked with an adipose fin clip (Table 3.0-4). Additionally, 10% of those from the Segregated Hatchery Program and all of those from the Integrated Hatchery Program have a CWT implanted. The new Integrated Hatchery Program will be 100% adipose fin-clipped and a percentage of them will also receive a CWT. We will implant CWTs in a sufficient number of the Integrated Hatchery Program smolts to insure that, even in years of low abundance, we will get enough identifiable F_1 returns to use for hatchery broodstock. An equal number of tags, with unique codes, will be applied to each raceway so that we can monitor the variation in survival among individual raceways and brood years. Currently, natural-origin fall Chinook Salmon smolts from the Tilton River are not marked when they are captured at the Mayfield Dam Downstream Collection Facility, but we will begin marking them with a CWT so that they can be partially differentiated from those produced in the Lower Cowlitz Subbasin. Because survival by passage route has not been evaluated, this will only identify an unknown portion of the returning adults from upstream of Mayfield Dam.

Marking and tagging schemes may vary from year to year, especially for hatchery-origin releases, which also may include experimental groups. Marking and tagging schemes for each group, within each brood year, will be set by the Monitoring and Evaluation subgroup and documented in each year's Annual Operating Plan.

Table 3.0-4. Current and proposed hatchery programs, smolt production, and marking/ tagging for fall Chinook Salmon.

Origin & Stock	Hatchery Program	Juvenile Production		Mark / Tag	
		Current	Proposed	Current	Proposed
Hatchery-origin					
Lower Cowlitz Subbasin	Integrated	1,100,000	None	100% Ad + CWT	None
	Segregated	2,400,000	None	100% Ad + 10% CWT	None
Combined Lower and Upper Cowlitz subbasins	Integrated	None	3,500,000	None	100% Ad + Fractional CWT
	Segregated	None	As needed	None	As needed
Natural-origin					
Lower Cowlitz Subbasin	None	Unknown	NA	None	None
Upper Cowlitz Subbasin	None	NA		NA	
Tilton Subbasin	None	13,000-142,000		None	All Captured/ handled

3.0.13. Summary

- Continued genetic exchange across the Upper Cowlitz and Lower Cowlitz subbasins since 1963 has caused Cowlitz Basin fall Chinook Salmon to functionally become a single population.
  - For consistency with the ESA framework, this FHMP separates fall Chinook Salmon into two populations, the Lower Cowlitz Subbasin population and the Tilton Subbasin population, with the latter representing the entirety of the current Upper Cowlitz Subbasin population.
  - Recovery efforts for fall Chinook Salmon will focus on the Lower Cowlitz and Tilton subbasins; fall Chinook Salmon will not be released above Cowlitz Falls Dam to avoid interfering with spring Chinook Salmon recovery there.
  - A framework will be developed using Viable Salmonid Population parameters for the eventual release of fall Chinook Salmon above Cowlitz Falls Dam, which will occur after spring Chinook Salmon have become established there.
- A single Integrated Hatchery Program will be used to supplement restoration of the Tilton Subbasin and support fisheries, both downstream and upstream of Mayfield Dam.
  - Integrated Hatchery Program goal of 3.5 million sub-yearling smolts; pNOB >0.5 so that all hatchery-origin offspring have at least one natural-origin parent; broodstock will be collected from those returning to Cowlitz Salmon Hatchery.
  - Segregated Hatchery Program will only be used if needed to ensure that the annual hatchery production goal of 3.5 million sub-yearling smolts is met.
- During this period, we will continue to evaluate the appropriate program structure to manage for individual populations and Local Adaptation.

The following sections present information on the two managed fall Chinook Salmon populations in the Cowlitz Basin: fall Chinook Lower Cowlitz Subbasin population (Section 3.1), and fall Chinook Tilton Subbasin population (Section 3.2).

Intentionally blank page

Population: Lower Cowlitz Subbasin Fall Chinook Salmon
Oncorhynchus tshawytscha

ESA Listing

Status:	Threatened Listed in 2005, reaffirmed in 2011 and 2016
Evolutionarily Significant Unit:	Lower Columbia River Chinook Salmon
Major Population Group:	Cascade Chinook Salmon
Recovery Region:	Lower Columbia River Salmon
Population Recovery Designation:	Contributing
Population Viability Rating:	
Baseline	Very Low
Objective	Medium +
Recovery Target:	3,000 natural-origin adults spawning in nature in the Lower Cowlitz Subbasin
Current Recovery Phase:	Local Adaptation
Current Hatchery Program(s):	Cowlitz Salmon Hatchery Segregated Hatchery Program, 2.4 million smolts Cowlitz Salmon Hatchery Integrated Hatchery Program, 1.1 million smolts
Proposed Hatchery Program(s):	None

3.1. Fall Chinook Salmon: Lower Cowlitz Subbasin Population

3.1.1. Purpose

This section describes the current status of the Lower Cowlitz Subbasin fall Chinook Salmon population based on recent and available data. In addition, we identify Viable Salmonid Population (VSP) metrics needed to evaluate the status of this population with regard to reaching recovery under ESA guidelines. Where appropriate, we propose changes to both hatchery and monitoring programs to facilitate evaluation of progress toward population recovery. During the period covered by this FHMP, we will use a single Integrated Hatchery Program to produce 3.5 million sub-yearling (age-1) smolts that will supplement natural spawning in the Tilton Subbasin population and provide fisheries both below and above Mayfield Dam. We will continue to evaluate the hatchery program and fisheries management and will make refinements or adjustments, as described in this FHMP, to effectively supplement and manage the Lower Cowlitz Subbasin fall Chinook Salmon population.

3.1.2. Population Description

The Lower Cowlitz Subbasin fall Chinook Salmon population includes all natural-origin fall Chinook Salmon that occupy the lower Cowlitz River and all tributaries from the mouth of the Cowlitz River up to the Barrier Dam (rkm 81), including those from the current hatchery programs at Cowlitz Salmon Hatchery but excluding those from the Toutle and Coweeman rivers (Figure 3.1-1; NMFS 2016). Except for the Toutle and Coweeman rivers, it is the sole remaining population of the original two fall Chinook Salmon populations that inhabited the Cowlitz Basin (NOAA Fisheries 2004). It was found to be “Depressed” (WDFW 2002) and, as part of the lower Columbia River ESU, was listed as threatened under the ESA in 2005 and reaffirmed in 2011 and 2016. This population is classified as a Contributing population for recovery of the lower Columbia River ESU and must attain its recovery and viability goals for the ESU to be considered recovered (LCFRB 2010).

The Lower Cowlitz Subbasin fall Chinook Salmon population is currently supplemented by hatchery production. The combined hatchery- and natural-origin Lower Cowlitz Subbasin population is relatively abundant (Table 3.1-1) and is the source population for restoring the population originally found above Mayfield Dam (Figure 3.1-1). The most recent 5-year mean hatchery-origin adult run size and return to the Lower Cowlitz Subbasin have met hatchery production goals, while the number of natural-origin spawners in nature is approaching the minimum recovery target. Numbers of broodstock spawned in the hatchery and smolts produced have also consistently met their respective targets.

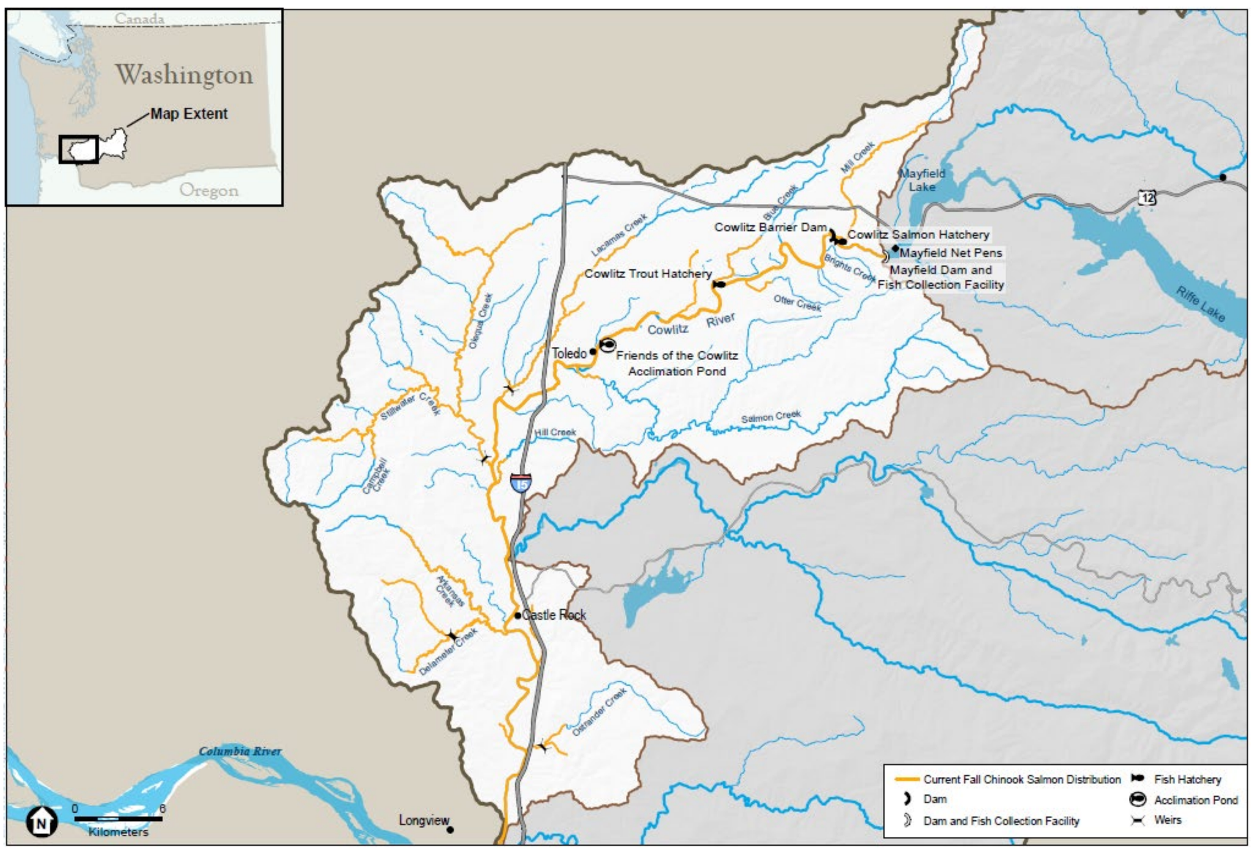


Figure 3.1-1. Distribution of fall Chinook Salmon in the Lower Cowlitz Subbasin, excluding the Coweeman and Toutle rivers.

Table 3.1-1. Estimated mean, minimum, and maximum numbers of all hatchery- and natural-origin fall Chinook Salmon from the Lower Cowlitz Subbasin population that could be accounted for at recovery locations, and percentage of total at that recovery location, 2011-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Origin and Recovery Location	Mean	Minimum	Maximum
Hatchery-origin			
Total Run[1]	20,567	5,222	35,113
Harvest[2]	14,214	2,701	24,218
Ocean harvest	7,518	1,478	14,110
Columbia River harvest	3,424	562	6,737
Lower Cowlitz River harvest	2,931	658	4,997
Upper Cowlitz Subbasin harvest	340	3	938
Total Return to Cowlitz River[3]	9,624	3,182	18,464
Remain in Lower Cowlitz Subbasin	1,086	650	1,879
Return to Cowlitz Salmon Hatchery	5,607	1,876	3,380
Collected for Broodstock	1,739	803	2,264
Transported to Upper Cowlitz Subbasin	3,763	59	9,902
Spawners in Upper Cowlitz Subbasin	2,674	44	6,998
Natural-origin			
Total Run[1]	5,956	4,186	7,526
Harvest[2]	2,867	1,245	3,699
Ocean harvest	1,936	883	2,445
Columbia River harvest	846	323	1,248
Lower Cowlitz River harvest	84	39	125
Upper Cowlitz Subbasin harvest	0	0	0
Total Return to Cowlitz River[3]	3,174	2,245	4,307
Remain in Lower Cowlitz Subbasin	3,090	2,180	4,182
Return to Cowlitz Salmon Hatchery	0	0	0
Collected for Broodstock	0	0	0
Transported to Upper Cowlitz Subbasin	0	0	0
Spawners in Upper Cowlitz Subbasin	0	0	0
Combined Hatchery- and Natural-origin			
Total Run[1]	15,115	5,853	26,299
Harvest[2]	6,732	2,085	12,494
Ocean harvest	2,422	959	7,166
Columbia River harvest	993	341	2,373
Lower Cowlitz River harvest	2,975	697	5,318
Upper Cowlitz Subbasin harvest	342	0	1,284
Total Return to Cowlitz River[3]	11,700	3,025	22,771
Remain in Lower Cowlitz Subbasin	3,627	1,395	6,061
Return to Cowlitz Salmon Hatchery	3,210	1,876	5,689
Collected for Broodstock	1,439	117	2,264
Transported to Upper Cowlitz Subbasin	3,531	1	9,902
Spawners in Upper Cowlitz Subbasin	2,489	1	6,998

[1] Sum of all harvest Mayfield Dam, remaining in the Lower Cowlitz subbasin, and returns to Cowlitz Salmon Hatchery.
[2] Total of harvest in ocean, Columbia River, lower Cowlitz River, and above Mayfield Dam.
[3] Sum of lower Cowlitz River harvest, remaining in the Lower Cowlitz subbasin, and returns to Cowlitz Salmon Hatchery.

3.1.3. Natural Production

3.1.3.1. Abundance

Among the suite of VSP metrics, critical monitoring metrics for salmon management are the numbers of smolts leaving the system and of mature salmon (all ages) that return at maturation and their dispositions, by origin and age (Table 3.1-1). Lower Cowlitz Subbasin fall Chinook Salmon that survive to begin their spawning migration may be harvested in commercial, sport, or tribal fisheries in the ocean, Columbia River, or Cowlitz River. Those escaping harvest may return to Cowlitz Salmon Hatchery or natural spawning grounds, where they may be recovered and counted. They may also die from predation or disease at any time and not be recovered. Monitoring the returns and their dispositions is critical for evaluating population health, productivity, and progress toward recovery. However, these data have only been collected in the Lower Cowlitz Subbasin since improved monitoring was implemented in 2010.

Prior to mass marking of the hatchery salmon in 2011, estimates of natural production from the Lower Cowlitz Subbasin were unreliable because only a small fraction of the hatchery-origin salmon were marked, so we have presented data only since 2011. Since the implementation of mass marking, the estimate of total natural-origin salmon for this population has improved but is still subject to error associated with: (1) spawning or harvest observations in the Lower Cowlitz Subbasin of unmarked fall Chinook Salmon that originated from upstream of Mayfield Dam; (2) collection of unmarked fall Chinook Salmon at Cowlitz Salmon Hatchery that originated from the Lower Cowlitz Subbasin (all natural-origin salmon captured at Cowlitz Salmon Hatchery are assumed to have originated from above Mayfield Dam); and (3) spawning or harvest observations in the Lower Cowlitz Subbasin of unmarked fall Chinook Salmon that originated from outside the Cowlitz Basin.

The minimum recovery goal for the Lower Cowlitz Subbasin fall Chinook Salmon population is an annual abundance of 3,000 natural-origin adults spawning in nature in the Lower Cowlitz Subbasin (LCFRB 2010). From 2011-2017, mean total natural-origin fall Chinook Salmon run size was 5,956 adults and a mean of 3,174 natural-origin adults entered the Cowlitz River (Table 3.1-1).

3.1.3.2. Harvest

Harvest is an important component of the management of Lower Cowlitz Subbasin fall Chinook Salmon and potentially affects population recovery. Both hatchery- and natural-origin Lower Cowlitz Subbasin fall Chinook Salmon contribute to important commercial and recreational fisheries in the Pacific Ocean and lower Columbia River.

From 2011-2017, an estimated mean of 48% of the natural-origin fall Chinook Salmon returning to the Lower Cowlitz Subbasin were harvested (Table 3.1-1; Figures 3.1-2 and 3.1-3). For natural-origin salmon, means of 33% were harvested in the ocean and 14% in the lower Columbia River. Only hatchery-origin salmon are harvested in the Cowlitz Basin, but natural-origin salmon are also caught and suffer a low rate (approximately 7%) of hooking mortality; we estimate that 1% of the total run was lost due to the fishery in the Lower Cowlitz Subbasin.

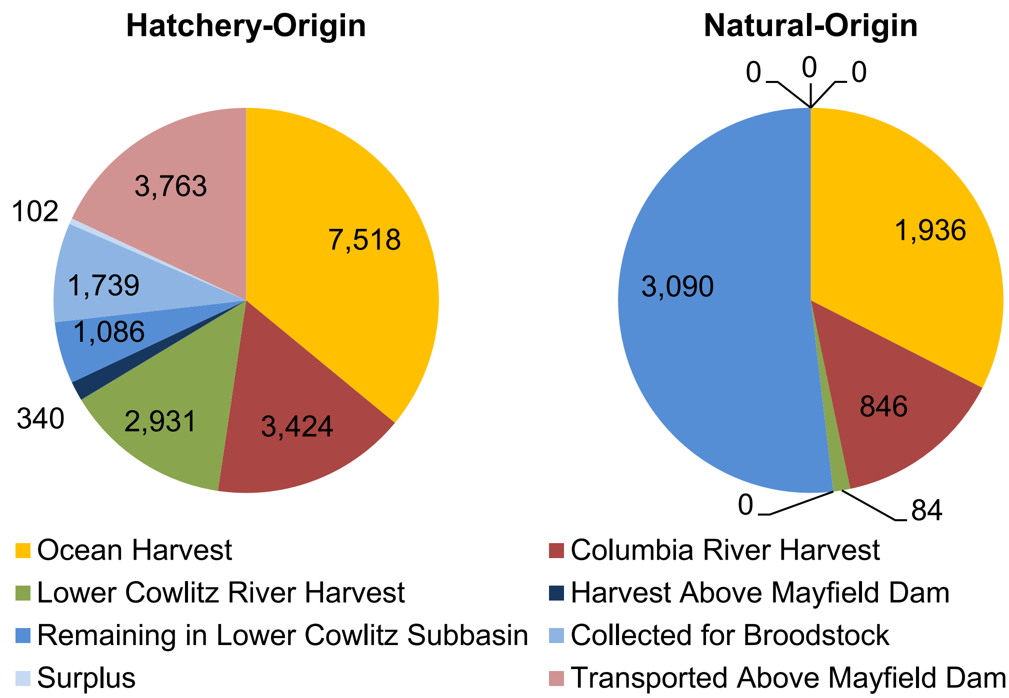


Figure 3.1-2. Estimated mean numbers and proportions of hatchery- and natural-origin Lower Cowlitz Subbasin fall Chinook Salmon caught in ocean, Columbia River, or lower Cowlitz River fisheries, or that were transported above Cowlitz Falls Dam (and were harvested or remained in the Upper Cowlitz Subbasin), 2011-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

3.1.3.3. Disposition

None of the natural-origin salmon collected at Cowlitz Salmon Hatchery were collected for broodstock, as they were considered to have originated from above Mayfield Dam (Table 3.1-1).

Transport to the Tilton River of natural-origin fall Chinook Salmon caught at Cowlitz Salmon Hatchery likely reduces the documented abundance of natural-origin Lower Cowlitz Subbasin fall Chinook Salmon, as well as the actual number spawning in nature in the Lower Cowlitz Subbasin, and their subsequent juvenile production, in the Lower Cowlitz Subbasin. On the other hand, it is also likely that some Tilton Subbasin natural-origin salmon remain in the Lower Cowlitz Subbasin to spawn. No effort is currently conducted to identify the true origin of salmon returning to Cowlitz Salmon Hatchery, so the effect of these adult returns spawning out of location on actual adult natural-origin abundance is uncertain but should be considered in the future to effectively manage populations in both the Lower Cowlitz and Upper Cowlitz subbasins.

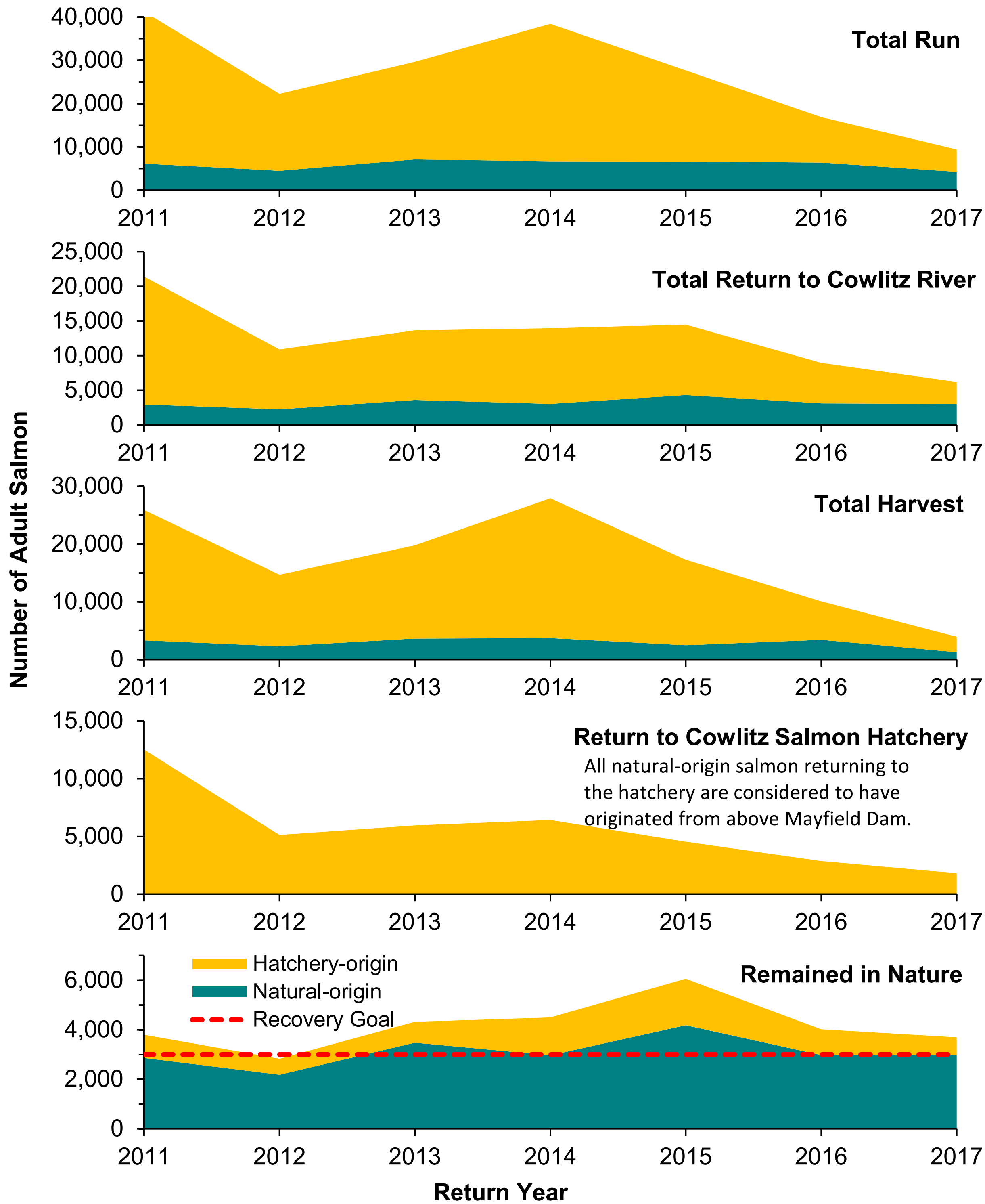


Figure 3.1-3. Estimated total run size for adult hatchery- and natural-origin Lower Cowlitz Subbasin fall Chinook Salmon and the numbers that returned to the Cowlitz River, were harvested, returned to Cowlitz Salmon Hatchery, or remained in nature in the Lower Cowlitz Subbasin, 2011-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

3.1.3.4. Spawning in Nature

The Lower Cowlitz Subbasin fall Chinook Salmon population minimum recovery goal of 3,000 natural-origin salmon spawning in nature was exceeded in 2013 (3,477) and 2015 (4,182) (Figure 3.1-3; Tables 3.1-1 and 3.1-2). From 2011-2017, a mean of 3,090 natural-origin adults (52% of the natural-origin total run) spawned in the Lower Cowlitz Subbasin.

3.1.3.5. Smolt Production

No estimate of fall Chinook Salmon smolt abundance is available for the Lower Cowlitz Subbasin population. A smolt trap is operated on the lower Cowlitz River, but any juveniles captured may be from the Lower Cowlitz or Upper Cowlitz subbasins and may be either fall or spring Chinook Salmon, so the data are confounded. Additionally, production from spawning areas downstream from the smolt trap is unsampled.

3.1.3.6. Natural-origin Survival and Productivity

Survival and productivity are key metrics for monitoring populations. However, productivity has not been calculated and SAR cannot be calculated for the Lower Cowlitz Subbasin fall Chinook Salmon population because smolt abundance estimates are not available. Production of natural-origin juveniles in the Lower Cowlitz Subbasin is not well-documented, as minimal monitoring is conducted. A smolt trap is operated in the mainstem lower Cowlitz River and, while over 100,000 juvenile Chinook Salmon have been captured during the past three years of operation, the relative numbers captured and capture efficiency are low in the large river and the origin of those captured cannot be identified as being from the Lower Cowlitz Subbasin or above Mayfield Dam. Although smolt production could be roughly estimated by using the number of spawners in nature, it would not account for the wide annual variability in egg-to-smolt survival. Additionally, doing so would require more rigorous monitoring of natural spawning in many tributaries and hatchery production, including parameters like age and origin of females spawning in nature, pre-spawn mortality rates, and fecundity estimates by origin and age.

3.1.3.7. Age Composition

Age composition data for natural-origin fall Chinook Salmon from the Lower Cowlitz Subbasin are not available.

Table 3.1-2. Estimated mean, minimum, and maximum hatchery and natural spawning metrics for Lower Cowlitz Subbasin fall Chinook Salmon, 2011-2017 spawn/brood years. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

	2011-2017 Spawn/Brood Years		
Spawning Location, Metric	Mean	Minimum	Maximum
Hatchery			
Adults Collected for Broodstock	1,796	803	2,264
Hatchery-origin	1,739	803	2,264
Natural-origin	47	0	139
Pre-spawn Survival Rate	92%	88%	96%
Adults Spawned	1,711	748	2,162
Hatchery-origin	1,603	748	2,162
Natural-origin	43	0	125
Total Green Eggs	4,690,819	1,707,046	6,087,141
Mean Fecundity	4,810	4,476	5,281
Smolts Released [2]	4,108,772	1,519,271	5,104,829
Green Egg-to-Smolt Survival	82%	79%	86%
Smolt Productivity (smolts / spawner)	1,911	1,723	2,086
Nature			
Spawners	4,176	2,830	6,061
Hatchery-origin	1,086	650	1,879
Natural-origin	3,090	2,180	4,182
Smolts Produced		no data	
Smolt Productivity (smolts / spawner)		not available	

3.1.4. Hatchery Production

Hatchery production metrics must be monitored to ensure that production goals are met, to evaluate the effectiveness of the program, and to understand the magnitude of hatchery influence on the natural population. Key monitoring metrics are the numbers of salmon harvested, collected, and spawned (by origin, age, and sex); smolts released; and adult salmon returning to the Cowlitz River and Cowlitz Salmon Hatchery, as well as remaining in nature in the Cowlitz Basin and elsewhere. Using these data, managers also calculate and monitor smolt-to-adult survival and return rates.

Cowlitz Salmon Hatchery initiated a fall Chinook Salmon hatchery program in 1967 (WDFW 2014). The program was integrated by default because the hatchery-origin fall Chinook Salmon were not 100% marked until the 2011 return year; in addition, because only a fraction of the hatchery-origin salmon was marked at all, the integration rates were unknown. A truly segregated program began in 2011 when the hatchery-origin salmon were 100% adipose fin-clipped and managers could be fairly certain about the origin of the salmon collected for broodstock. The Segregated Hatchery Program for the Lower Cowlitz Subbasin fall Chinook Salmon population currently has a production goal of 2,400,000 smolts.

The current Integrated Hatchery Program was initiated in 2013 with a consistent annual production goal of 1.1 million smolts for Lower Cowlitz Subbasin fall Chinook Salmon. It has a target of 30% of the broodstock being of natural-origin (assumed to be those with an intact adipose fin) but has struggled to reach a meaningful integration rate due to difficulty collecting natural-origin salmon for broodstock - mean pNOB = 0.077 for the 2013-2017 spawn years.

3.1.4.1. Abundance

Based on a maximum combined release of 3.5 million smolts from both hatchery programs and SAR of 0.22%, WDFW (2014) estimated an annual production goal of 7,700 hatchery-origin adults. From 2011-2017, mean total run size was 20,567 hatchery-origin fall Chinook Salmon (Table 3.1-1). Means of 9,624 hatchery-origin fall Chinook Salmon entered the Cowlitz River, 5,607 returned to Cowlitz Salmon Hatchery, and 1,086 remained on the spawning grounds in the Lower Cowlitz Subbasin.

3.1.4.2. Harvest

From 2011-2017, an estimated mean of 69% of the hatchery-origin fall Chinook Salmon returning to the Lower Cowlitz Subbasin were harvested (Table 3.1-1; Figures 3.1-2 and 3.1-3). Of the total hatchery-origin fall Chinook Salmon harvest, means of 53% were harvested in the ocean, 24% in the lower Columbia River, 21% in the lower Cowlitz River, and 2% above Mayfield Dam.

3.1.4.3. Disposition

Hatchery-origin salmon captured at Cowlitz Salmon Hatchery that were not used for broodstock nor transported upstream are considered surplus. From 2011-2017, a mean of 3,865 (65-10,243) hatchery-origin fall Chinook Salmon were collected at Cowlitz Salmon Hatchery that were in excess of broodstock needs. Of those, a mean of 3,763 were released above Mayfield Dam and 102 were donated to food banks.

3.1.4.4. Hatchery Spawning

From 2007-2017, a mean of 5,607 hatchery-origin fall Chinook Salmon returned to Cowlitz Salmon Hatchery and 1,739 were kept for broodstock (Figures 3.1-2 and 3.1-3; Table 3.1-1). Mean pre-spawn survival for hatchery broodstock was 92%, and a mean of 1,603 of those were spawned, 49% of which were females. From 2013-2017, an annual mean of 83 natural-origin adults were captured by WDFW in the Lower Cowlitz Subbasin. Sperm was collected from most males, after which they were released. Some males and all females were taken to Cowlitz Salmon Hatchery for spawning. Gametes were collected from a mean of 76 of those adults.

3.1.4.5. Hatchery Rearing

Hatchery juvenile production for Lower Cowlitz Subbasin fall Chinook Salmon comes from the Integrated and Segregated Hatchery Programs at Cowlitz Salmon Hatchery. From 2011-2017, a mean of 3,027,955 age-1 (sub-yearling) smolts were released annually from Cowlitz Salmon Hatchery (Table 3.1-2).

Prior to 2011, managers could not identify all hatchery-origin salmon, so the numbers of hatchery- and natural-origin salmon spawned are unknown. In 2011 and 2012, the Segregated

Hatchery Program was initiated and only hatchery-origin salmon were used as broodstock. The Integrated Hatchery Program began in 2013, and mean pNOB has been 0.077 through 2017. The natural-origin component of the fall Chinook Salmon Integrated Hatchery Program has come solely from salmon that were captured by netting, hook and line, or snagging in the lower Cowlitz River in order to assert that they truly belong to the Lower Cowlitz Subbasin population. A mean of 10 females, 66 adult males, and 1 jack were collected annually from 2013-2018, and a mean of 74% of the females and 87% of the adult males collected contributed to the F_1 generation. Sperm was collected from most males, after which they were released, and their sperm was transported to Cowlitz Salmon Hatchery, where it was used to fertilize the eggs of hatchery-origin females. Some males and all females were taken to Cowlitz Salmon Hatchery for spawning.

Relying so heavily on males (87%) for the natural-origin contribution is a poor practice for integrating a hatchery population and is discouraged by geneticists because any alleles that were linked to females were less likely to be included in the hatchery population (R. Waples, J. Hard, and P. Moran, NOAA Fisheries, personal communication). However, because of low abundance in recent years (i.e., 2017 and 2018), natural-origin broodstock have been collected from those captured at the hatchery. Prior efforts for broodstock collection resulted in poor PNI values, so this change is a positive one. All hatchery-origin salmon have been visually identifiable since 2011, and we have developed and will implement a plan to mark natural-origin smolts captured at Mayfield Dam. In addition, with the transition to the single Upper Cowlitz Subbasin Integrated Hatchery Program, all future broodstock (both hatchery- and natural-origin) will be collected solely from returns to Cowlitz Salmon Hatchery.

From 2011-2015, a mean of 4,690,819 green eggs were collected from a mean of 967 females at Cowlitz Salmon Hatchery, and mean fecundity was 4,810 green eggs / female (Table 3.1-2). Mean green egg-to-smolt survival was 82%, and a mean of 4,108,722 smolts were released.

3.1.4.6. Hatchery-origin Survival and Productivity

Smolt-to-adult survival and return rates are the key metrics for monitoring hatchery populations. Mean total smolt-to-adult survival rate (all salmon that could be accounted for) and smolt-to-adult return rate (to Cowlitz Salmon Hatchery) for hatchery-origin Lower Cowlitz Subbasin fall Chinook Salmon were 0.306% (0.011-1.955%) and 0.103% (0.006-0.569%), respectively, for the 1977-2011 brood years. TSAR must be $\geq$0.22% to achieve the hatchery return goal of 7,700 adults. While the mean TSAR was well over 0.22%, this target was actually achieved for only 14 of the 35 years from 1977-2011. Mean TSAR was only 0.243% for the last 10 complete brood years (2002-2011) and exceeded 0.22% for only half of those brood years. Similarly, the mean SAR has not achieved the required level for self-sufficiency (0.056%) for 15 of the 35 brood years and for 4 of the most recent 10 brood years. The Cowlitz Basin fall Chinook Salmon Hatchery Program is close to not being self-sufficient.

All of the data are not available to calculate productivity (adult returns/spawner). We will collect all of the data necessary to calculate productivity for the hatchery populations to ensure that they are always exceeding replacement (1), as is expected for hatchery programs.

3.1.4.7. Age Composition

We are able to use the extensive data from CWTs (RMIS) to estimate age composition for hatchery-origin salmon. For brood years 1977–2013, means of 0.02%, 6%, 35%, 51%, 8%, and 0.1% of the fall Chinook Salmon with CWTs were recovered at age-1, age-2, age-3, age-4, age-5, and age-6, respectively.

3.1.5. Proportionate Natural Influence

PNI is a useful metric for monitoring both hatchery and natural populations. Changes in PNI can indicate an increase or decrease in the effect of hatchery-origin salmon on the natural population.

From 2011-2017, mean pHOS for the Lower Cowlitz Subbasin was 0.254 and ranged from 0.194-0.340. Prior to 2013, no natural-origin salmon were used as broodstock, so both pNOB and PNI during that period were equal to 0. The Integrated Hatchery Program began in 2013 and, from 2013-2017, pNOB has ranged from 0.010-0.234 (mean = 0.077). During this period, mean pHOS = 0.260 (0.194-0.340) and PNI has ranged from 0.048-0.546, with a mean of 0.198.

3.1.6. Future Management

The Lower Cowlitz Subbasin fall Chinook Salmon population is designated as a Contributing population for achieving MPG and ESU recovery goals, with a minimum abundance target of 3,000 natural-origin spawners in the lower Cowlitz River. Population viability was rated as Very Low in 2010 (LCFRB 2010), but natural-origin abundance has improved since then (Table 3.1-1). The minimum abundance target was exceeded in 2013 (3,477) and 2015 (4,182), and the most recent (2013-2017) 5-year mean was 3,090 natural-origin adults spawning in nature, so this population appears to have met its minimum natural-origin spawner abundance target of 3,000. This population also met the HSRG standard of pHOS <0.3 in 3 of the 5 years from 2013-2017 (mean pHOS was 0.260). However, because the Integrated Hatchery Program began in only 2013 and has struggled to achieve its integration goal, the resulting mean PNI (0.198) over that period was well below the PNI target of >0.5. As we transition hatchery production to an integrated hatchery program for the Upper Cowlitz Subbasin, pNOB and PNI will increase dramatically, which will benefit the Lower Cowlitz Subbasin fall Chinook Salmon population and the entire Cowlitz Basin population.

3.1.6.1. Goals for Conservation and Recovery

This section describes the metrics for improving both population health and fishing opportunity. Some metrics have a proposed timeline within the period covered by this FHMP, while others will likely not be accomplished until a later date, although progress toward achieving long-term goals should be made.

Progress toward achieving conservation and recovery goals is evaluated through monitoring of standard fisheries management metrics (Table 3.1-3; Appendix A, Full Big Table). The Lower Cowlitz Subbasin fall Chinook Salmon population had an historical abundance of about 24,000 salmon and has a recovery goal of 3,000 natural-origin spawners in nature. In 2010, the abundance and productivity of this population were rated as Very Low (LCFRB 2010). Today, it is on the verge of meeting its minimum recovery goal (Figure 3.1-3; Table 3.1-1).

- **Long-term Goals:** The goal for this Contributing fall Chinook Salmon population is full recovery, which would include, but not be limited to:
    - >3,000 natural-origin adults spawning in nature in the Lower Cowlitz Subbasin (Table 3.1-4).

  - pHOS <0.3 (HSRG 2009).
  - pNOB >0.6 for the Upper Cowlitz Subbasin Integrated Hatchery Program, so that PNI >0.5 (HSRG 2009).
  - Harvestable population of Lower Cowlitz Subbasin natural-origin fall Chinook Salmon.
- **FHMP Goals:** Goals for this program are attainable steps toward population recovery and emphasize natural-origin spawners in nature and hatchery-origin return to Cowlitz Salmon Hatchery as key population metrics for fall Chinook Salmon. The goals for the Lower Cowlitz Subbasin fall Chinook Salmon population for the period covered by this FHMP are:
  - Shift all hatchery production to an Upper Cowlitz Subbasin fall Chinook Salmon Integrated Hatchery Program with maximum total hatchery production of 3.5 million sub-yearling smolts, with:
    - All broodstock collected from those salmon returning to Cowlitz Salmon Hatchery.
    - pNOB >0.6 and all offspring with at least one natural-origin parent.
  - Maintain natural-origin spawner abundance >3,000.
  - Continue monitoring of natural spawning in the Lower Cowlitz Subbasin.
  - Keep pHOS <0.3 in the Lower Cowlitz Subbasin.
  - Increase and improve data collection for monitoring and evaluation of the program, including numbers and age, sex, and origin of all recoveries:
    - Natural smolts produced.
    - Returning to Cowlitz Salmon Hatchery.
    - Retained as broodstock.
    - Transported and released upstream of Mayfield Dam.
    - Hatchery surplus.
    - Hatchery strays to/from outside of the Cowlitz Basin.
    - Actual spawners in lower Cowlitz River habitats.
    - Reduce the abundance of hatchery surplus by increasing hatchery-origin harvest without a concomitant increase in natural-origin exploitation rate.

Table 3.1-3. Current values (5-year mean) and FHMP and long-term (recovery) goals for key monitoring metrics for Lower Cowlitz Subbasin fall Chinook Salmon.

Metric		Current	FHMP Goal	Long-Term Goal
Total Adult Abundance		24,426	23,109	23,109
Hatchery-origin		18,217	15,307	15,307
Natural-origin		6,209	7,802	7,802
Total Adult Abundance to Mouth of Cowlitz River		11,455	10,182	10,182
Hatchery-origin		8,051	5,141	5,141
Natural-origin		3,404	5,042	5,042
Hatchery Broodstock Spawned (adults)		1,722	1,944	1,944
Hatchery-origin		1,662	778	778
Natural-origin		60	1,167	1,167
pNOB (Spawner = spawned)		0.077	≥0.2	1
Adult Spawners in Nature in Lower Cowlitz Subbasin		4,520	4,286	4,286
Hatchery-origin		1,203	1,286	1,286
Natural-origin		3,317	3,000	3,000
pHOS (Spawner = spawners in nature)		0.260	<0.5	0.2
PNI (Spawner)		0.198	0.380	0.667
Smolt Abundance		?	3,800,000	3,800,000
Hatchery-origin (Smolts Released)		2,962,151	3,500,000	3,500,000
Natural-origin		?	300,000	300,000
Smolt Collection Efficiency / Passage Survival		NA	NA	NA
Smolt-to-Adult Survival (to hatchery / spawning grounds; excluding Jacks)				
Hatchery-origin		0.56%	NA	NA
Natural-origin (if unavailable, presumed higher than hatchery-origin)		?	?	?
Mean Age (by Run Year)				
Hatchery-origin		3.6	NA	NA
Natural-origin		?	?	4.6
Precocious Maturation Rate (by Run Year)				
Hatchery-origin	Mini-jacks	6%	2%	2%
	Jacks	35%	10%	10%
Natural-origin	Jacks	6%	5%	5%
Natural-origin Productivity (assume 1% Smolt-to-Adult Return to hatchery)				
Smolts / spawner		?	>100	≥100
Adults + Jacks / spawner		?	>1	≥1
Total Harvest (from all fisheries)		5,785	?	?
Hatchery-origin		2,893	?	?
Natural-origin		2,891	?	?
Harvest (% of total adult return)		40%	?	?
Hatchery-origin		35%	?	?
Natural-origin		47%	?	?

Table 3.1-4. Recovery phase targets for Lower Cowlitz Subbasin fall Chinook Salmon. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Recovery Designation: Contributing
Current Recovery Phase: Local Adaptation

	RECOVERY PHASE				
Target Metric	Preser-vation	Recolon-ization	Local Adaptation	Fully Recovered	Last 5 Years (2013-2017)
Natural Production					
Natural-origin Spawners in Nature	500	1,000	2,000	3,000	3,317
Smolt Abundance (below hatchery)	20,000 [1]	40,000[1]	80,000[1]	120,000[1]	?
Smolt Passage Survival	N/A	N/A	N/A	N/A	N/A
Productivity (5-year mean)	>1	>1	>1	>1	?
Hatchery Production					
Type of Hatchery Program	Int/Seg	Int	Int	Int	Seg/Int
Broodstock to be Collected	1,108	530	530	530	1,849
Integrated Hatchery Program	530	530	530	530	1,688
Hatchery-Origin	265	265	265	265	1,628
Natural-Origin	265	265	265	265	60
Segregated Hatchery Program	578	0	0	0	?
Smolts to be Produced	2,300,000	1,100,000	as needed		2,962,151
Integrated Hatchery Program	1,100,000	1,100,000	as needed		?
Segregated Hatchery Program	1,200,000	0	as needed		?
Total Smolt-to-Adult Survival	0.5%	0.7%	0.8%	1%	0.374%[2]
Proportionate Natural Influence					
pHOS (<)					
Total	0.5	0.4	0.3	0.2	0.260
Integrated Hatchery Program Segregated Hatchery Program	0.1	0.1	0.05	0.05	0.260
pNOB (>)	0.2	0.5	N/A	N/A	0.077
PNI (>)	0.3	0.55	N/A	N/A	0.198
Max % of Natural-Origin Return to Cowlitz Salmon Hatchery Collected for Broodstock	50%	40%	30%	30%	1.2%

[1] Natural-origin smolt abundance target set based on target for natural-origin spawners in nature and SAR = 1%.
[2] Data from RMIS.

3.1.6.2. Management Targets

As part of this FHMP, Tacoma Power will develop and begin to implement a rigorous monitoring program that is focused on evaluating program effectiveness based on regionally accepted VSP parameters. We will focus our monitoring efforts on documenting the total number of hatchery- and natural-origin salmon entering the Cowlitz River, the numbers that are harvested/exploited, the number of hatchery-origin salmon that return to Cowlitz Salmon Hatchery, the numbers of both origins that survive to spawn, their respective pre-spawn mortality rates, and pHOS, as these metrics are critical for achieving recovery. Counts of salmon returning to the hatchery are considered to be reliable numbers, while estimates of harvest, returns to spawning grounds, and spawners in nature have unacceptably wide variances due to low sampling rates, when estimated at all.

High pre-terminal exploitation rates and proportions of hatchery-origin salmon spawning in nature prevent this population from meeting its conservation goals. Unknown factors (perhaps hatchery-origin salmonid predation, *Ceratonova shasta* infection, altered flow regime, etc.) affecting natural-origin survival result in the observed poor natural productivity. To retain harvest benefits and meet conservation goals, the Upper Cowlitz Subbasin Integrated Hatchery Program, with pNOB >0.6 and a production goal of 3.5 million sub-yearling smolts, will be used to supplement natural spawning and support fisheries.

- **Natural Production:** The goal of population restoration is to develop self-sustaining, naturally reproducing populations, and the Settlement Agreement has the additional objective that this population be sufficiently large to be harvestable. Monitoring the Lower Cowlitz Subbasin fall Chinook Salmon population is difficult because we cannot adequately monitor juvenile abundance. Instead, we must use the broader metric of spawner-to-spawner productivity to monitor the benefit of management actions, such as habitat improvement. Other specific monitoring issues are identified below.
    - **Abundance – Natural Spawning:** Recent data indicate that the Lower Cowlitz Subbasin fall Chinook Salmon population may have achieved its minimum recovery goal of 3,000 natural-origin spawners in nature in the Lower Cowlitz Subbasin, even when a mean of 48% of the natural-origin run is lost due to harvest. If exploitation remains at or below the present level, the population may be able to maintain itself above 3,000. Exploitation in the lower Cowlitz River is low, with only 3% of the total harvest-related mortality of natural-origin salmon occurring there and 3% of the natural-origin salmon entering the Cowlitz River being exploited. Two issues may confound accurately estimating abundance of the Lower Cowlitz Subbasin fall Chinook Salmon population. First, the accuracy of spawner abundance estimates are a function of the statistical rigor of spawning ground surveys and may have broad error bounds. Secondly, we cannot determine the origin of unmarked salmon returning to the Cowlitz River; specifically, we cannot distinguish between those from the Lower Cowlitz and Tilton subbasins or any other source of unmarked fall Chinook Salmon. For management purposes, all unmarked/untagged (assumed to be natural-origin) salmon that are captured at Cowlitz Salmon Hatchery are considered to be from the Tilton Subbasin because they have swum past the spawning reaches in the lower Cowlitz River. Likewise, all natural-origin salmon remaining in the Lower Cowlitz Subbasin are assumed to have originated there. While it is likely that this is an accurate characterization for most salmon, we cannot know for certain; it is very likely that some Tilton Subbasin salmon remain below Cowlitz Salmon Hatchery and that some of those captured at the hatchery were from the Lower Cowlitz Subbasin (and simply wandered a little too far upstream while exploring suitable spawning

areas) or strayed from some other location. These scenarios compromise our ability to accurately evaluate recovery but they also provide a source of genetic diversity to the respective populations. However, if this straying becomes excessive, it may preclude the ability of the respective populations to differentiate and adapt to local conditions.

- **Smolts Produced in Nature:** Natural-origin smolt production from the Lower Cowlitz Subbasin is unknown and cannot be estimated at present. Smolt monitoring in the Lower Cowlitz Subbasin is conducted using a screw trap in the mainstem Cowlitz River and is difficult due to the large size of the river. Additionally, the presence of fall Chinook Salmon smolts from the Tilton Subbasin and spring Chinook Salmon smolts from the Lower Cowlitz and Upper Cowlitz subbasins, which cannot be discerned from those from the Lower Cowlitz Subbasin, further confounds these estimates. We will increase collection efficiency at Cowlitz Falls Dam and improve survival and our estimation of collection efficiency at Mayfield Dam, which will help to distinguish production from the Lower Cowlitz Subbasin.
- **Smolt-to-Adult Survival:** Because smolt abundance is not estimated and returns are not documented by age, SAR cannot be estimated. This metric is important but less critical for monitoring natural populations than for hatchery populations. We will monitor this index as the means to do so become available, through our M&E Program.
- **Productivity (Recruits/Spawner):** Productivity (mature natural-origin F_1 recruits / F_0 spawner) is the primary metric for monitoring natural populations, so collection of the necessary data is critical. However, mature returns are not documented by age, so this metric cannot be calculated. We will monitor this index as the data become available through our M&E Program.
- **Age Composition:** In ISIT, age classes are only characterized as "adults (>49 cm)" or "jacks (<49 cm)," and these data are only available for the returns to Cowlitz Salmon Hatchery; all other abundance data in ISIT (e.g., harvest, spawners in nature, or hatchery broodstock) provide no information about the ages of the salmon included in the number provided. For natural-origin salmon, we have only the incomplete ISIT data, so we can only provide percentages of "jacks" and "adults" (and only for those that returned in 2007-2015), as we cannot separate the age-4, age-5, and age-6 adults. We will improve our monitoring of this metric by collecting the necessary samples and data so that we can estimate the contribution of each age to the mature returns.
- **Habitat:** Activities by Tacoma Power to protect and enhance habitat in the Lower Cowlitz Subbasin are expected to benefit smolt production and the subsequent return of natural-origin salmon. However, it is difficult to monitor these benefits due to a large number of confounding factors. Because we cannot estimate smolt production from the Lower Cowlitz Subbasin, we cannot directly evaluate the effectiveness of those efforts.

- **Hatchery Production:** Recently, the numbers of hatchery-origin salmon that return to Cowlitz Salmon Hatchery have not been sufficient to support the program. Strategies will be developed, tested, and evaluated to improve the survival and subsequent returns of the hatchery-origin salmon.

  We will shift the focus of hatchery production from combined Segregated and Integrated Hatchery Programs for the Lower Cowlitz Subbasin to a single Integrated

Hatchery Program for supplementing natural production and harvest in the Tilton Subbasin, as well as to maintain support for fisheries both below and above Mayfield Dam. Hatchery production will remain at 3.5 million smolts, and any shortfall in Upper Cowlitz Subbasin Integrated Hatchery Program production will be made up using HxH crosses (Segregated Hatchery Program), which will be uniquely marked and used only for harvest, unless absolutely necessary. We will also use best management practices for well-managed hatchery programs as a critical component to our strategy (Piper et al. 1982; IHOT 1995; Flagg and Nash 1999; Wedemeyer 2002; Williams et al. 2003; Campton 2004; Galbreath et al. 2008; HSRG 2004, 2009, 2017).

- **Abundance:** The Cowlitz Salmon Hatchery fall Chinook Salmon Program is expected to produce an annual run of 7,700 adult hatchery-origin fall Chinook Salmon (WDFW 2014). We will focus our monitoring of hatchery-origin abundance on the numbers that are harvested and that return to the Cowlitz River and to Cowlitz Salmon Hatchery (by age), which are critical for calculating SAR and TSAR, as well as the number that remain to spawn in nature, which are used for pHOS and PNI calculations.
- **Broodstock Collection and Spawning:** A mean of 1,796 adult fall Chinook Salmon were collected for hatchery broodstock at Cowlitz Salmon Hatchery each year from 2011-2017, and 1,711 have been spawned. Of the hatchery broodstock, a mean of 1,739 and 1,603 hatchery-origin adults were collected and spawned, respectively. The remaining 3% of the adults that were collected and 9% that were spawned were natural-origin adults that were captured in the lower Cowlitz River. In the future, all broodstock for the new Upper Cowlitz Subbasin Fall Chinook Salmon Integrated Hatchery Program will be collected from salmon returning to Cowlitz Salmon Hatchery, and we will ensure that both male and female natural-origin genotypes are incorporated in approximately equal numbers into the broodstock. Additionally, at least 50% of the broodstock will be of natural-origin, and all crosses will include at least one natural-origin parent to maximize the natural influence on the hatchery population and the entire Cowlitz Basin fall Chinook Salmon population. Transferring the hatchery production to the Upper Cowlitz Subbasin Integrated Hatchery Program will make it easier to achieve the hatchery smolt production targets and integration rates, as we can collect all broodstock from those salmon captured at the hatchery.
- **Strays and Spawning in Nature:** Only about 5% of the total hatchery-origin run, and about 8% of the hatchery-origin run entering the Cowlitz River, are recovered on the natural spawning grounds. This is likely a low estimate, based only on hatchery-origin salmon being identified as having spawned in monitored reaches in the Lower Cowlitz Subbasin and when visibility is sufficient for observations and carcass recovery. Additionally, this is not a complete estimate of straying because it specifically does not include salmon recovered at locations outside of the Cowlitz Basin. Examining CWT data for strays outside of the Cowlitz Basin will improve rigor for estimating stray rates and our understanding of the biology and management of these salmon.
- **Surplus:** A surplus of hatchery-origin salmon returning to the Cowlitz River can affect the viability of the natural-origin population if a sufficient number of them remain to spawn in nature and increase pHOS. Our goal is to maximize the harvest of hatchery-origin salmon and to use any that return to the hatchery for improving Cowlitz Basin populations.
- **Smolt Production:** Fall Chinook Salmon hatchery-origin smolts are reared at

Cowlitz Salmon Hatchery. Smolts are targeted for release as age-1 sub-yearlings in May or June and at a mean weight of 5.7 g. We want to release smolts that perform as well as possible in nature, so we will develop, test, and evaluate different rearing and release strategies to develop an optimum strategy for this population.

- **Smolt-to-Adult Survival and Productivity:** SAR is the primary metric for monitoring hatchery populations, especially those for which return abundance is lower than expected. However, because smolt abundance is not estimated and returns are not documented by age, SAR cannot be estimated. To support calculations of SAR, estimates of returns of hatchery-origin salmon by age class are needed. Additional data needs include the rate of precocious maturation and the sex ratio of hatchery-origin salmon by age class. We will monitor this index as the means to do so become available, through our M&E Program.

  Population productivity (number of F_1 generation recruits that survive to spawn for each F_0 generation spawner) is the primary monitoring metric for any population, especially natural populations. This metric is of less importance for monitoring hatchery populations, where survival to the smolt stage is unnaturally high, but is still useful. Productivity has not been calculated, but we will begin to do so and monitor this critical metric over time through our M&E Program.

- **Age Composition:** In ISIT, age classes are only characterized as “adults (>49 cm)” or “jacks (<49 cm),” and these data are only available for the returns to Cowlitz Salmon Hatchery; all other abundance data in ISIT (e.g., harvest, spawners in nature, or hatchery broodstock) provide no information about the ages of the salmon included in the number provided. However, we can use the data from CWTs in the RMIS database (www.rmis.org), which provides reliable age composition data for the tagged hatchery-origin salmon for brood years 1977-2011 (later brood years have not completely returned). For natural-origin salmon, we have only the incomplete ISIT data, so we can only provide percentages of “jacks” and “adults” (and only for those that returned in 2007-2015), as we cannot separate the age-4, age-5, and age-6 adults.

  Given the high proportion of hatchery-origin mini-jacks (age-2) and both hatchery- and natural-origin jacks, and the potential for hatchery production to increase these rates in both the hatchery and in nature, we will more carefully monitor this trend. Collection of samples (scales and tags) to estimate the age of both hatchery- and natural-origin salmon will be done regularly at all collection sites to better characterize each cohort and more clearly understand the age composition of these salmon and the factors influencing their age at maturity. To reverse this trend in hatchery-origin salmon maturing precociously, we will evaluate our hatchery rearing practices. Large smolts tend to mature at a younger age, so we will develop, implement, and evaluate alternative strategies to decrease the abundance of mini-jacks and jacks, and increase the abundance of the older age-5 and age-6 adults.

- **Harvest:** Harvest of natural-origin salmon reduces the abundance of natural-origin salmon that return to the spawning grounds and is one of the factors that constrains the ability of managers to meet pHOS and, therefore, PNI targets for this Contributing population. Conversely, harvest of hatchery-origin salmon would ideally be higher to reduce pHOS. While harvest management of the Lower Cowlitz Subbasin fall Chinook Salmon population should focus on increasing the harvest of hatchery-origin salmon, especially in the lower Cowlitz River, doing so is likely to also result in an increase in the natural-origin catch and subsequent mortality (exploitation). Identifying a means to increase harvest of hatchery-origin salmon while also maintaining or increasing existing escapement of natural-origin salmon remains a challenge. Hatchery-origin harvest will be monitored using the CWT recovery and sampling rate data in RMIS and robust creel surveys.

- **Proportionate Natural Influence:** We will manage this population to maximize the total numbers of spawners in nature (HSRG guidelines), natural smolt production, and survival but also with the goal of reducing the effect of hatchery-origin salmon on the natural population. We propose to increase the influence of the natural environment on the Lower Cowlitz Subbasin fall Chinook Salmon population in three ways:
    - Eliminate the Segregated Hatchery Program but increase the size of the Integrated Hatchery Program to maintain total hatchery production at the current level of 3.5 million smolts and focus on supplementing natural production in the Tilton Subbasin.
    - Increase natural influence on hatchery-origin salmon by continuing to increase the percentage of natural-origin salmon used as broodstock (pNOB) for the new Upper Cowlitz (Tilton) Subbasin Integrated Hatchery Program, which will have pNOB >0.5 and all offspring will have at least one natural-origin parent.
    - Explore means of decreasing pHOS by increased harvest of hatchery-origin salmon and/or improved return rates to Cowlitz Salmon Hatchery.

  Under the Upper Cowlitz Subbasin Integrated Hatchery Program, more natural-origin salmon will be incorporated as broodstock, so PNI should increase, depending on pHOS. We will meet or exceed the HSRG guidelines by maintaining pHOS <0.3 and pNOB >0.5, which will keep PNI >0.62 (HSRG 2009).

3.1.6.3. Monitoring and Evaluation (M&E) and Research

<u>Baseline Monitoring</u>

Monitoring and evaluation needs of the Upper Cowlitz Subbasin fall Chinook Salmon population are similar to other populations in the basin and include spawning ground surveys, accurate counts of hatchery releases and returns of both hatchery- and natural-origin salmon, additional marking, and evaluation of alternative management and hatchery rearing strategies. To support recovery, we will need rigorous monitoring programs that will allow for estimation, with greater confidence, of population abundance when the population is self-sufficient, as well as to identify ways to improve survival. Improvement is needed to monitor and evaluate the recovery status and trends that are specific to this population. We will increase monitoring rigor for VSP and hatchery metrics, including, but not limited to:

- Natural-origin smolt abundance.
- Hatchery- and natural-origin age at maturity (age of salmon from all recovery locations).
- Natural-origin productivity.
- Smolt-to-adult survival and return rates.
- Estimates of total mature salmon abundance, by origin, age, and sex.
- Estimates of numbers of spawners in nature, strays, and pre-spawn mortalities, by origin, sex, and age.
- Returns to Cowlitz Salmon Hatchery, by origin, age, and sex.

- Improved harvest estimates of both hatchery- and natural-origin salmon, by age.
- Numbers of salmon collected for broodstock and spawned, by origin, age, and sex.
- Fecundity and fertility rates, survival rates between age classes, disease prevalence, and numbers of smolts produced at Cowlitz Salmon Hatchery.

Directed Studies

Directed studies are designed to diagnose and solve specific problems associated with achieving FHMP goals and to fill management needs and information gaps in the Big Table (Table 3.1-3; Appendix A). Important areas of study for the Upper Cowlitz Subbasin fall Chinook Salmon population include the following:

- **Spawning Ground Surveys -** Scales, marks, and tags, numbers of actual spawners, pHOS, pre-spawn mortality rates, genetics, spatial distribution (upper extent), and reach-specific adult densities.
- **Freshwater Life History and Natural-origin Juvenile Rearing Studies -** Abundance and life stage-specific survival rates, available habitat, habitat-specific (run/riffle/pool) densities, and carrying capacity.
- **In-river Migratory Survival and Behavior** - Survival of migrating juveniles and movement timing and rates.
- **Hatchery Supplementation Experiments** - Assessing the impact of returning hatchery-origin adults on natural-origin salmon.
- **Hatchery Practices** - Broodstock collection and spawning protocols, growth rate in hatchery, and examining smolt size and timing of release.

3.1.7. Summary

- The Lower Cowlitz Subbasin population is the only remaining population of the two original fall Chinook Salmon populations. The Recovery Plan intends for the distinct populations in the Lower Cowlitz and Upper Cowlitz subbasins to me managed separately moving forward.
- We will focus on recovery of the Tilton Subbasin portion of the entire Upper Cowlitz Subbasin population in order to avoid confounding M&E efforts for recovery of the spring Chinook Salmon populations above Cowlitz Falls Dam.
- Natural-origin spawner abundance in the Lower Cowlitz Subbasin is approaching the minimum recovery abundance goal.
- Mean pHOS has remained below the HSRG recommended maximum but pNOB and PNI remain well below their goals (but are increasing).
- A specific Lower Cowlitz Subbasin fall Chinook Salmon Segregated Hatchery Program was initiated in 2011 and the Integrated Hatchery Program was initiated in 2013.
- We will transition to a single Upper Cowlitz Subbasin Integrated Hatchery Program that will:
    - Produce 3.5 million sub-yearling smolts.
    - Supplement natural production in the Tilton Subbasin

  - Support fisheries both below and above Mayfield Dam.
- Collect all natural-origin broodstock from returns to Cowlitz Salmon Hatchery. Changes to monitoring rigor for VSP metrics are needed to evaluate recovery status and trends, including, but not limited to:
  - Hatchery- and natural-origin smolt numbers.
  - Estimates of total run size by origin, age, and sex.
  - Harvest estimates of both hatchery- and natural-origin salmon, by age.
  - Estimates of numbers of spawners in nature, strays, and pre-spawn mortalities, by origin, sex, and age.
  - Returns to Cowlitz Salmon Hatchery by origin, age, and sex.

Intentionally blank page

Population: Upper Cowlitz Subbasin Fall Chinook Salmon
Oncorhynchus tshawytscha

ESA Listing

Status:	Threatened Listed in 2005, reaffirmed in 2011 and 2016
Evolutionarily Significant Unit:	Lower Columbia River Chinook Salmon
Major Population Group:	Cascade Chinook Salmon
Recovery Region:	Lower Columbia River Salmon
Population Recovery Designation:	Stabilizing
Population Viability Rating:	
Baseline	Very Low
Objective	Very Low
Recovery Target:	No recovery target was set for Stabilizing populations. We propose a recovery target of 3,000 natural-origin adults spawning in nature, 1,000 in each of the Cispus, upper Cowlitz, and Tilton subbasins.
Current Recovery Phase:	Local Adaptation
Current Hatchery Program(s):	None
Proposed Hatchery Program(s):	Integrated Hatchery Program of 3.5 million sub-yearling (age-1) smolts

3.2. Fall Chinook Salmon: Upper Cowlitz Subbasin Population

3.2.1. Purpose

This section describes the current status of the Upper Cowlitz Subbasin fall Chinook Salmon population, based on available data. For management purposes, fall Chinook Salmon are currently only being reintroduced into the Tilton River and not the Cispus and upper Cowlitz rivers. For the sake of clarity, specificity, and to reduce confusion among other species for which there are separate populations in the Tilton and Upper Cowlitz subbasins, we will hereafter refer to this as the Tilton Subbasin population (Figure 3.2-1). The FHMP identifies the VSP metrics needed to evaluate the status of this population with regard to recovery under ESA guidelines. Where appropriate, we propose changes to both hatchery and monitoring programs to facilitate progress toward population recovery and our evaluation of that progress. During the period covered by this FHMP, we will use a single Integrated Hatchery Program to produce 3.5 million sub-yearling (age-1) smolts to supplement the Tilton Subbasin population and provide fisheries both below Mayfield Dam and in the Tilton River. We will continue to evaluate the hatchery program and fisheries management and make refinements or adjustments, as described in this FHMP, to effectively supplement and manage the Tilton Subbasin fall Chinook Salmon population.

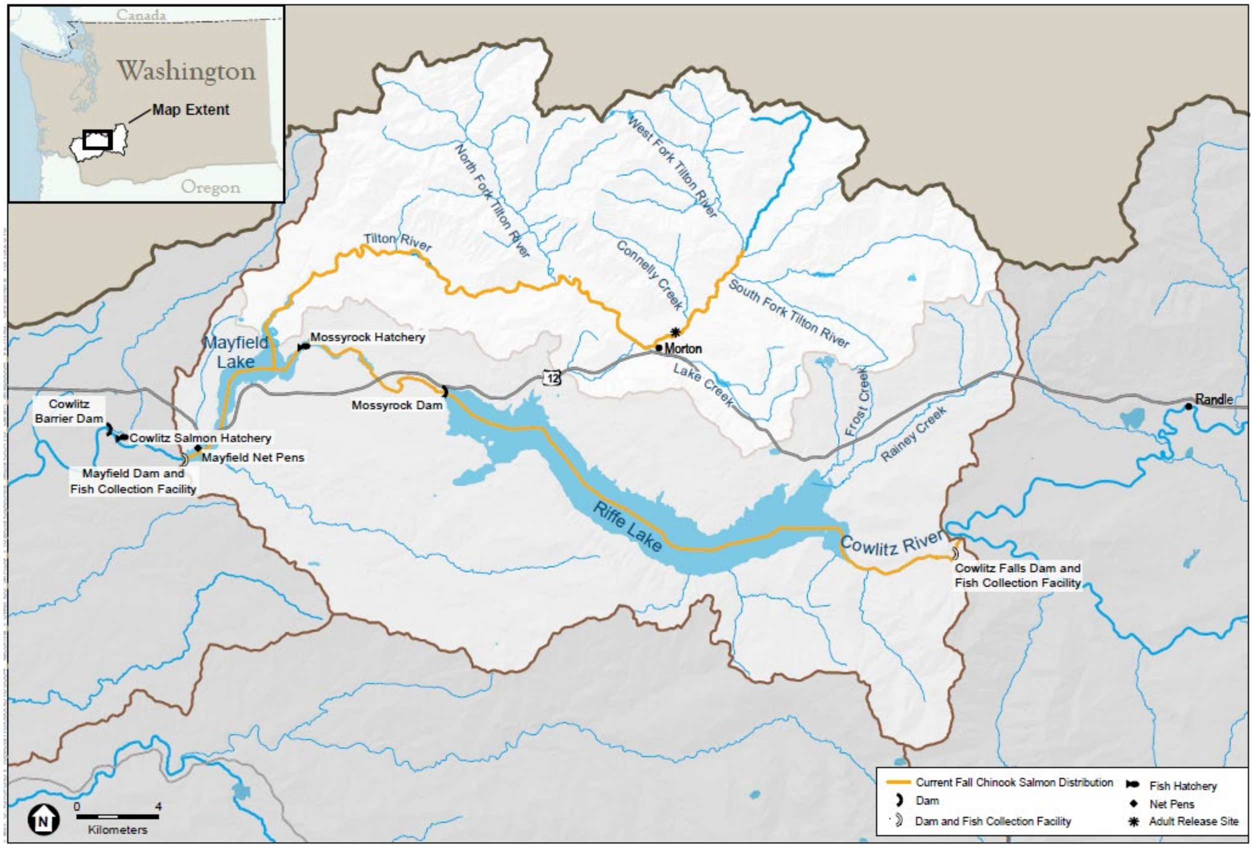


Figure 3.2-1. Distribution of fall Chinook Salmon in the Tilton Subbasin.

3.2.2. Population Description

The Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan (LCFRB 2010) delineates a demographically independent fall Chinook Salmon population above Mayfield Dam, comprising the Cispus, Upper Cowlitz, and Tilton subbasins. Currently, and for the near term, the Upper Cowlitz Subbasin population is found only in the Tilton Subbasin, which is the focus of this section, and is comprised of all hatchery- and natural-origin fall Chinook Salmon transported and released above Mayfield Dam (LCFRB 2010).

After construction of Mayfield Dam blocked access, adult fall Chinook Salmon were not transported upstream from 1976 until 1996, extirpating them from habitats above the dam for 20 years (Figure 3.2-2). However, it is likely that the persisting Lower Cowlitz Subbasin and hatchery populations absorbed the adult salmon returning from the Upper Cowlitz Subbasin, resulting in an aggregated population that replaced the original populations. Beginning in1997, an inconsistent number of adults from this aggregated population returning to the hatchery trap have been transported to the Tilton River, as well as to the Cispus and upper Cowlitz rivers (2010-2016). In addition, the Lower Cowlitz Subbasin population has been incorporated into an Integrated Hatchery Program, which serves as the founding stock for ongoing restoration of the Tilton Subbasin fall Chinook Salmon population (WDFW 2014b).

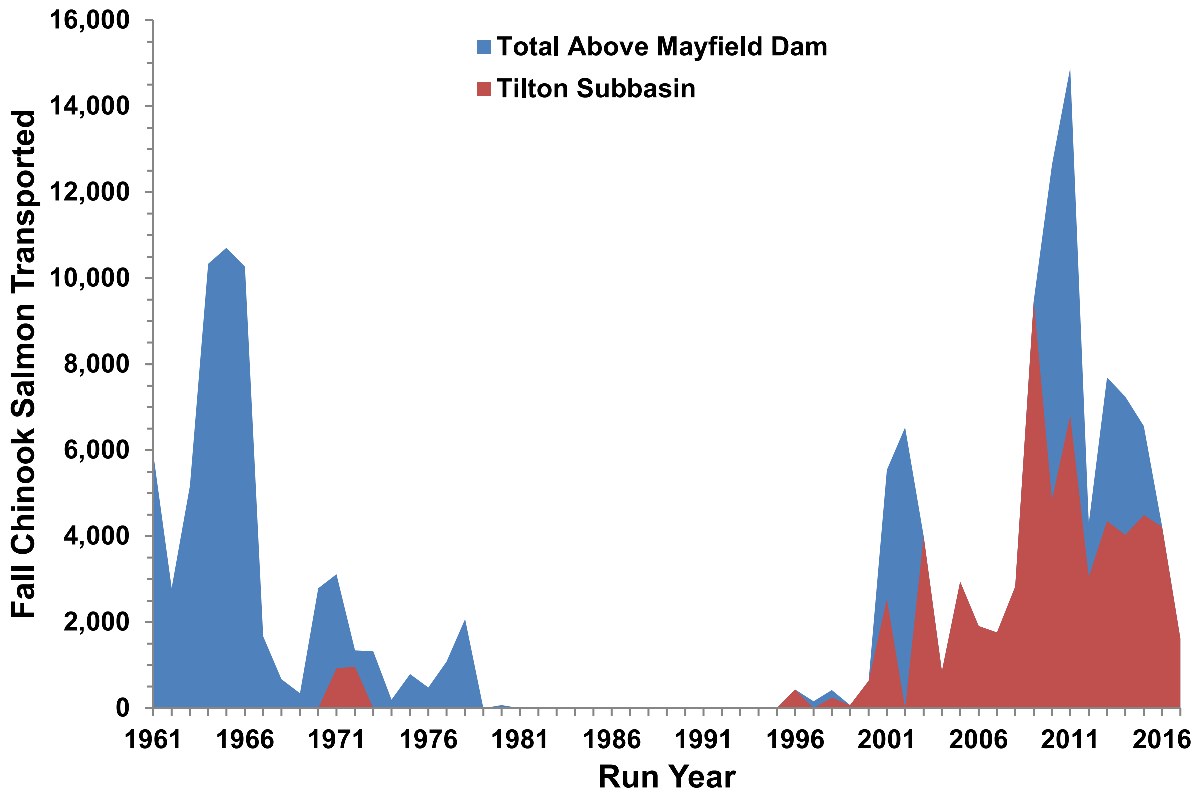


Figure 3.2-2. Total number of fall Chinook Salmon transported above Mayfield Dam and specifically to the Tilton Subbasin, 1961-2017. Note: specific destination of the salmon was not documented in all years. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

The Tilton Subbasin fall Chinook Salmon population was found to be “Depressed” (WDFW 2018) and, as part of the lower Columbia River ESU, was listed as threatened under the ESA in 2005, and reaffirmed in 2011 and 2016. With a current baseline viability rating of Very Low, and its classification as a Stabilizing population for recovery of the lower Columbia River ESU, recovery goals for this population have not been set (WDFW and LCFRB 2016). Herein, we propose a level of 3,000 natural-origin adults spawning in nature as a target recovery goal for the Upper Cowlitz Subbasin - 1,000 for each of the Cispus, upper Cowlitz, and Tilton rivers.

3.2.3. Natural Production

3.2.3.1. Abundance

Two critical monitoring metrics for salmon management are the numbers that return at maturation and their disposition, especially those that spawn in nature (Figures 3.2-3 and 3.2-4; Table 3.2-1). Tilton Subbasin fall Chinook Salmon that survive to begin their spawning migration may be harvested in commercial, sport, or tribal fisheries in the ocean, Columbia River, or Cowlitz Basin. Those escaping harvest may return to Cowlitz Salmon Hatchery or the natural spawning grounds, where they may be recovered and counted. They may also die from predation or disease at any time and not be recovered. Monitoring these dispositions allows us to evaluate population health, productivity, and progress toward recovery, but not all of these data, which are critical to monitoring the Tilton Subbasin fall Chinook Salmon population, have been collected for each year, making population trends difficult to discern at this time.

Although the total number of adult salmon transported and released in the Tilton Subbasin is accurately and precisely known, no spawning ground surveys are conducted. Therefore, we can only roughly estimate spawners by simply using the numbers of hatchery- and natural-origin adults transported multiplied by a standard survival rate, which does not reflect inter-annual variability.

Additionally, estimates of total natural-origin salmon returning to the subbasin have been subject to error. Prior to mass marking of the hatchery salmon in 2011, estimates of natural production from the Lower Cowlitz Subbasin were unreliable because only a small fraction of the hatchery-origin salmon were marked, so we have presented data only since 2011. Since the implementation of mass marking, the estimate of total natural-origin salmon for this population has improved but is still subject to error associated with: (1) spawning or harvest observations in the Lower Cowlitz Subbasin of unmarked fall Chinook Salmon that originated from upstream of Mayfield Dam; (2) collection of unmarked fall Chinook Salmon at Cowlitz Salmon Hatchery that originated from the Lower Cowlitz Subbasin (all natural-origin salmon captured at Cowlitz Salmon Hatchery are assumed to have originated from above Mayfield Dam); and (3) spawning or harvest observations in the Lower Cowlitz Subbasin of unmarked fall Chinook Salmon that originated from outside the Cowlitz Basin.

Abundance of the Tilton Subbasin population is largely determined by the number of adults that are transported above Mayfield Dam and our estimate of those that survive to spawn, and the number of resulting progeny that are captured at Mayfield Dam, transported to the lower Cowlitz River, and subsequently return as natural-origin adults. From 2011-2017, a mean of 2,677 adult natural-origin salmon were transported and released above Mayfield Dam (Table 3.2-1). Of those, a mean of 1,173 natural-origin fall Chinook Salmon were released into the Tilton Subbasin and 4 were released above Cowlitz Falls Dam.

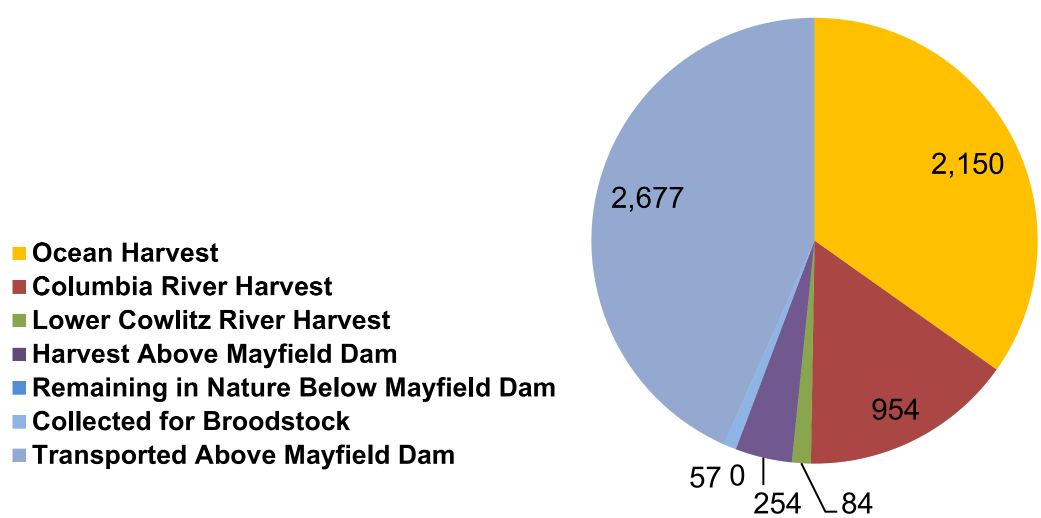


Figure 3.2-3. Estimated mean numbers and proportions of natural-origin Tilton Subbasin fall Chinook Salmon caught in ocean, Columbia River, or lower Cowlitz River fisheries, or that returned to Cowlitz Salmon Hatchery (and were collected for broodstock or were transported to the Tilton Subbasin from 2011-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

3.2.3.2. Harvest

Harvest is an important component of the management of Tilton Subbasin fall Chinook Salmon and has great potential for impacting population recovery. Natural-origin salmon contribute to important commercial and recreational fisheries in the Pacific Ocean and lower Columbia River. They are not targeted in Cowlitz Basin fisheries but are caught and suffer a low rate (approximately 7%) of hooking mortality. From 2011-2017, a mean of 58% of the natural-origin run was harvested in all fisheries combined (Figure 3.2-3). Means of 37% and 16% of the run were harvested in the ocean and lower Columbia River, respectively, while means of 2% and 4% suffered hooking mortality fisheries in the lower Cowlitz River and above Mayfield Dam, respectively.

3.2.3.3. Disposition

No effort is currently conducted to identify the true origin of natural-origin salmon returning to Cowlitz Salmon Hatchery, so all natural-origin returns to the hatchery are assumed to have originated from the Tilton Subbasin and are transported upstream of Mayfield Dam. For the 2011-2017 run years, a mean of 2,677 natural-origin Tilton Subbasin fall Chinook Salmon were transported and released upstream of Mayfield Dam (Figures 3.2-3 and 3.2-4; Table 3.2-1).

3.2.3.4. Spawning in Nature

Because the Tilton (Upper Cowlitz) Subbasin fall Chinook Salmon population is classified as Stabilizing for recovery of the lower Columbia River ESU, no population recovery goal has been established for the abundance of natural-origin spawners in nature (LCFRB 2010). However, we are proposing a recovery target of 1,000 natural-origin adults spawning in nature in each of the Cispus, upper Cowlitz, and Tilton drainages. Adults were transported above Mayfield Dam from 1961-1975, which resumed in 1997 and continues through present day.

All natural-origin fall Chinook Salmon returns to Cowlitz Salmon Hatchery are assumed to have originated from the Tilton Subbasin, but some may originate from the Lower Cowlitz Subbasin or include strays from outside the basin. Transport to the Tilton Subbasin of natural-origin fall Chinook Salmon caught at Cowlitz Salmon Hatchery likely reduces the abundance of natural-origin Lower Cowlitz Subbasin fall Chinook Salmon, as well as the actual number spawning in nature, and their subsequent juvenile production, in the lower Cowlitz River. On the other hand, it is also likely that some Tilton Subbasin natural-origin salmon remain in the Lower Cowlitz Subbasin to spawn. The effect that this spawning out of location has on natural-origin adult abundance is uncertain but should be considered in the future to facilitate effective management of populations in both the Lower Cowlitz and Tilton subbasins.

Table 3.2-1. Estimated mean, minimum, and maximum numbers of all hatchery- and natural-origin adult fall Chinook Salmon from the Tilton Subbasin population that could be accounted for, and percentage of total at that recovery location, 2011-2017. Note: there was no hatchery program dedicated to supplementing the Tilton Subbasin. Data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Origin and Recovery Location	Mean	Minimum	Maximum
Hatchery-origin			
Total Run[1]			
Harvest[2]			
Ocean harvest			
Columbia River harvest	No hatchery programs are dedicated to supplementing the fall Chinook Salmon populati above Mayfield Dam		
Lower Cowlitz River harvest			
Upper Cowlitz Subbasin harvest			
Total Return to Cowlitz River[3]			
Remain in Lower Cowlitz Subbasin			
Return to Cowlitz Salmon Hatchery			
Collected for Broodstock			
Transported Above Mayfield Dam	3,763	59	9,902
Spawners Above Mayfield Dam[4]	2,674	44	6,998
Natural-origin			
Total Run[1]	5,943	3,853	7,141
Harvest[2]	3,424	2,056	5,051
Ocean harvest	2,170	1,403	3,207
Columbia River harvest	944	513	1,564
Lower Cowlitz River harvest	94	62	154
Upper Cowlitz Subbasin harvest	216	79	332
Total Return to Cowlitz River[3]	2,830	1,938	3,534
Remain in Lower Cowlitz Subbasin	0	0	0
Return to Cowlitz Salmon Hatchery	2,735	1,876	3,380
Collected for Broodstock	57	0	396
Transported Above Mayfield Dam	2,677	1,478	3,380
Spawners Above Mayfield Dam[4]	1,925	1,100	2,447
Combined Hatchery- and Natural-origin			
Total Run[1]	5,943	3,853	7,141
Harvest[2]	3,424	2,056	5,051
Ocean harvest	2,170	1,403	3,207
Columbia River harvest	944	513	1,564
Lower Cowlitz River harvest	94	62	154
Upper Cowlitz Subbasin harvest	216	79	332
Total Return to Cowlitz River[3]	2,830	1,938	3,534
Remain in Lower Cowlitz Subbasin	0	0	0
Return to Cowlitz Salmon Hatchery	2,735	1,876	3,380
Collected for Broodstock	57	0	396
Transported Above Mayfield Dam	5,351	1,522	10,304
Spawners Above Mayfield Dam[4]	4,600	1,144	9,335

[1] Sum of all harvest Mayfield Dam, remaining in the Lower Cowlitz Subbasin, and returns to Cowlitz Salmon Hatchery.
[2] Total of harvest in ocean, Columbia River, lower Cowlitz River, and above Mayfield Dam.
[3] Sum of lower Cowlitz River harvest, remaining in the Lower Cowlitz Subbasin, and returns to Cowlitz Salmon Hatchery.
[4] Estimated by subtracting the estimated harvest loss and multiplying by standard fallback (12%) and pre-spawn mortality (10%) rates from the numbers transported.

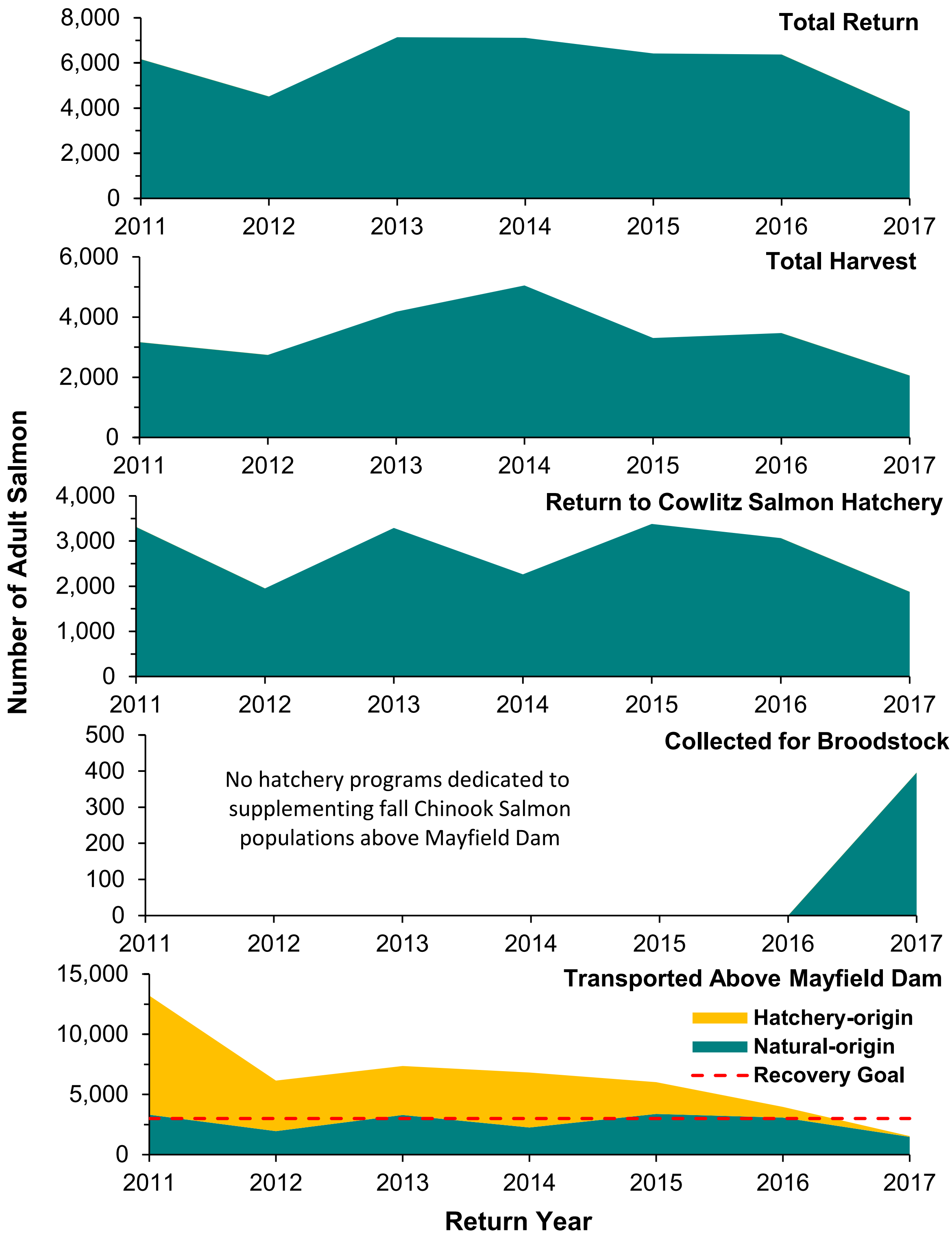


Figure 3.2-4. Estimated total run size for natural-origin Tilton Subbasin fall Chinook Salmon and the numbers that were harvested, returned to Cowlitz Salmon Hatchery, were collected for broodstock, or were transported to the Tilton River, 2010-2017 return years. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

3.2.3.5. Smolt Production

From 2013-2017, a mean of 65,859 juvenile fall Chinook Salmon were captured at the Mayfield Dam Juvenile Collection Facility, which captures juveniles from the Tilton Subbasin. Of those, a mean of 61,132 (92.8%) were age-1 (sub-yearlings) and 4,727 (7.2%) were age-2 (yearlings).

From 2010-2015, a mean of 3,983 fall Chinook Salmon adults were also released above Cowlitz Falls Dam (only 11 fall Chinook Salmon adults were released above Cowlitz Falls Dam in 2016). However, during those same years, a mean of 5,214 adult spring Chinook Salmon were released above Cowlitz Falls Dam. During 2011-2016, a mean of 14,463 age-1 (sub-yearling) Chinook Salmon were captured at the Cowlitz Falls Fish Facility, which captures juveniles emigrating from the Cispus and upper Cowlitz river drainages. Of those captured, 13,930 (96.3%) were age-1 and 533 (3.7%) were age-2. However, offspring of fall and spring Chinook Salmon cannot be differentiated and both seem to migrate past Cowlitz Falls Dam as sub-yearlings, so we do not know how many were juvenile fall Chinook Salmon.

3.2.3.6. Natural-origin Survival and Productivity

Survival and productivity are key metrics for monitoring populations. However, neither SAR nor productivity can be calculated for Tilton Subbasin fall Chinook Salmon because smolt abundance estimates are imprecise, as capture efficiency at the Mayfield Dam Collection Facility has varied widely. Additionally, returns are not documented by age, so a full run reconstruction of each brood year is not possible.

3.2.3.7. Age Composition

Age composition cannot be completely calculated because the data in ISIT are not compiled by age or brood year. Age classes are only characterized as “jacks (<49 cm)” or “adults (>49 cm),” and these data are only available for the returns to Cowlitz Salmon Hatchery. From run years 2011-2017, a mean of 6% of the natural-origin returns to Cowlitz Salmon Hatchery were jacks and 94% were adults.

3.2.4. Hatchery Production

At present, no hatchery programs are dedicated to supplementing the Tilton Subbasin fall Chinook Salmon population. However, we plan to shift all hatchery production from the Lower Cowlitz Subbasin to a single Tilton (Upper Cowlitz) Subbasin Fall Chinook Salmon Integrated Hatchery Program. This new program is expected to completely replace the entire 3.5 million smolts produced for the Lower Cowlitz Subbasin. As such, it will continue to support fisheries, both below and above Mayfield Dam, as well as supplement natural production in the Tilton Subbasin.

3.2.4.1. Hatchery-origin Upstream Transport

Hatchery-origin fall Chinook Salmon returning to Cowlitz Salmon Hatchery that are deemed in excess of broodstock requirements to supplement the Lower Cowlitz Subbasin population may be transported upstream of Mayfield Dam. Salmon transported to the Tilton Subbasin are available for harvest, and those that survive may spawn naturally. From 2011-2017, a mean of 3,763 hatchery-origin fall Chinook Salmon were transported and released above Mayfield Dam, a mean of 1,014 were released into the Tilton Subbasin, and 2,749 were released above Cowlitz Falls Dam. We estimate that 340 of them were harvested and 2,674 survived to spawn in nature.

3.2.5. Proportionate Natural Influence

PNI is a useful metric for monitoring both hatchery and natural populations. Changes in PNI can indicate an increase or decrease in the effect of hatchery-origin salmon on the natural population.

From 2011-2017, we estimate that mean pHOS (based on the numbers transported above Mayfield Dam, rather than observed spawners) was 0.480. Because there is no dedicated hatchery program for supplementing populations above Mayfield Dam, neither pHOS nor PNI can be calculated. Since inception of the Lower Cowlitz Subbasin fall Chinook Salmon Integrated Hatchery Program in 2013, pNOB has ranged from 0.010-0.234.

3.2.6. Future Management

The entire Upper Cowlitz Subbasin fall Chinook Salmon population is designated as a Stabilizing population for achieving MPG and ESU recovery goals. Population viability is rated as Very Low (LCFRB 2010), and recovery efforts for the Upper Cowlitz Subbasin population are currently limited to the Tilton Subbasin. Specific recovery targets are not quantified for Stabilizing populations, so we propose a recovery target of 1,000 natural-origin adults spawning in nature in each of the Cispus, upper Cowlitz, and Tilton drainages. This level is well below the historical levels for these populations and should be achievable.

3.2.6.1. Goals for Conservation and Recovery

Progress toward achieving conservation and recovery goals is evaluated through monitoring of standard fisheries and hatchery management metrics (Table 3.2-2; Appendix A, Full Big Table). The historical Upper Cowlitz Subbasin fall Chinook Salmon population had an abundance of about 28,000 salmon with an estimated production capacity of 522,294 smolts. Although it has “Very Low” viability (WDFW and LCFRB 2016), it can still provide a Stabilizing role in the recovery of the lower Columbia River Chinook Salmon ESU (LCFRB 2010). The number of natural-origin adults transported above Mayfield Dam from 2007-2017 peaked at 3,380 in 2015 (Figure 3.2-3; Table 3.2-1); however, transport of fall Chinook Salmon upstream of Cowlitz Falls Dam is currently suspended.

- **Long-term Goals:** To establish a population that is self-sustaining through natural production, we have identified goals for achieving full recovery (Table 3.2-3), which would include, but not be limited to:
    - >1,000 natural-origin adults spawning in nature in each of the Cispus, Upper Cowlitz, and Tilton basins.
    - pHOS <0.3, pNOB = 1, and PNI >0.67.
    - Harvestable population of natural-origin fall Chinook Salmon above Mayfield Dam.
- **FHMP Period Goals:** Program goals for this FHMP period are attainable steps toward population recovery. Within the current Recolonization phase of population recovery, the FHMP goals for the Tilton Subbasin fall Chinook Salmon population are:
    - At the end of this FHMP period, we anticipate that the population will be in the

Local Adaptation phase.

- Shift all hatchery production to a Tilton Subbasin fall Chinook Salmon Integrated Hatchery Program with maximum total hatchery production of 3.5 million sub-yearling (age-1) smolts, with:
    - All broodstock collected from salmon returning to Cowlitz Salmon Hatchery.
    - pNOB >0.5.
    - All offspring with at least one natural-origin parent.
- Maintain natural-origin spawner abundance >1,000 and initiate monitoring of natural spawning in the Tilton Subbasin.
- Keep spawner pHOS <0.5.
- Increase and improve monitoring, evaluation, and data collection, including for:
    - Natural smolt production.
    - Age, sex, and origin of all recoveries.
    - Length and weight of a sample of all recoveries.
    - Hatchery-origin strays to/from locations outside of the Cowlitz Basin.
    - Numbers:
        - Returning to Cowlitz Salmon Hatchery.
        - Retained as broodstock.
        - Spawned.
        - Transported and released upstream of Mayfield Dam.
        - Numbers of spawners in nature, not just the number transported and released.
        - Hatchery surplus.
- Reduce the abundance of hatchery-origin spawners in the Tilton Subbasin either by reducing the number transported and released upstream or by increasing hatchery-origin harvest without a concomitant increase in natural-origin exploitation rate.
- Develop, evaluate, and implement strategies for improving hatchery SAR and age composition to be similar to those of natural-origin salmon.

Table 3.2-2. Current values (5-year mean) and FHMP and long-term (Recovery Plan) goals of key monitoring metrics for Tilton Subbasin fall Chinook Salmon. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Metric		Current	FHMP Goal	Long-Term Goal
Total Adult Abundance		6,183	11,675	12,650
Hatchery-origin		NA	7,700	7,700
Natural-origin		6,183	3,975	4,950
Total Adults to Mouth of Cowlitz River		2,878	6,236	6,236
Hatchery-origin		NA	2,261	1,286
Natural-origin		2,878	3,975	4.950
Hatchery Broodstock Spawned (adults)		73	1,950	1,950
Hatchery-origin		NA	975	0
Natural-origin		73	975	1,950
pNOB (Spawner = spawned; both programs)		NA	≥0.5	1
Adult Spawners in Nature Above Mayfield Dam*		3,700	4,286	4,286
Hatchery-origin		2,449	1,286	1,286
Natural-origin		1,951	3,000	3,000
pHOS (Spawner = spawners in nature; adults)		0.385	<0.5	<0.3
PNI (Spawner)		NA	>0.220	>0.667
Smolt Abundance		101,428	3,800,000	3,800,000
Hatchery-origin (Smolts Released)		NA	3,500,000	3,500,000
Natural-origin from Above Mayfield Dam		?	300,000	300,000
Smolt Collection Efficiency / Passage Survival		101,428	75%	75%
Smolt-to-Adult Survival (to hatchery / spawning grounds; including Jacks)				
Hatchery-origin		NA	0.22%	0.22%
Natural-origin (if unavailable, presumed higher than hatchery-origin)		?	?	?
Mean Age (by Run Year)				
Hatchery-origin		NA	3.8	4.2
Natural-origin		?	?	4.6
Precocious Maturation Rate (by Run Year)				
Hatchery-origin	Mini-jacks	NA	≤2%	≤2%
	Jacks	NA	≤10%	≤10%
Natural-origin	Jacks	6%	≤5%	≤5%
Natural-origin Productivity (assume 1% Smolt-to-Adult Return to hatchery)				
Smolts / spawner		?	>100	≥100
Adults + Jacks / spawner		?	>1	≥1
Total Harvest (from all fisheries)		3,611	?	?
Hatchery-origin		NA	?	?
Natural-origin		3,611	?	?
Harvest (% of total adult return)		58%		?
Hatchery-origin		NA	?	?
Natural-origin		58%	?	?

* Estimated by subtracting estimated harvest loss and multiplying by standard fallback (12%) and pre-spawn mortality (10%) rates from the numbers transported.

Table 3.2-3. Recovery phase targets for Tilton Subbasin fall Chinook Salmon. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Recovery Designation: Stabilizing
Current Recovery Phase: Recolonizing

	RECOVERY PHASE				
Target Metric	Preser-vation	Recolon-ization	Local Adaptation	Fully Recovered	Last 5 Years
Natural Production					
Natural-origin Spawners in Nature	300	500	750	1,000	1,951[1]
Smolt Abundance (below hatchery)	?	?	?	?	92,242
Smolt Passage Survival	40%	60%	70%	75%	~77%
Productivity (5-year mean)	>1	>1	>1	>1	?
Hatchery Production					
Type of Hatchery Program	Int/Seg	Int	Int	Int	Seg/Int
Broodstock to be Collected	1,108	1,686	1,686	1,686	NA
Integrated Hatchery Program	530	1,686	1,686	1,686	NA
Hatchery-Origin	265	843	422	0	NA
Natural-Origin	265	843	1,265	1,686	NA
Segregated Hatchery Program	578	0	0	0	NA
Smolts to be Produced	2,300,000	3,500,000	3,500,000	3,500,000	NA
Integrated Hatchery Program	1,100,000	3,500,000	3,500,000	3,500,000	NA
Segregated Hatchery Program	1,200,000	As Needed	As Needed	As Needed	NA
Total Smolt-to-Adult Survival	0.5%	0.7%	0.8%	1%	NA
Proportionate Natural Influence					
pHOS (<)					
Total	0.5	0.4	0.3	0.2	0.385
Integrated Hatchery Program					?
Segregated Hatchery Program	0.1	N/A	N/A	N/A	?
pNOB (>)	0.2	0.5	0.75	1	NA
PNI (>)	0.3	0.55	0.7	0.8	NA
Max % of Natural-Origin Return to Cowlitz Salmon Hatchery Collected for Broodstock	50%	40%	30%	30%	NA

[1] Estimated by subtracting estimated harvest loss and multiplying by standard fallback (12%) and pre-spawn mortality (10%) rates from the numbers transported.

3.2.6.2. Management Targets

In every year since 2009, the number of natural-origin fall Chinook Salmon transported and released into the Tilton Subbasin has exceeded the recovery abundance target of 1,000 natural-origin spawners in nature. However, the proportion of transported adults that originated from the Tilton Subbasin, and their subsequent spawning success following release, is largely unknown. Improvements in smolt passage survival will be required before a naturally spawning population can be reliably sustained in the subbasin without being supplemented by hatchery-origin salmon. Unknown factors (such as Cutthroat Trout predation, Ceratonova shasta infection, etc.) can affect natural-origin survival and result in poor natural productivity. To retain harvest benefits and meet conservation goals, the Integrated Hatchery Program, with pNOB >0.5 and a production goal of 3.5 million sub-yearling smolts, will supplement natural spawning and support fisheries. Additionally, harvest estimates and the numbers and ages of spawners in nature have unacceptably wide variances due to low sampling rates, when estimated at all.

- **Natural Production:** The goal of population recovery is to develop self-sustaining, naturally reproducing populations. Efforts to improve downstream smolt passage survival continue and recruitment from natural production will increase with the success of these efforts. Likewise, the ability to accurately estimate natural production will improve as collection efficiency at downstream passage facilities improves. Counts of salmon transported to the Tilton Subbasin are reliable numbers, but we are not certain that all natural-origin salmon transported to the Tilton Subbasin originated there. In addition, pre-spawn mortality (a critical measure for estimating natural production) has not been estimated for salmon (both hatchery- and natural-origin) spawning in nature, so spawner pHOS can only be roughly estimated. As part of this FHMP, Tacoma Power will develop and begin to implement a rigorous monitoring program that is focused on evaluating program effectiveness based on regionally accepted VSP parameters.
- **Abundance – Transport and Natural Spawning:** Although recent data indicate that the number of natural-origin fall Chinook Salmon transported and released in the Tilton Subbasin has exceeded the recovery goal of 1,000 natural-origin adults spawning in nature for every year since 2009, these are two substantially different metrics. To reestablish a self-sustaining population will ultimately require natural spawning by a sufficient number of natural-origin salmon and that their survival exceeds replacement (spawner-to-spawner productivity >1). We will focus our monitoring of natural-origin production on documenting the total number of hatchery- and natural-origin salmon released, their respective pre-spawn mortality rates, the number that survive to spawn, and spawner pHOS. These metrics are critical for achieving recovery.

  Our inability to determine the origin of unmarked salmon returning to Cowlitz Salmon Hatchery affects our ability to effectively monitor recovery of the Tilton Subbasin fall Chinook Salmon population. For management purposes, all unmarked/untagged (assumed to be natural-origin) salmon that are captured at Cowlitz Salmon Hatchery are considered to be from the Tilton Subbasin because they have swum past the spawning reaches in the lower Cowlitz River. Likewise, all natural-origin salmon remaining in the Lower Cowlitz Subbasin are assumed to have originated there. While it is likely that this is an accurate characterization for most of them, it is very likely that some Tilton Subbasin salmon remain below Cowlitz Salmon Hatchery and that some of those captured at the hatchery were from the Lower Cowlitz Subbasin salmon or strayed from some other location. These scenarios compromise our ability to evaluate recovery but also provide a source of genetic diversity to the respective populations and, if this straying rate becomes excessive, may also preclude the ability of populations to differentiate and adapt to local conditions. This will continue to be an information gap unless we can greatly increase our collection efficiency at the Mayfield Collection Facility and uniquely mark these salmon as outmigrants, or a technique is developed to differentiate Tilton Subbasin salmon from those originating in the Lower Cowlitz Subbasin.

- **Smolts Produced in Nature:** Natural-origin smolt production from the Tilton Subbasin is not well known. We will increase collection efficiency at the Mayfield Collection Facility to improve our estimate of natural-origin smolt production.
- **Smolt-to-Adult Survival:** Because smolt abundance is not well estimated and returns are not well documented by age, SAR cannot be estimated. This metric is important and we will monitor this index as the means to do so become available, through our M&E Program.
- **Productivity (Recruits/Spawner):** Because returns are not documented by age, productivity also cannot be estimated. Productivity (mature natural-origin F_1 recruits / F_0 spawner) is the primary metric for monitoring natural populations, so collection of the necessary data is critical. We will monitor this index as the means to do so become available through our M&E Program.
- **Hatchery Production:** The numbers of hatchery-origin salmon that return to Cowlitz Salmon Hatchery have not always been sufficient to support the program in recent years. Strategies will be developed, tested, and evaluated to improve the survival and subsequent returns of the hatchery-origin salmon.

  We will shift the focus of hatchery production from combined segregated and integrated hatchery programs for the Lower Cowlitz Subbasin to a single integrated hatchery program for supplementing natural production and harvest in the Tilton Subbasin, as well as fisheries downstream from Mayfield Dam. Broodstock for the new Tilton Subbasin Integrated Hatchery Program will be collected from salmon returning to Cowlitz Salmon Hatchery. Hatchery production will remain at 3.5 million smolts and any shortfall in Tilton Subbasin Integrated Hatchery Program production will be made up using salmon from the Integrated Hatchery Program, which will be uniquely marked.
- **Abundance:** The Cowlitz Salmon Hatchery fall Chinook Salmon Program is expected to be able to produce an annual run of 7,700 adult hatchery-origin fall Chinook Salmon (WDFW 2014b). We will focus our monitoring of hatchery-origin abundance on the numbers that are harvested and that return to the Cowlitz River and to Cowlitz Salmon Hatchery, which are critical for calculating SAR and TSAR, as well as the number that remain to spawn in nature, used for pHOS and PNI calculations.
- **Broodstock Collection and Spawning:** We will employ hatchery best management practices for broodstock collection and spawning to ensure that the broodstock represents the entire population in age and run timing and to maximize genetic diversity of the F_1 generation. Transferring the hatchery production to a Tilton Subbasin Integrated Hatchery Program will make it easier to achieve the hatchery smolt production targets and integration rates, as we can collect all broodstock from those salmon returning to Cowlitz Salmon Hatchery. This will ensure that both male and female natural-origin genotypes are incorporated in the broodstock for the Integrated Hatchery Program. The Integrated Hatchery Program will maintain a high level of natural influence in the hatchery-origin salmon by having at least 50% of the broodstock of natural-origin and avoiding HxH crosses. This will also minimize the hatchery influence on the F_1 generation and any population that it spawns with.

Additionally, we will rigorously monitor and report important hatchery metrics, such as numbers of salmon collected for broodstock, pre-spawn mortality rates, numbers spawned, fecundity, fertility, and survival rates to release. We will use the most recent 5-year means of these metrics to determine the numbers of adults to collect for broodstock in order to have the maximum number available to be released to support fisheries above Mayfield Dam and to spawn in nature.

- **Smolt Production:** Currently, smolts are targeted for release as sub-yearlings in May-June (mean weight = 5.7 g). However, releases from 2002-2013 consistently occurred after 1 June and at a mean weight of 6.6 g. We will develop, test, and evaluate different rearing and release strategies to develop an optimum strategy for this population.
- **Smolt-to-Adult Survival:** SAR is the primary metric for monitoring hatchery populations, especially those for which return abundance is lower than expected. To support calculations of SAR, we will rigorously estimate returns of hatchery-origin salmon, by age class. Additional data needs include the rate of precocious maturation and the sex ratio of hatchery-origin salmon by age class. We will monitor this index, using the coded-wire tag data in RMIS (www.rmis.org), through our M&E Program.
- **Productivity:** Population productivity (number of F_1 generation recruits that survive to spawn for each F_0 generation spawner) is the primary monitoring metric for any population, especially natural populations. This metric is of less importance, but is still useful, for monitoring hatchery populations, where survival to the smolt stage is unnaturally high. We will use the CWT data in RMIS to develop age compositions of each brood year of hatchery-origin salmon and support calculations of productivity and to monitor this metric over time through our M&E Program.
- **Strays and Spawning in Nature:** Only about 5% of the total hatchery-origin run, and about 8% of the hatchery-origin run entering the Cowlitz River, are recovered on the natural spawning grounds. This estimate is likely a low estimate based only on hatchery-origin salmon being identified as having spawned in monitored reaches in the mainstem lower Cowlitz River. Additionally, the data from ISIT specifically do not include salmon recovered at locations outside of the Cowlitz Basin. Implementation of spawning surveys, as well as examining CWT data for strays outside of the Cowlitz Basin, will improve data collection and rigor for estimating stray rates and our understanding of the biology and management of these salmon.
- **Surplus:** A surplus of hatchery-origin salmon returning to the Cowlitz River can affect the viability of the natural-origin population if a sufficient number of them spawn in nature and increase pHOS. Our goal is to maximize the harvest of hatchery-origin salmon but, if hatchery-origin salmon are going to spawn in nature, we would prefer that they came from an integrated program, hence the priority to advance that program.
- **Harvest:** Harvest of natural-origin salmon constrains the ability of managers to meet pHOS and, therefore, PNI targets for this Stabilizing population. Conversely, harvest of hatchery-origin salmon would ideally be higher to reduce pHOS. Given the ability to control numbers of hatchery-origin salmon transported upstream, harvest management of the Tilton Subbasin fall Chinook Salmon population should focus on minimizing the harvest of natural-origin salmon rather than increasing harvest on hatchery-origin salmon. Hatchery-origin harvest will be monitored using the CWT recovery and sampling rate data in RMIS and robust creel surveys.
- **Proportionate Natural Influence:** We will manage this population to maximize the total numbers of spawners in nature, natural smolt production, and survival but also with the

goal of reducing the effect of hatchery salmon on the natural population. We propose to increase the influence of the natural environment on the Tilton Subbasin fall Chinook Salmon population in three ways:

- Maintain total hatchery production at the current level of 3.5 million smolts, while eliminating the Segregated Hatchery Program and transitioning all production to the new Tilton Subbasin Integrated Hatchery Program.
- Increase natural influence on hatchery-origin salmon by continuing to increase the percentage of natural-origin salmon used as broodstock (pNOB) for the new Tilton Subbasin Integrated Hatchery Program, which will have pNOB >0.5 and all offspring will have at least one natural-origin parent.
- Explore means of decreasing pHOS by increased harvest of hatchery-origin salmon and/or improved return rates to Cowlitz Salmon Hatchery. We will meet or exceed the HSRG guidelines by maintaining pHOS <0.3 and pNOB >0.5, which will keep PNI >0.625 (HSRG 2009).

The low PNI for Cowlitz Basin fall Chinook Salmon is a reflection of the low numbers of natural-origin salmon incorporated into the broodstock (14-125). Under the Tilton Subbasin Integrated Hatchery Program, more natural-origin salmon will be incorporated as broodstock, and pNOB will be >0.5, so PNI should also increase, depending on pHOS. We expect that pHOS will decrease with increased natural production.

- **Age Composition:** In ISIT, age classes are only characterized as "adults (>49 cm)" or "jacks (<49 cm)" and these data are only available for the returns to Cowlitz Salmon Hatchery; all other abundance data in ISIT (e.g., harvest, spawners in nature, or hatchery broodstock) provide no information about the ages of the salmon included in the number provided. However, the RMIS database (www.rmis.org) provides reliable age composition data for the CWT hatchery-origin salmon for brood years 1977-2011 (later brood years have not completely returned). For natural-origin salmon, we have only the incomplete ISIT data, so we can only provide percentages of "jacks" and "adults" (and only for those that returned in 2011-2017), as we cannot separate the age-4, age-5, and age-6 adults.

  Given the high proportion of hatchery-origin mini-jacks (age-2) and both hatchery- and natural-origin jacks and the potential for hatchery production to increase these rates in both the hatchery and in nature, we will more carefully monitor this trend. Collection of samples (scales and tags) to estimate the age of both hatchery- and natural-origin salmon will be done regularly at all collection sites to better characterize each cohort and more clearly understand the age composition of these salmon and the factors influencing their age at maturity. To reverse this trend in hatchery-origin salmon maturing precociously, we will evaluate our hatchery rearing practices. Large smolts tend to mature at a younger age, so we will develop, implement, and evaluate alternative strategies that we believe will decrease the abundance of mini-jacks and jacks and increase the abundance of the older age-5 and age-6 adults.

3.2.6.3. Monitoring & Evaluation (M&E) and Research

Baseline Monitoring

Monitoring and evaluation needs of the Tilton Subbasin fall Chinook Salmon population are similar to other populations in the basin and include spawner surveys, accurate counts of hatchery releases and returns of both hatchery- and natural-origin salmon at all recovery locations, additional marking, and evaluation of alternative management and hatchery rearing strategies. To support recovery, monitoring programs must be rigorous and allow for estimation, with greater confidence, of population abundance when the population is self-sufficient, as well as to identify ways to improve survival. Improved monitoring rigor for VSP and hatchery metrics is needed to monitor and evaluate the recovery status and trends that are specific to this population:

- Natural-origin smolt abundance.
- Hatchery- and natural-origin age at maturity (age of salmon from all recovery locations).
- Natural-origin productivity.
- Smolt-to-adult survival and return rates.
- Estimates of total mature salmon abundance, by origin, age, and sex.
- Estimates of actual numbers of spawners in nature, strays, and pre-spawn mortalities, by origin, sex, and age.
- Returns to Cowlitz Salmon Hatchery, by origin, age, and sex.
- Improved harvest estimates of both hatchery- and natural-origin salmon, by age.
- Numbers of salmon collected for broodstock and spawned, by origin, age, and sex.
- Fecundity and fertility rates, survival rates between age classes, disease prevalence, and numbers of smolts produced at Cowlitz Salmon Hatchery.

Directed Studies

Directed studies are designed to diagnose and solve specific problems associated with achieving FHMP goals and to fill management needs and information gaps in the Big Table (Table 3.3-2; Appendix A). Important areas of study for the Tilton Subbasin fall Chinook Salmon population include the following:

- **Spawning Ground Surveys:** Scales, marks, and tags; numbers of actual spawners; pHOS; pre-spawn mortality rates; genetics; spatial distribution (upper extent); and reach-specific adult densities.
- **Freshwater Life History and Natural-origin Juvenile Rearing Studies:** Abundance and life stage-specific survival rates, available habitat, habitat-specific (run/riffle/pool) densities, and carrying capacity.
- **In-river Migratory Survival and Behavior:** Survival of migrating juveniles and movement timing and rates.
- **Hatchery Supplementation Experiments:** Assessing the impact of returning hatchery-origin adults on natural-origin salmon.
- **Hatchery Practices:** Broodstock collection and spawning protocols, growth rate in hatchery, and examining smolt size and timing of release.

3.2.7. Summary

- Although functionally extirpated from upstream habitats following the completion of Mayfield Dam, Upper Cowlitz Subbasin population genes were likely absorbed into the persisting Lower Cowlitz Subbasin population, which became an aggregated population and has provided the founding stock for recovery.

- Fall Chinook Salmon recovery efforts since 2016 have focused exclusively on the recovery of the Tilton Subbasin portion of the Upper Cowlitz Subbasin population; releases of fall Chinook Salmon upstream of Cowlitz Falls Dam were suspended in 2016 to avoid conflicting with spring Chinook Salmon recovery efforts above Cowlitz Falls Dam. This approach will continue in the near-term, with a goal of eventually expanding fall Chinook Salmon reintroduction to include habitats upstream of Cowlitz Falls Dam.
- Mean numbers of natural-origin adults transported and released into the Tilton Subbasin have exceeded 1,000 since at least 2004. However, the number of natural-origin salmon that survive to spawn is uncertain and goals for pHOS, pNOB, and PNI have not been met.
- Increasing monitoring rigor for VSP metrics is needed to evaluate recovery status and trends, including, but not limited to:
    - Hatchery- and natural-origin smolt numbers.
    - Estimates of total run size by origin, age, and sex.
    - Harvest estimates of both hatchery- and natural-origin salmon, by age.
    - Estimates of numbers of spawners in nature, strays, and pre-spawn mortalities, by origin, sex, and age.
    - Returns to Cowlitz Salmon Hatchery by origin, age, and sex.
- Rely on a single Integrated Hatchery Program that will:
    - Produce 3.5 million sub-yearling smolts.
    - Collect all natural-origin broodstock from returns to Cowlitz Salmon Hatchery.
    - Have pNOB >0.5.

CHAPTER 4:
SPRING CHINOOK SALMON

Spring Chinook Salmon *Oncorhynchus tshawytscha*

ESA Listing

Status:	Threatened Listed in 2005, reaffirmed in 2011 and 2016
Evolutionarily Significant Unit:	Lower Columbia River Chinook Salmon
Major Population Group:	Cascade Chinook Salmon
Recovery Region:	Lower Columbia River Salmon
Populations, Recovery Designations, and Abundance Targets (natural-origin adults spawning in nature):	Tilton River drainage – Stabilizing, not established Upper Cowlitz River drainage – Primary, 1,800 Cispus River drainage – Primary, 1,800
Current Hatchery Program(s):	Cowlitz Salmon Hatchery Segregated Hatchery Program, 1.8 million smolts
Proposed Hatchery Program(s):	<u>FHMP period</u> Segregated Hatchery Program Integrated Hatchery Program Combined 1.8 million age-2 (yearling) smolts <u>Long-term</u> Integrated Hatchery Program; 1.8 million age-2 (yearling) smolts

4.0. Spring Chinook Salmon: Overview

4.0.1. Program Focus

The management focus for spring Chinook Salmon will be population recovery in the Upper Cowlitz Subbasin and harvest opportunity in the Lower Cowlitz Subbasin. The Recovery Plan (LCFRB 2010) identifies three spring Chinook Salmon populations, all upstream of Mayfield Dam (Figure 4.0-1):

- Cispus River - Primary population
- Upper Cowlitz River - Primary population
- Tilton River - Stabilizing population

Near-term recovery efforts for Cowlitz River spring Chinook Salmon are focused on the Cispus and upper Cowlitz drainages, which are combined to comprise the Upper Cowlitz Subbasin because we have no way to differentiate these populations, at present. To maximize spring Chinook Salmon recovery efforts and to prevent the confounding of recovery monitoring results, only spring Chinook Salmon will be transported and released above Cowlitz Falls Dam - no fall Chinook Salmon will be released there for the period of this FHMP. For the same reason, no spring Chinook Salmon will be released into the Tilton Subbasin for the period of this FHMP. The FTC will re-evaluate this management strategy at the end of this FHMP period and will develop a framework for the eventual release of spring Chinook Salmon into the Tilton Subbasin.

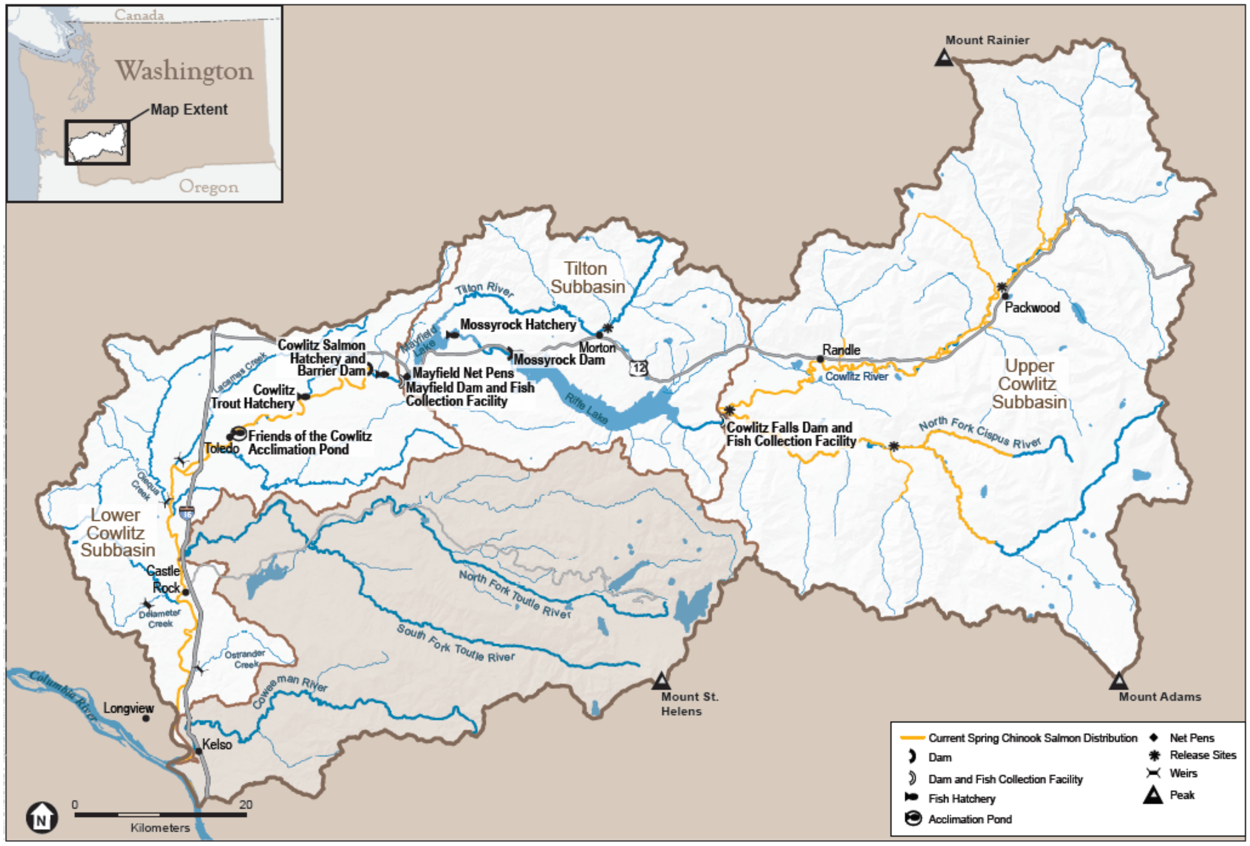


Figure 4.0-1. Distribution of spring Chinook Salmon and locations of important fish management sites in the Cowlitz Basin (not including the Coweeman and Toutle basins).

This framework will require an understanding of the key population parameters (VSP parameters; population abundance, productivity, spatial structure, and diversity) of both fall and spring Chinook Salmon in the affected basins, which will be amongst the parameters and considerations for releasing spring Chinook Salmon into the Tilton Subbasin (McElhany et al. 2000).

The initial management focus for restoration of spring Chinook Salmon will be in the Upper Cowlitz Subbasin, and for fall Chinook Salmon will be the Tilton Subbasin. This will allow each restoration effort to proceed without being confounded by the other population. Nevertheless, a framework will be developed for the eventual release of spring Chinook Salmon into the Tilton Subbasin once fall Chinook Salmon have been reestablished there. Because the smolt collection point for the Cispus and upper Cowlitz rivers is at Cowlitz Falls Dam, downstream of the confluence of these rivers, we cannot differentiate smolts from these two populations, which also means that we cannot differentiate returning adults by population. Therefore, the upper Cowlitz River and Cispus River populations are currently managed as one combined "Upper Cowlitz Subbasin" population, with a combined recovery target of 3,600 natural-origin adults spawning in nature (Tacoma Power 2011; WDFW and LCFRB 2016). The population-level sections that follow (Sections 4.1 and 4.2) provide performance indicators for each of these populations and strategies for achieving their recovery.

The current Recolonization phase will focus on increasing abundance of spring Chinook Salmon spawners in the Upper Cowlitz Subbasin. The current Segregated Hatchery Program will continue and be the main source of hatchery-origin salmon used to supplement natural spawning. However, during the first year, we will develop a plan to begin integrating the hatchery program with natural-origin broodstock. This initial Integrated Hatchery Program will comprise a portion of the total 1.8 million smolt production from Cowlitz Salmon Hatchery with the balance coming from the Segregated Hatchery Program. The Integrated Hatchery Program will be implemented as quickly as possible and the timeline will be the described in the plan, using new Decision Rules (triggers) that include adult abundance and the VSP parameters (McElhany et al. 2000). The long-term goal (beyond this FHMP) for spring Chinook Salmon recovery is to use the Integrated Hatchery Program to support all of the supplementation and mitigation for lost production and harvest.

Poor collection efficiency and passage survival of downstream migrants at Cowlitz Falls Dam has been a key limiting factor for population recovery. We will continue to monitor and improve collection efficiency and passage survival but these metrics will not be used to limit management options.

Lastly and consistent with a focus on recovery of spring Chinook Salmon in the Cowlitz Basin, in the first year of this FHMP, we will also develop a disposition plan regarding the use of spring Chinook Salmon for hatchery broodstock, recovery objectives, nutrient enhancement, and to meet WDFW obligations in other basins. Spring Chinook Salmon eggs from Cowlitz Salmon Hatchery are currently used by WDFW to meet other State obligations outside of the Cowlitz Basin but this reduces the number of salmon that would otherwise have been available to spawn naturally in the Cowlitz Basin. Here, too, new Decision Rules will be developed to define surplus, balancing when salmon and/or their offspring are surplus and no longer critical to Cowlitz Basin restoration needs and may be used to meet other State obligations outside of the Cowlitz Basin.

4.0.2. Population Structure

Historically, three distinct populations of Cowlitz River spring Chinook Salmon spawned in the upper mainstem and tributaries of the Cispus, upper Cowlitz, and Tilton rivers (Figure 4.0-1; Table 4.0-1; WDFW and LCFRB 2016). However, the genetic composition of these populations has been heavily influenced by past overharvest and any distinct population substructure that previously existed was eliminated by the construction of Mayfield Dam and subsequent failure of the adult passage systems in the 1960s and early 1970s, which blocked all of these salmon from reaching their historical spawning locations. This forced them to spawn in the Lower Cowlitz Subbasin, if they were not incorporated into the Cowlitz Salmon Hatchery broodstock, creating the current Cowlitz River spring Chinook Salmon population, which is one hybridized, composite hatchery population with limited natural spawning in the Lower Cowlitz Subbasin.

Since completion of Cowlitz Salmon Hatchery in 1967, the Cowlitz River spring Chinook Salmon population has been sustained by hatchery production, with unknown amounts of spawning in nature in the Lower Cowlitz Subbasin and an unknown level of natural-origin integration into the hatchery broodstock until a fully segregated program with mass-marked releases began in 1998. Although Cowlitz River spring Chinook Salmon have been heavily influenced by in-basin hatchery practices over the years (Table 4.0-2), influence from non-endemic stocks has been minimal, as 96% of all spring Chinook Salmon hatchery releases from 1948-1993 and 100% of subsequent releases were Cowlitz hatchery stock (WDFW 2014).

This new composite population, created from the mixing of the three extirpated populations, does not functionally exist within the historic distribution of spring Chinook Salmon spawning and rearing in the Cowlitz Basin. Nevertheless, the current Cowlitz Salmon Hatchery spring Chinook Salmon is considered a genetic legacy population, as it is an endemic hatchery population that is derived from the original native populations that we aim to restore. It will serve as a gene bank and will be the founding population for the reintroduction and recovery of spring Chinook Salmon populations in the Cispus, upper Cowlitz, and Tilton rivers. Spring Chinook Salmon from this composite population are currently found in the Lower Cowlitz and Upper Cowlitz subbasins. Recovery objectives ultimately include reestablishing spring Chinook Salmon in the Tilton Subbasin.

With the listing of these populations under the ESA in 2005, the management focus turned to recovery of the original population structure, and conservation was elevated to a higher management priority, resulting in changes in hatchery, harvest, and habitat actions. In the Recovery Plan, the Cispus and upper Cowlitz rivers spring Chinook Salmon populations are designated as Primary populations for ESU recovery, each with a recovery target of 1,800 natural-origin adults spawning in nature (LCFRB 2010). The Tilton River population is classified as a Stabilizing population; the current operating conditions were considered adequate to meet conservation goals, so no recovery target was established. We propose a target of 1,000 natural-origin adults spawning in nature.

Table 4.0-1. Recovery priority, baseline viability status, viability and abundance objectives, and productivity improvement targets for Cowlitz River spring Chinook Salmon populations (from LCFRB 2010).

	Demographically Independent Population		
	Upper Cowlitz River	Cispus River	Tilton River
Recovery Priority Designation[1]	Primary	Primary	Stabilizing
Abundance			
Historic[2]	22,000	7,800	5,400
Current (last 5 years)[3]	300	150	100[4]
Target[5]	1,800	1,800	1,000[6]
Baseline Viability[7]			
Abundance & Productivity	Very Low	Very Low	Very Low
Spatial Structure	Low	Low	Very Low
Diversity	Medium	Medium	Very Low
Net Viability Status	Very Low	Very Low	Very Low
Viability Improvement[8]	>500%	>500%	0%
Recovery Viability Objective[7]	High +	High +	Very Low
Proportionate Natural Influence			
pHOS	<0.3	<0.3	<0.3[6]
pNOB	>0.6	>0.6	>0.5[6]
PNI	>0.67	>0.67	>0.63[6]

[1] Primary, Contributing, and Stabilizing designations reflect the relative contribution of the population to Major Population Group recovery goals.
[2] Historical population size was mean number, inferred from presumed habitat conditions using EDT Model and NMFS back-of-envelope calculations.
[3] Current mean annual number of naturally-produced fish returning to the watershed.
[4] Currently, only released above Cowlitz Falls Dam.
[5] Abundance targets were estimated by population viability simulations based on viability goals.
[6] For Stabilizing populations, the current operating conditions were considered adequate to meet conservation goals and no criteria were developed for pHOS, pNOB, or PNI (LCFRB 2010). We propose the values indicated.
[7] Viability status is based on Technical Recovery Team viability rating approach. Viability objective is based on the scenario contribution. Very Low (>60% chance of extinction); Low (26-60% chance of extinction); Medium (6-25% chance of extinction); High (1-5% chance of extinction); Very High (<1% chance of extinction).
[8] Improvement is the relative increase in population abundance and productivity required to reach the prescribed viability goal.

Table 4.0-2. Hatchery releases of spring Chinook Salmon into the Cowlitz Basin, excluding the Toutle River (updated from Myers et al. 2006).

Release Location	Release Years	Years[1]	Broodstock Origin	Total Released
Cowlitz River	1948-1970	4	Unknown[2]	1,716,588
	1968-1969	2	Willamette Hatchery[3]	999,295
	1968-2018	26	Cowlitz Hatchery	133,101,370
	1979	1	Little White Salmon NFH	224,590
Grand Total				136,041,843

[1] The total number of years that fish were actually released within the time frame.
[2] Stocks of unknown origin are assumed to be from within the ESU. Releases derived from adults returning to that river are also assumed to be native regardless of past introductions, unless the hatchery broodstock is known to be from outside the ESU.
[3] Releases classified by Myers et al. (2006) as derived from outside the lower Columbia Chinook Salmon ESU.

4.0.3. Life History Diversity

In the Cowlitz Basin, maturing spring Chinook Salmon return to Cowlitz Salmon Hatchery before 30 September, which distinguishes them from fall Chinook Salmon, which return later. There is also a temporal separation between the spawn timing and spatial separation between spawning areas of the spring and fall runs. Spring Chinook Salmon typically enter the Cowlitz River from March through June and natural spawning occurs between late August and early October, with a peak around mid-September (LCFRB 2010). All Cowlitz River spring Chinook Salmon historically spawned upstream of the current site of Mayfield Dam, particularly in the upper reaches of the Cispus River and upper Cowlitz River mainstem and their tributaries. Early entry into fresh water is a defining characteristic of spring Chinook Salmon populations, which are thought to take advantage of higher spring and summer flows to access the higher reaches of watersheds in which they typically spawn (Myers et al. 2006).

Spring Chinook Salmon fry emerge from November to March and rear in fresh water for a full year before migrating downstream to the Columbia River as age-2 smolts (LCFRB 2010). The age at which mature salmon return ranges from age-3 jacks to ages-4-6 adults. The dominant age-class for mature salmon is age-4 (44%).

4.0.4. History

The history of spring Chinook Salmon in the Cowlitz Basin is similar to those of other Columbia Basin populations. Historically, spring Chinook Salmon population sizes in the upper Cowlitz, Cispus, and Tilton rivers were 22,000, 7,800, and 5,400 salmon, respectively (Table 4.0-1; WDFW and LCFRB 2016). However, the combination of overharvest in the early to mid-1900s, hydropower development in the 1960s, and the consistent, continuing, and pervasive effects of habitat loss and hatchery supplementation took their toll on these populations (WDF et al. 1993; Myers et al. 2006). Current population estimates represent a small fraction of historic returns despite continued recovery efforts. Early efforts to mitigate for the problems caused by dams, habitat loss, and overharvest included poorly managed hatchery supplementation programs, which did not provide the desired increase in natural-origin abundance and further degraded the populations. Land development and increasing human population pressures will likely continue to degrade habitat in the Cowlitz Basin, especially in lowland areas. Likewise, poor ocean conditions can cause rapid population declines and most populations in the lower

Columbia River ESU are considered to be at High Risk, including the Cowlitz River populations (NWFSC 2015).

In 1948, WDF estimated that 32,490 spring Chinook Salmon returned to the Cowlitz Basin (LCFRB 2010), but harvest in the 1940s and 1950s was heavy and WDF reported that only 10,400 returned to the basin in the early 1950s. Run size decreased further and dramatically in 1961, when Mayfield Dam blocked access to the Cowlitz Basin above rkm 84, including the entirety of the spring Chinook Salmon spawning habitat. From 1962-1970, a mean of 10,038 spring Chinook Salmon were caught at the Cowlitz River fish facilities and a trap-and-haul program released a mean of 5,976 adults upstream until the operation was terminated (Hager and De Cew 1970; Hager 1970). Mossyrock Dam was completed in 1968 and created an additional seasonally warm reservoir that smolts had to traverse, greatly reducing the number of natural-origin smolts that survived to the mouth of the Cowlitz River. As a result, annual escapement estimates of Cowlitz River spring Chinook Salmon continued to decline, ranging from 36-1,116 (mean = 338) from 1980-2001(LCFRB 2010).

Fish hatcheries have been operated on the Cowlitz River for over 100 years, with releases of spring Chinook Salmon beginning in the 1940s (Table 4.0-2). Mean annual releases have exceeded 5 million smolts, but the broodstock source has largely been from within the Cowlitz Basin and almost solely from within the ESU, so there appears to be little influence from out-of-basin populations (Myers et al. 2006). Cowlitz River spring Chinook Salmon are genetically similar to, but distinct from, Kalama Hatchery and Lewis River wild stocks, and significantly different from other Columbia River stocks (LCFRB 2010).

Following the construction of Mayfield and Mossyrock dams, WDFW and Tacoma Power reached a Settlement Agreement with a mitigation goal of 17,300 adult spring Chinook Salmon returning annually to Cowlitz Salmon Hatchery (WDFW 2014). To accomplish this, Cowlitz Salmon Hatchery has been producing spring Chinook Salmon smolts for release into the lower Cowlitz River; the current production goal for the Segregated Hatchery Program is 1.8 million yearling (age-2) smolts.

Following completion of Cowlitz Falls Dam in 1994, a new Settlement Agreement was reached, prioritizing recovery of “wild, indigenous salmonid runs,” including spring Chinook Salmon, to harvestable levels. The recovery goal for the Upper Cowlitz Subbasin population was set at 3,600 natural-origin adults spawning in nature (1,800 for each of the Cispus and upper Cowlitz rivers; LCFRB 2010). A trap-and-haul program was reinstituted in 1994 in an effort to reintroduce the historical populations above Cowlitz Falls Dam, and hatchery-origin spring Chinook Salmon were transported and released into the Upper Cowlitz Subbasin, upstream of Cowlitz Falls Dam, but not into the Tilton Subbasin. As soon as the natural-origin offspring of these salmon began returning, a combination of hatchery- and natural-origin spring Chinook Salmon adults were transported and released, with the intent to produce as many natural smolts as possible, with the ultimate goal of producing a self-sustaining natural population above the Cowlitz River Hydroelectric Complex (Myers et al. 2006). Transport and release of fall Chinook Salmon upstream of Mayfield Dam is currently limited to the Tilton Subbasin until spring Chinook Salmon have become established above Cowlitz Falls Dam and managers are able to distinguish between spring and fall Chinook Salmon smolts originating from the Upper Cowlitz Subbasin. The spring Chinook Salmon populations in the Cispus River and upper Cowlitz River are both Primary populations, critical for recovery of the ESU, and managers do not want to hinder the recovery effort. Likewise, spring Chinook Salmon are not currently released in the Tilton Subbasin.

Since 1996, juvenile spring Chinook Salmon have been collected at Cowlitz Falls Dam and transported and released downstream to complete their migration. The upstream and downstream transport and release programs have restored natural-origin adult returns to the Upper Cowlitz Subbasin. However, collection efficiency at Cowlitz Falls Dam has been poor and subsequent adult abundance remains low, with a maximum of only 397 natural-origin adults transported upstream of Cowlitz Falls Dam annually since 2007 (Figure 4.0-2; Table 4.0-3). However, improvements to downstream collection facilities at Cowlitz Falls Dam appear to have increased collection efficiency from a mean of 19% (3-39%) from 1996-2016 to 46% in 2017 and 66% in 2018. The subsequent increase in outmigrants released into the lower Cowlitz River should help to further increase the abundance of natural-origin adults returning to the Upper Cowlitz Subbasin.

Recovery actions have been undertaken over the past three decades, but delisting cannot occur until all populations that historically existed have been restored with a probability of persistence that is consistent with Recovery Plan objectives. The Northwest Fisheries Science Center (NMFS 2016) reported generally minor changes in abundance, productivity, diversity, and spatial structure of Cowlitz River Chinook Salmon populations. Natural-origin abundance remains low and hatchery supplementation still provides an overwhelming contribution to escapement. With access to historical spawning grounds requiring direct handling/transport and generally low downstream juvenile passage efficiencies, Cowlitz River spring Chinook Salmon populations are not currently self-sustaining. Under the 2011 FHMP update (Tacoma Power 2011), all natural-origin returns plus hatchery-origin returns in excess of broodstock requirements (minus those used to supplement populations outside of the Cowlitz Basin), up to a combined total of 8,000 salmon, were to be released upstream of Cowlitz Falls Dam.

4.0.5. Distribution

Historically, all Cowlitz River spring Chinook Salmon spawned in the Upper Cowlitz Subbasin, upstream of the site of Mayfield Dam (LCFRB 2010); specific spawning grounds included the mainstem upper Cowlitz River above Packwood and the Cispus River between Iron and East Canyon creeks. Spring Chinook Salmon are also presumed to have spawned historically in the Tilton River, although this has not been confirmed and their specific spawning distribution within the Tilton River is unknown.

Construction of Mayfield Dam (rkm 83.7) in 1962-1963 blocked access to the spawning tributaries in the Upper Cowlitz Subbasin, although the intermittent transport of spring Chinook Salmon in the ensuing years allowed for spawning to continue upstream of Mayfield Dam. Adult spring Chinook Salmon collected at Cowlitz Salmon Hatchery have been transported and released upstream of Cowlitz Falls Dam into the Cispus and upper Cowlitz rivers since 1994 (LCFRB 2010; Tacoma Power 2011). To date, these reintroduction efforts have not included releases into the Tilton River, where no population is currently thought to exist. As noted above, the current management strategy is to preclude releases of spring Chinook Salmon into the Tilton River until the fall Chinook Salmon population has been restored there and smolt production can be discerned between fall and spring Chinook Salmon.

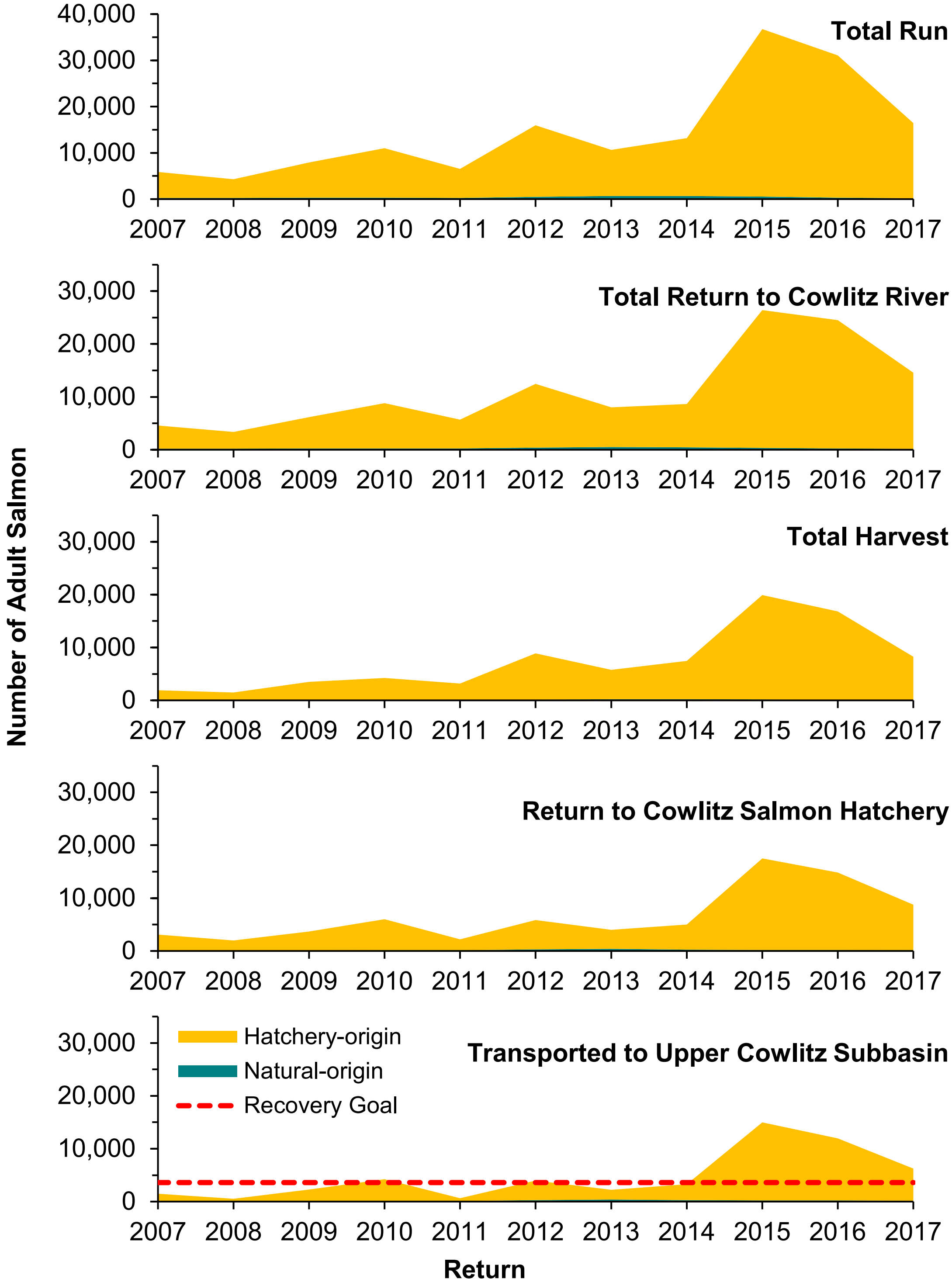


Figure 4.0-2. Estimated total run size for adult natural- and hatchery-origin spring Chinook Salmon and the numbers that returned to the Cowlitz River, were harvested, returned to Cowlitz Salmon Hatchery, and were transported above Cowlitz Falls Dam, 2007-2017. Note: numbers of natural-origin adults may be too small to be visible. Data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Table 4.0-3. Estimated mean, minimum, and maximum numbers of all hatchery- and natural-origin adult spring Chinook Salmon from the Cowlitz Basin, excluding the Toutle River, that could be accounted for at recovery locations and percentage of total at that recovery location, 2007-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Origin and Recovery Location	Mean	Minimum	Maximum
Hatchery-origin			
Total Run (unique to or below hatchery)[1]	14,145	4,070	36,233
Harvest (total for harvest rate)[2]	7,306	1,453	19,747
Total Return to Cowlitz River[3]	13,998	3,180	26,052
Return to Cowlitz Salmon Hatchery	6,458	1,884	17,318
Collected for Broodstock	1,459	906	2,146
Transported to Upper Cowlitz Subbasin	4,538	475	14,790
Spawned in Nature[4]	3,266	347	10,446
Natural-origin			
Total Run (unique to or below hatchery)[1]	380	171	693
Harvest (total for harvest rate)[2]	98	24	224
Total Return to Cowlitz River[3]	335	154	523
Return to Cowlitz Salmon Hatchery	180	80	397
Collected for Broodstock	0	0	0
Transported to Upper Cowlitz Subbasin	178	70	397
Spawned in Nature[4]	140	55	314
Combined Hatchery- and Natural-origin			
Total Run (unique to or below hatchery)[1]	14,525	4,317	36,760
Harvest (total for harvest rate)[2]	7,404	1,507	19,921
Total Return to Cowlitz River[3]	11,207	3,374	26,412
Return to Cowlitz Salmon Hatchery	6,638	1,964	17,511
Collected for Broodstock	1,459	906	2,146
Transported to Upper Cowlitz Subbasin	4,716	555	14,983
Spawned in Nature[4]	3,406	428	10,598

[1] Sum of all harvest below Mayfield Dam, returns to hatchery, and spawning in nature in Lower Cowlitz Subbasin.
[2] Total of harvest in ocean, Columbia River, lower Cowlitz River, and Upper Cowlitz Subbasin fisheries.
[3] Sum of Lower Cowlitz Subbasin harvest, returns to hatchery, and spawning in nature in Lower Cowlitz Subbasin.
[4] Calculated as number transported to the Upper Cowlitz Subbasin minus harvest in the Upper Cowlitz Subbasin, 12% fallback, and 10% pre-spawn mortality.

4.0.6. Abundance

The abundance estimates provided in this FHMP include all of the hatchery-origin spring Chinook Salmon that could be accounted for in the most recent data set provided by WDFW, as well as all of the Upper Cowlitz Subbasin natural-origin spring Chinook Salmon that could be accounted for. Natural-origin spring Chinook Salmon that were considered to have originated in the Lower Cowlitz Subbasin were not included because they are not considered for determination of recovery. All spring Chinook Salmon from the Toutle River were also excluded.

From 2007-2017, mean total run size of spring Chinook Salmon was 14,525 (4,317-36,760), which included all hatchery- and natural-origin spring Chinook Salmon that can be accounted for Figure 4.0-2; Table 4.0-3). The vast majority (97%) of those salmon were hatchery-origin, with only 3% being natural-origin.

Productive spawning and rearing habitats still exist above the Cowlitz River Hydroelectric Complex, but reintroduction efforts have been hindered by poor survival of smolts through the dams and associated reservoirs. Downstream migrant traps are operated for juvenile salmon at Cowlitz Falls Dam and help to assess the success of the adult releases, but their poor collection efficiency has hindered the recovery efforts. However, collection efficiency has greatly improved in the last two years, so the uncertainty regarding the annual production of natural-origin spring Chinook Salmon smolts in the Cowlitz Basin is diminishing.

4.0.7. Harvest

Harvest is an important component of Cowlitz River spring Chinook Salmon management and has great potential for impacting population recovery. Cowlitz River spring Chinook Salmon are an important component of commercial, sport, and tribal harvest and are harvested in ocean, lower Columbia River, and lower Cowlitz River fisheries, as well as in fisheries above Cowlitz Falls Dam (where salmon captured at Cowlitz Salmon Hatchery may be transported).

Managing for population recovery would support high harvest rates for hatchery-origin salmon while keeping harvest of the natural-origin salmon as low as possible until the population can support harvest (Paquet et al. 2011). Until recent years, naturally produced spring Chinook Salmon were managed the same as hatchery salmon and were subjected to similar harvest rates. However, harvest restrictions were placed on ocean and mainstem Columbia River fisheries to protect ESA-listed natural-origin spring Chinook Salmon (LCFRB 2010). Cowlitz River fisheries only target hatchery-origin spring Chinook Salmon. However, natural-origin spring Chinook Salmon are caught in ocean and Columbia River fisheries, which are not stock-selective and hooking mortality in mark-selective (i.e., hatchery-origin) or catch-and-release fisheries in the Cowlitz River can still result in harvest impacts on natural-origin salmon. CWT recoveries of hatchery-origin Cowlitz River spring Chinook Salmon (brood years 1989-1994) indicated that 40% of Cowlitz River spring Chinook Salmon were harvested; harvest was greatest in the Cowlitz River sport fishery (35%), followed by British Columbia (29%), Washington Coast (22%), Columbia River (6%), Oregon Coast (5%), and Alaska (3%) fisheries (LCFRB 2010).

WDFW established long-term harvest goals for Cowlitz River spring Chinook Salmon in terms of catch numbers, harvest rates, and seasons by fishery (Tacoma Power 2011). These are not necessarily the goals associated with the 1994 Settlement Agreement, but rather long-term goals that may require implementation of measures beyond the scope of the Settlement Agreement. From 2010-2017, the mean ocean harvest rate for hatchery-origin spring Chinook Salmon was 19%, and from 2013-2017, the harvest rate in the Columbia River was 3%. From 2007-2017, a mean of 3,712 hatchery-origin Cowlitz River spring Chinook Salmon were harvested annually in the lower Cowlitz River, and 365 were harvested above Mayfield Dam (Table 4.0-3; Figure 4.0-3). The harvest/exploitation of natural-origin spring Chinook Salmon is not known. WDFW uses a standard 10% hooking mortality rate for released salmon, so we estimate that 8 and 1 natural-origin spring Chinook Salmon died annually in the lower Cowlitz River and Upper Cowlitz Subbasin, respectively, due to the fisheries.

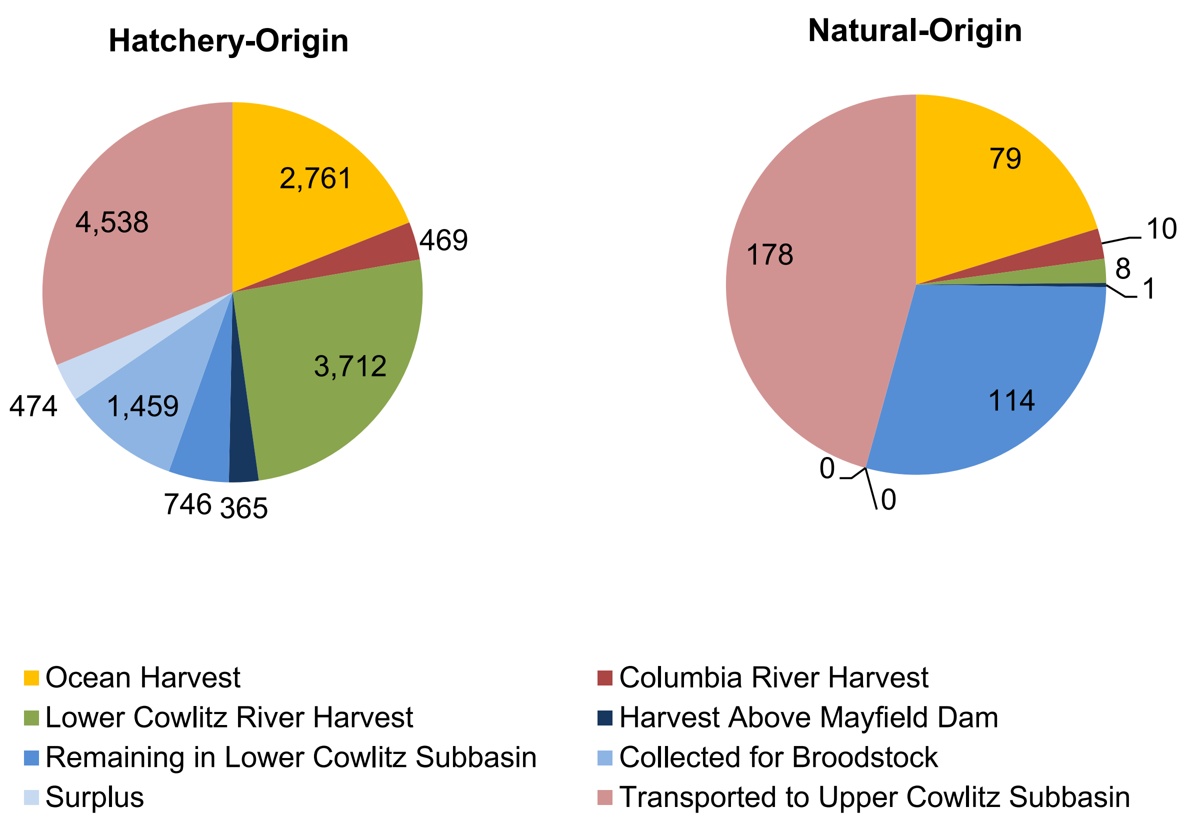


Figure 4.0-3. Percentages and mean numbers of hatchery-origin and natural-origin Cowlitz River spring Chinook Salmon harvested, by fishery location, collected for broodstock, surplused, and transported to the Upper Cowlitz Subbasin, 2007-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

4.0.8. Natural Production

To recover a salmon population, we must develop a self-sustaining natural population. To successfully manage toward population recovery, it is also important to know the abundance of the population at important points in their life history. Overall, we need to know (by origin, sex, and age) how many salmon are spawning in nature (F_0 generation) and how many of their offspring (F_1 generation) smolt and leave the Cowlitz River and subsequently survive to produce the next (F_2) generation. Because spawning ground surveys are not conducted in the Upper Cowlitz Subbasin, any estimates to date of spring Chinook Salmon successfully reproducing on the spawning grounds are based simply on the number transported above the dams; we do not know how many survive to spawn, but we roughly estimate that number by simply subtracting a harvest mortality estimate from the number transported and multiplying that by standard fallback (12%) and pre-spawn mortality (10%) rates). Collections of spring Chinook Salmon smolts at Cowlitz Falls Dam offer an important monitoring point and provide a reliable number of smolts transported and released downstream but the accuracy of the actual smolt production estimates has been constrained by poor collection efficiency.

The recovery abundance target for spring Chinook Salmon in the Cowlitz River is 3,600 natural-origin adults spawning in nature (Table 4.0-1); this target consists of 1,800 adult spawners in each of the Primary populations in the Cispus and upper Cowlitz drainages (LCFRB 2010). No recovery abundance target was established in the Recovery Plan for the Tilton Subbasin population because it is only a Stabilizing population; however, we propose 1,000 natural-origin spawners as a long-term recovery target for the Tilton Subbasin population once reintroduction efforts begin.

Consistent with the recent approach of managing spring Chinook Salmon in the Upper Cowlitz Subbasin as a combined population, ISIT provides combined data for the Cispus River and upper Cowlitz River populations. No spring Chinook Salmon are transported to the Tilton Subbasin and natural-origin spring Chinook Salmon spawners in the Lower Cowlitz Subbasin are not considered part of the ESU. Thus, the Upper Cowlitz Subbasin population currently represents the entirety of natural production of spring Chinook Salmon in the Cowlitz River.

Although natural spawning of hatchery-origin salmon is not directly credited toward meeting natural production targets, hatchery-origin adults are currently transported upstream of Cowlitz Falls Dam to spawn naturally as part of the recovery program. Ultimately, the goal is to eliminate natural spawning of hatchery-origin salmon once natural-origin abundance targets are met.

4.0.8.1. *Adult Transport and Natural Spawning*

No effort is currently conducted to identify the true origin of natural-origin salmon returning to Cowlitz Salmon Hatchery, so all natural-origin returns to the hatchery are assumed to have originated from the Upper Cowlitz Subbasin and are transported upstream of Cowlitz Falls Dam. For the 2007-2017 run years, a mean of 178 natural-origin Upper Cowlitz Subbasin spring Chinook Salmon were transported and released upstream of Cowlitz Falls Dam, and we estimate that 140 survived to spawn (Table 4.0-3).

4.0.8.2. *Smolt Production*

Natural-origin smolt production from the Upper Cowlitz Subbasin is not well known. From 1997-2018, a mean of 16,425 smolts (age-1 and age-2) were collected and mean collection efficiency has been 22%. However, from 2011-2017, smolt numbers were confounded by the presence of fall Chinook Salmon, whose parents had been released into the Upper Cowlitz Subbasin. Collection efficiency at the Cowlitz Falls Fish Facility has increased with the operation of the new North Shore Collector and we expect our collections to further improve by expanding our operation into the fall. This should further improve our estimate of natural-origin smolt production, increase the numbers of natural-origin smolts released downstream, and subsequently, of adults returning.

4.0.9. Artificial Production

Cowlitz Salmon Hatchery initiated a Chinook Salmon hatchery program in 1967 (WDFW 2014). The program was integrated by default because hatchery-origin Chinook Salmon were not 100% marked until 1998 and, because only a fraction of hatchery-origin salmon were marked at all, the integration rates (pNOB) were unknown. A truly segregated program began once the hatchery-origin salmon were 100% adipose fin-clipped and managers could be certain about the origin of the salmon collected for broodstock.

Moving forward, the near-term goal is to continue the Segregated Hatchery Program, while developing a plan for integrating a portion of the hatchery production. Decision Rules for this new Integrated Hatchery Program will be developed, based on adult abundance and VSP metrics. The long-term goal is for all hatchery production to come from the Integrated Hatchery Program, which will support both the recovery of Cowlitz River spring Chinook Salmon populations and provide for lost harvest opportunities.

Hatchery best management practices will be used and hatchery production metrics must be monitored to ensure that production goals are met, and also to understand the magnitude of hatchery influence on the natural population that it is supplementing. Key monitoring metrics are the numbers of salmon collected and spawned (by origin, age, and sex), green eggs, eyed eggs, fry, parr, smolts released, and of mature hatchery-origin salmon returning to the Cowlitz River and Cowlitz Salmon Hatchery (by age and sex). Using these data, we also calculate and monitor hatchery effectiveness metrics and smolt-to-adult survival and return rates.

4.0.9.1. *Overall Hatchery Program Goals*

The overall goals of the hatchery program for spring Chinook Salmon within the Cowlitz Basin are to:

1) Promote recovery of populations inhabiting the Cowlitz Basin,
2) Provide harvest opportunities for commercial, recreational, and tribal fisheries, and
3) Support educational and research opportunities.

Specific and quantifiable objectives of the hatchery program to achieve these goals are described in detail within the respective sections for each of the Cowlitz River spring Chinook Salmon populations (Section 4.1 and Section 4.2).

4.0.9.2. *Existing Hatchery Program*

The Cowlitz River spring Chinook Salmon hatchery production currently comes exclusively from the Segregated Hatchery Program, which has an annual production goal of 1.8 million age-2 (yearling) smolts released into the Cowlitz River from Cowlitz Salmon Hatchery. The corresponding total run-size goal is to produce 17,000 adults (WDFW 2014). From 2010-2017, a mean of 1,272,801 age-2 and 334,540 age-1 (2007-2011, only) juvenile spring Chinook Salmon were released from Cowlitz Salmon Hatchery. Over that same period, a mean of 13,998 adults have returned to the Cowlitz River (Table 4.0-4).

4.0.9.3. *Adult Transport and Natural Spawning*

In addition to all natural-origin spring Chinook Salmon collected at the hatchery trap, hatchery-origin returns in excess of broodstock requirements are transported above Cowlitz Falls Dam. From 2007-2017, an annual mean of 4,716 adult spring Chinook Salmon were transported and released into the Upper Cowlitz Subbasin, of which 4,538 (97%) were hatchery-origin (Table 4.0-3). We estimate that 3,266 of these survived to spawn.

Spring Chinook Salmon transported and released above Cowlitz Falls Dam provide for natural spawning and harvest opportunity. Because all salmon must be transported above the dams, the number of hatchery-origin salmon in the Upper Cowlitz Subbasin can be managed. However, because harvest rates have not been estimated and spawning ground surveys have not been regularly conducted, the number of those transported spring Chinook Salmon that actually spawn in nature and the proportion of spawners that are of hatchery-origin are unknown.

Table 4.0-4. Current and proposed hatchery programs, smolt production, and marking/tagging for spring Chinook Salmon.

	Hatchery Program		Juvenile Production		Mark / Tag	
Origin & Stock	Current	Proposed	Current	Proposed	Current	Proposed
Hatchery						
Cowlitz Salmon Hatchery	Segre-gated	Segre-gated	1,385,715	1,800,000[1]	100% Ad + 100k CWT/group[2]	100% Ad + 100k CWT/group[2]
Upper Cowlitz Subbasin	None	Integrated	None		NA	?
Natural						
Upper Cowlitz Subbasin	NA		23,982[3]	~50,000[4]	No Mark	No Mark
Tilton Subbasin	NA		NA		NA	

[1] Numbers of smolts proposed for production from the Segregated and Integrated Hatchery Programs will gradually change during recovery, to 1.8 million smolts exclusively from the Integrated Hatchery Program.
[2] All hatchery-origin salmon are adipose fin clipped; 100,000 are implanted with a coded-wire tag.
[3] Number of juvenile Chinook Salmon captured at Cowlitz Falls Fish Facility, 2014-2018.
[4] Reflects expected increases in numbers of spawners and improvements in collection efficiency at Cowlitz Falls Dam.

Currently, hatchery-origin salmon comprise the vast majority of adults reaching the Upper Cowlitz Subbasin, and they provide a large demographic boost to natural production, likely well over what it would be without them, given the relative numbers of hatchery- and natural-origin salmon that have been transported. As downstream passage survival improves and an increasing number of natural-origin salmon are available to spawn naturally, the Cowlitz River spring Chinook Salmon populations will benefit in two ways: (1) the size of the Integrated Hatchery Program can increase, and (2) the number of hatchery-origin salmon transported and that subsequently spawn naturally in the Upper Cowlitz Subbasin will be reduced. Both of these actions will result in a beneficial reduction of the influence of the hatchery environment on the natural population.

4.0.10. Survival and Productivity

Mean SAR (includes all mature salmon that could be accounted for) of hatchery-origin spring Chinook Salmon with CWTs for the 2000-2011 brood years was 1.03%. SAR of natural-origin salmon is unknown because returns are not distinguished by age, but is expected to be greater than that of the hatchery-origin salmon. Because the numbers of spawners and the numbers of returns by brood year are unavailable, productivity (spawner-to-spawner) also cannot be calculated.

4.0.11. Proportionate Natural Influence and Age Composition

Proportionate natural influence (PNI) is an index of the potential influence of hatcheries on salmon populations, as a whole. PNI is calculated using two proportions: the proportion of spawners in nature that are hatchery-origin (pHOS) and the proportion of the hatchery broodstock that is comprised of natural-origin salmon (pNOB). The Hatchery Scientific Review Group (HSRG 2009) recommended that Primary populations with segregated hatchery programs should have pHOS <0.05. For those with integrated hatchery programs, pHOS should be <0.3 and pNOB should exceed pHOS by a factor of two so that PNI >0.67.

For the period over which we can calculate PNI (2007-2017), the Cowlitz River spring Chinook Salmon population was supplemented only by the Segregated Hatchery Program. Mean pHOS was 0.921, well above the upper HSRG recommendation. However, we must recognize that the restoration program was in its early years and in the Recolonization phase, where increasing the number of total spawners in nature is more critical than the origin of those spawners. Collection efficiency of Chinook Salmon smolts at the Cowlitz Falls Fish Facility was highly variable and generally very poor. Mean collection efficiency was 19% from 1996-2016, but increased to 46% in 2017 and 66% in 2018, with the operation of the new North Shore Collector. As the natural-origin abundance increases and we begin the Integrated Hatchery Program, we will have a target pHOS <0.3 and a target pNOB >0.6, with a PNI of >0.67 in the Upper Cowlitz Subbasin, where we have the benefit of being able to completely control the number and origin of salmon that reach the subbasin.

For hatchery-origin spring Chinook Salmon recovered with CWTs from brood years 2000-2011, a mean of 10% were recovered at age-2, 27% at age-3, 52% at age-4, 11% at age-5, and 0.2% at age-6. The age of natural-origin salmon at maturity is currently not available but it is assumed that natural-origin salmon will be older than hatchery-origin salmon. Similar comparisons for returning salmon to calculate productivity (spawning recruits/parent) will also be conducted once data are available.

4.0.12. Marking and Tagging

Currently, all hatchery-origin spring Chinook Salmon are marked with an adipose fin clip and 100,000 of them have a CWT implanted (Table 4.0-4). We plan to maintain this marking/tagging scheme for the ongoing Segregated Hatchery Program for the Cowlitz Salmon Hatchery population. If only a portion of a group is to be tagged, an equal number of tags, with unique codes, will be applied to each raceway so that we can monitor the variation in survival among each raceway and brood year. When the Integrated Hatchery Program begins, we will adjust our marking/tagging scheme, as needed. Currently, the juvenile natural-origin spring Chinook Salmon from the Upper Cowlitz Subbasin are not marked when they are captured at the Cowlitz Falls Fish Facility.

Marking and tagging schemes may vary from year to year, especially for hatchery-origin releases, which may also include experimental groups. Marking and tagging schemes for each group, within each brood year, will be set by the Monitoring and Evaluation subgroup and documented in each year's Annual Operating Plan (as described in more detail in Chapters 9 and 11, respectively, of this FHMP).

4.0.13. Summary

- The continued genetic exchange among spring Chinook Salmon in the hatchery and the few spawning naturally in the Lower Cowlitz Subbasin since 1963 has caused Cowlitz River spring Chinook Salmon to functionally become a single population.
    - Although the ESA framework identifies distinct spring Chinook Salmon populations in the Cispus and upper Cowlitz rivers, returning adults cannot be differentiated. Thus, these populations are managed as a combined "Upper Cowlitz Subbasin" population.
    - Recovery efforts for spring Chinook Salmon will focus on the Upper Cowlitz

Subbasin; spring Chinook Salmon will not be released in the Tilton Subbasin to avoid conflicting management activities for fall Chinook Salmon recovery in the Tilton Subbasin.

  - A framework will be developed using VSP parameters for the eventual release of spring Chinook Salmon into the Tilton Subbasin once the fall Chinook Salmon population there has been established and the capacity to differentiate spring and fall Chinook Salmon smolts has been achieved.

- Cowlitz River spring Chinook Salmon are currently in the Recolonization phase of recovery and, over the period of this FHMP, the focus will be on rebuilding abundance of the natural-origin population by maximizing the numbers of salmon (regardless of origin) spawning in nature in the Upper Cowlitz Subbasin.
  - Juvenile fish passage survival is a key limiting factor for abundance.
  - The current Segregated Hatchery Program will be continued, with continued transport and release of hatchery-origin adults to supplement natural production while also sustaining harvest opportunity.
  - A plan for will be developed in the first year of this FHMP period for beginning to integrate the hatchery program.
  - An Integrated Hatchery Program will be initiated during this FHMP period.
  - Cowlitz Basin program needs, including both recovery and harvest objectives, will be prioritized over out-of-basin programs by developing a plan to define fish/egg disposition and harvest objectives, hatchery surplus, and associated triggers.
- The long-term goal (beyond this FHMP) will be for the Integrated Hatchery Program to support all recovery and harvest management needs, providing for:
  - Population recovery upstream of Mayfield Dam.
  - Mitigating for lost harvest opportunity, in which a percentage of the run will be managed exclusively for harvest.
- We will continue to evaluate the appropriate program structure to manage for individual populations and Local Adaptation.

The following sections present information on the Upper Cowlitz Subbasin spring Chinook population (Section 4.1) and Tilton Subbasin spring Chinook Salmon population (Section 4.2).

Population: Upper Cowlitz Subbasin Spring Chinook Salmon *Oncorhynchus tshawytscha*

Evolutionarily Significant Unit:	Cascade spring Chinook Salmon stratum Lower Columbia River Chinook Salmon Evolutionarily Significant Unit (ESU) Lower Columbia River Salmon Recovery Region
ESA Listing Status:	Threatened; Listed in 2005, reaffirmed in 2011 and 2016
Population Recovery Designation:	Primary
Population Viability Rating:	
Baseline:	Very Low
Objective:	Very High
Recovery Goal:	3,600 natural-origin salmon spawning in the Upper Cowlitz Subbasin
Current Recovery Phase:	Recolonization
Current Hatchery Program(s):	Cowlitz Salmon Hatchery Segregated Hatchery Program, 1.8 million smolts
Proposed Hatchery Program(s)	<u>FHMP period</u> Segregated Hatchery Program Integrated Hatchery Program Combined 1.8 million age-2 (yearling) smolts <u>Long-term</u> Integrated Hatchery Program; 1.8 million age-2 (yearling) smolts

4.1. Spring Chinook Salmon: Upper Cowlitz Subbasin Population

4.1.1. Purpose

This section describes the current status of the Upper Cowlitz Subbasin spring Chinook Salmon population based on recent and available data. For management purposes, spring Chinook Salmon are currently only being reintroduced above Cowlitz Falls Dam (Cispus and upper Cowlitz drainages). All spring Chinook Salmon above Cowlitz Falls Dam are being managed as a single population because unique populations in the Cispus and upper Cowlitz rivers cannot be managed separately. Therefore, for the sake of clarity, specificity, and to reduce confusion, this population is hereafter referred to in the FHMP as the Upper Cowlitz Subbasin spring Chinook Salmon population (Figure 4.1-1). The FHMP identifies VSP metrics needed to evaluate this population's status with regard to reaching recovery under ESA guidelines. Where appropriate, the FHMP proposes changes to both hatchery and monitoring programs to facilitate evaluation of progress toward population recovery. We will continue to evaluate the hatchery program and fisheries management and will make refinements or adjustments, as described in this FHMP, to effectively supplement and manage the Upper Cowlitz Subbasin spring Chinook Salmon population.

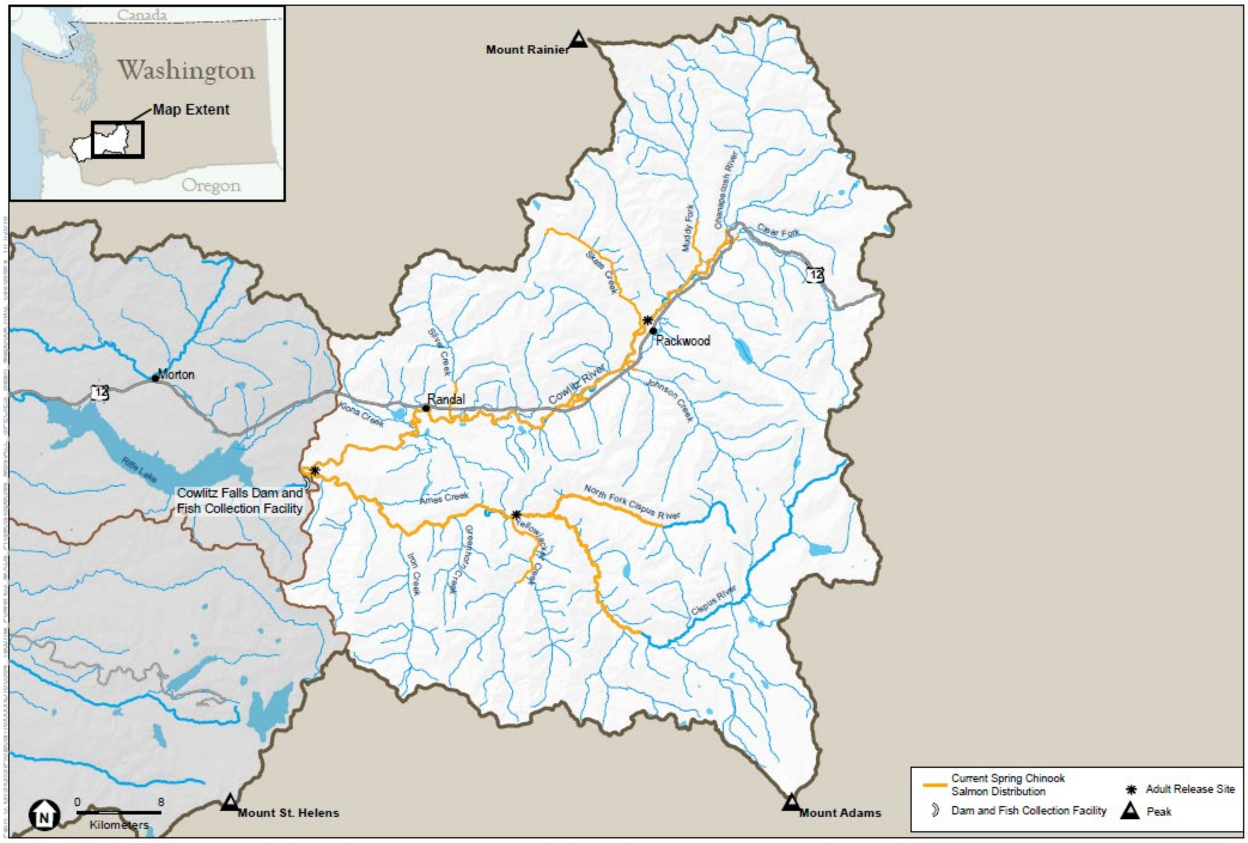


Figure 4.1-1. Distribution of spring Chinook Salmon in the Upper Cowlitz Subbasin.

4.1.2. Population Description

The Upper Cowlitz Subbasin spring Chinook Salmon population includes all natural-origin spring Chinook Salmon that occupy the Cispus River and upper Cowlitz River and all of their tributaries above Cowlitz Falls Dam (Figure 4.1-1). Spring Chinook Salmon from the Segregated Hatchery Program at Cowlitz Salmon Hatchery also contribute to this population through the transport and release of hatchery-origin adults in the Upper Cowlitz Subbasin to supplement natural production during the current Recolonization phase of recovery. This combined population in the Upper Cowlitz Subbasin is currently the only spring Chinook Salmon population remaining of the three populations (Cispus, upper Cowlitz, and Tilton rivers) that historically inhabited the Cowlitz Basin upstream of the Toutle River (NOAA Fisheries 2004).

This population was found to be “Depressed” (LCFRB 2010) and, as part of the lower Columbia River ESU, was listed as threatened under the ESA in 2005, and reaffirmed in 2011 and 2016. Because this population is classified as a Primary population for recovery of the lower Columbia River ESU, it must attain its recovery and viability goals for the ESU to be considered recovered (LCFRB 2010). Although hatchery-origin adult returns from the Segregated Hatchery Program are relatively abundant, returns of natural-origin adults remain well below the recovery target of 3,600 natural-origin adults spawning in the Upper Cowlitz Subbasin (Table 4.1-1), requiring continued supplementation of natural production through the transport and release of hatchery-origin adults to the Upper Cowlitz Subbasin (Figure 4.1-2).

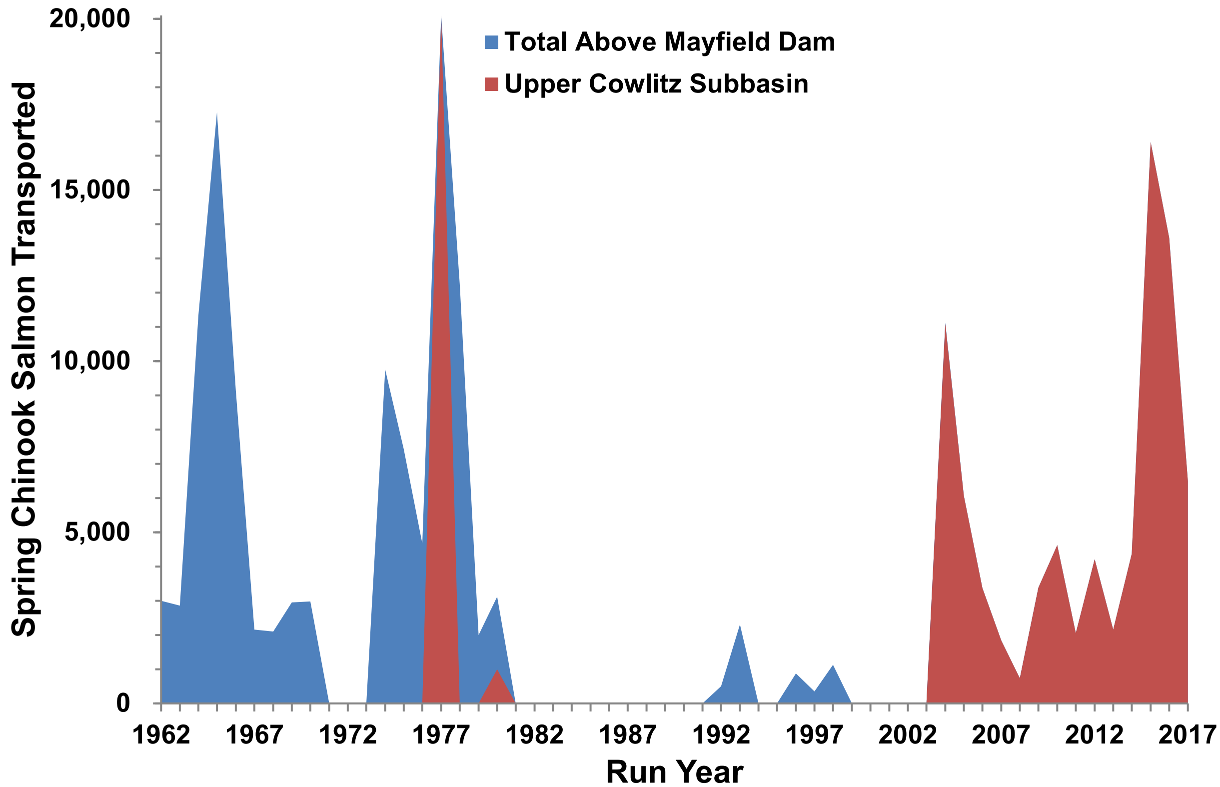


Figure 4.1-2. Numbers of total spring Chinook Salmon transported above Mayfield Dam and specifically to the Upper Cowlitz Subbasin, 1962-2017. Note: specific destination of the salmon was not documented in all years. Data are from WDFW annual reports and Tacoma Power data.

4.1.3. Natural Production

4.1.3.1. Abundance

Two critical monitoring metrics for salmon management are the numbers that return at maturation and their disposition (Figures 4.1-2 and 4.1-3; Table 4.1-1). Spring Chinook Salmon that survive to begin their return migration may be harvested in ocean, Columbia River, or lower Cowlitz River fisheries. Those escaping harvest may return to Cowlitz Salmon Hatchery and be used as broodstock or be transported upstream to the natural spawning grounds, where they may also be recovered and counted in fisheries or as carcasses on the spawning grounds. They may also die prior to spawning from predation or disease and never be recovered, or they may remain in the Lower Cowlitz Subbasin and attempt to spawn there. Monitoring these dispositions allows us to evaluate population health, productivity, and progress toward recovery.

The recovery goal for the Upper Cowlitz Subbasin spring Chinook Salmon population is a total annual abundance of 3,600 natural-origin adults spawning in nature in the Upper Cowlitz Subbasin - 1,800 in each of the Cispus and Upper Cowlitz subbasins (LCFRB 2010). Only natural-origin spring Chinook Salmon that are captured at Cowlitz Salmon Hatchery, transported to the Upper Cowlitz Subbasin, and survive to spawn in nature are counted toward the recovery goal.

Table 4.1-1. Estimated mean, minimum, and maximum numbers of all adult hatchery- and natural-origin adult spring Chinook Salmon from the Upper Cowlitz Subbasin population that could be accounted for at recovery locations, 2007-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Origin and Recovery Location	Mean	Minimum	Maximum
Hatchery-origin			
Total Run[1]	14,145	4,070	36,233
Harvest[2]	7,306	1,453	19,747
Ocean harvest	2,761	616	8,656
Columbia River harvest	469	117	1,525
Lower Cowlitz River harvest	3,712	550	9,199
Upper Cowlitz Subbasin harvest	365	12	1,408
Total Return to Cowlitz River[3]	13,998	3,180	26,052
Remain in Lower Cowlitz Subbasin	746	230	1,273
Return to Cowlitz Salmon Hatchery	6,458	1,884	17,318
Collected for Broodstock	1,459	906	2,146
Transported to Upper Cowlitz Subbasin	4,538	475	14,790
Spawners in Upper Cowlitz Subbasin[4]	3,266	347	10,446
Natural-origin			
Total Run[1]	240	102	554
Harvest[2]	62	14	158
Ocean harvest	49	9	131
Columbia River harvest	6	0	31
Lower Cowlitz River harvest	6	0	22
Upper Cowlitz Subbasin harvest	1	1	2
Total Return to Cowlitz River[3]	185	80	419
Remain in Lower Cowlitz Subbasin	0	0	0
Return to Cowlitz Salmon Hatchery	180	80	397
Collected for Broodstock	0	0	0
Transported to Upper Cowlitz Subbasin	178	70	397
Spawners in Upper Cowlitz Subbasin[4]	140	55	314
Combined Hatchery- and Natural-origin			
Total Run[1]	14,525	4,317	36,760
Harvest[2]	7,404	1,507	19,921
Ocean harvest	2,840	641	8,767
Columbia River harvest	479	123	1,581
Lower Cowlitz River harvest	3,720	551	9,209
Upper Cowlitz Subbasin harvest	366	13	1,410
Total Return to Cowlitz River[3]	11,207	3,374	26,412
Remain in Lower Cowlitz Subbasin	849	230	1,359
Return to Cowlitz Salmon Hatchery	6,638	1,964	17,511
Collected for Broodstock	1,459	906	2,146
Transported to Upper Cowlitz Subbasin	4,716	555	14,983
Spawners in Upper Cowlitz Subbasin[4]	3,406	428	10,598

[1] Sum of all harvest in fisheries below Mayfield Dam, those remaining in the Lower Cowlitz Subbasin, and returns to Cowlitz Salmon Hatchery.
[2] Total of harvest in ocean, Columbia River, lower Cowlitz River, and Upper Cowlitz Subbasin fisheries.
[3] Sum of lower Cowlitz River harvest, those remaining in the Lower Cowlitz Subbasin, and returns to Cowlitz Salmon Hatchery.
[4] Estimated by subtracting estimated harvest loss and multiplying by standard fallback (12%) and pre-spawn mortality (10%) rates from the numbers transported.

Data that are critical to monitoring the Upper Cowlitz Subbasin spring Chinook Salmon population have been only sporadically collected and are incomplete. First, natural production estimates for juveniles are only collected at Cowlitz Falls Fish Facility, where collection efficiency has been poor and the data have been confounded by the presence of fall Chinook Salmon, which were released into the Upper Cowlitz Subbasin (2010-2016); thus, trends in juvenile spring Chinook Salmon abundance and survival are difficult to discern. Second, adult returns have not been reconstructed by brood year. However, our ability to evaluate abundance and survival will improve because fall Chinook Salmon releases into the Upper Cowlitz Subbasin have ceased, juvenile Chinook Salmon collection efficiency at Cowlitz Falls Fish Facility dramatically improved in 2017 and 2018, and the monitoring program has improved and will continue to do so, allowing for full reconstructions of each brood year.

Monitoring trends in adult production is more readily achieved because the number of adults caught at Cowlitz Salmon Hatchery and transported above Cowlitz Falls Dam is known. From 2007-2017, a mean 305 adult natural-origin Spring Chinook Salmon escaped the ocean and Columbia River fisheries and entered the Cowlitz River and 169 returned to Cowlitz Salmon Hatchery. A mean of 178 adult natural-origin spring Chinook Salmon were transported to the spawning grounds in the Upper Cowlitz Subbasin. We estimate that a mean of 1 natural-origin salmon was exploited annually in the Upper Cowlitz subbasin. Spawning ground surveys have not been conducted in the Upper Cowlitz Subbasin; however, by using our estimate of exploitation and standard fallback (over Cowlitz Falls Dam; 12%) and pre-spawn mortality (10%) rates, we estimate that a mean of 140 of those transported survived to spawn. Some natural spawning by spring Chinook Salmon occurs in the Lower Cowlitz Subbasin, these salmon are not considered part of the Upper Cowlitz Subbasin population and, therefore, are not included in abundance estimates.

4.1.3.2. Harvest

Natural-origin Upper Cowlitz Subbasin spring Chinook Salmon contribute to important commercial, sport, and tribal fisheries in the Pacific Ocean, lower Columbia River, and within the Cowlitz Basin. From 2007-2017, an annual mean of 62 natural-origin spring Chinook Salmon were harvested, comprising 26% of the total run, with 80%, 9%, 9%, and 2% of the total harvest/exploitation mortality occurring in ocean, Columbia River, lower Cowlitz River, and Upper Cowlitz Subbasin fisheries, respectively. Natural-origin spring Chinook Salmon must be released if caught in the Cowlitz Basin, so they suffer only post-release hooking mortality. From 2007-2017, a mean of 4% of the natural-origin salmon entering the Cowlitz River were lost to harvest.

4.1.3.3. Disposition

All natural-origin returns to Cowlitz Salmon Hatchery are assumed to have originated from the Upper Cowlitz Subbasin and are transported above Cowlitz Falls Dam. From 2007-2017, a mean of 180 natural-origin spring Chinook Salmon adults returned to Cowlitz Salmon Hatchery. Of those, none were kept for broodstock, so a mean of 178 natural-origin Upper Cowlitz Subbasin adult spring Chinook Salmon were transported and released into the Upper Cowlitz Subbasin (Figures 4.1-2 and 4.1-3; Table 4.1-1).

4.1.3.4. Spawning in Nature

Upper Cowlitz Subbasin natural-origin spring Chinook Salmon abundance has been far below its recovery goal of 3,600 natural-origin adults spawning in nature (Figure 4.1-3; Tables 4.1-1 and 4.1-2). From 2007-2017, a mean of 178 natural-origin spring Chinook Salmon adults were transported to the Upper Cowlitz Subbasin. Of these, a mean of 1 (0.8%) was removed by sport fisheries in the Upper Cowlitz Subbasin; using standard fallback (12%) and pre-spawn mortality (10%) rates, we estimate that 140 (79%) survived to spawn.

4.1.3.5. Smolt Production

In 2017 and 2018, 56,049 and 25,920 age-1 (sub-yearling) and 296 and 1,150 age-2 (yearling) spring Chinook Salmon were captured at Cowlitz Falls Fish Facility, which captures juveniles emigrating from the Upper Cowlitz Subbasin. Collection efficiency was estimated to be 46.2% and 65.7%, respectively, so we estimated that 121,318 and 39,452 age-1 spring Chinook Salmon were produced from the 2016 and 2017 brood years, respectively, and 641 and 1,750 age-2 spring Chinook Salmon were produced from the 2015 and 2016 brood years in the Upper Cowlitz Subbasin.

From 2007-2017, a mean of 4,716 (combined hatchery- and natural-origin) spring Chinook Salmon adults were released into the Upper Cowlitz Subbasin. However, from 2010-2015, a mean of 3,983 adult fall Chinook Salmon, along with a mean of 4,894 adult spring Chinook Salmon (a mean of 55% of the Chinook Salmon released were fall Chinook Salmon) were also released into the Upper Cowlitz Subbasin. During 2011-2016, a mean of 14,463 juveniles were captured at the Cowlitz Falls Fish Facility, of which 13,930 (96.0%) were age-1 and 533 (4.0%) were age-2. However, offspring of fall and spring Chinook Salmon cannot be differentiated and both seem to migrate past Cowlitz Falls Dam as sub-yearlings, so we do not know how many juvenile spring Chinook Salmon were produced in the Upper Cowlitz Subbasin from the 2010-2016 spawn years. It is likely that all of the age-2 Chinook Salmon caught in those years were spring Chinook Salmon.

4.1.3.6. Natural-origin Survival and Productivity

Survival and productivity are the key metrics for monitoring populations. However, currently neither SAR nor productivity can be calculated for the Upper Cowlitz Subbasin spring Chinook Salmon population. Smolt abundance estimates are accurate, based on the numbers captured at Cowlitz Falls Dam and transported to and released from Cowlitz Salmon Hatchery, but returns have not been documented by age, so a full run reconstruction of each brood year is not possible. Additionally, no spawning ground surveys have been conducted to document survival of adults from release to spawn, so the number of spawners can only be roughly estimated.

4.1.3.7. Age Composition

Age composition of natural-origin salmon cannot be completely calculated from the data in ISIT because they are not compiled by age or brood year. Age classes are only characterized as “jacks (<59 cm)” or “adults (>59 cm),” and these data are only available for returns to Cowlitz Salmon Hatchery, not for any other recovery locations. From ISIT data (provided by WDFW on 28 June 2019), jacks comprised 13% and adults 87% of the natural-origin salmon that returned to Cowlitz Salmon Hatchery from 2007-2017.

Table 4.1-2. Mean, minimum, and maximum hatchery and natural spawning metrics for Lower Cowlitz Subbasin fall Chinook Salmon, 2007-2017 spawn/brood years. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

	2007-2017 Spawn/Brood Years		
Spawning Location, Metric	Mean	Minimum	Maximum
Hatchery			
Adults Collected for Broodstock	1,459	906	2,146
Hatchery-origin	1,459	906	2,146
Natural-origin	0	0	0
Pre-spawn Survival Rate	90%	86%	96%
Adults Spawned	1,317	814	1,886
Hatchery-origin	1,317	814	1,886
Natural-origin	0	0	0
Total Green Eggs	1,864,239	1,072,235	2,772,220
Mean Fecundity	2,791	1,355	3,663
Smolts Released	1,424,865	881,377	1,990,454
Green Egg-to-Smolt Survival	77%	72%	82%
Smolt Productivity (smolts / spawner)	1,144	570	1,545
Nature			
Spawners*	3,406	428	10,598
Hatchery-origin	3,266	347	10,446
Natural-origin	140	55	314
Smolts Produced Smolt Productivity (smolts / spawner)	Unknown - fall Chinook Salmon were present		

* Calculated as Number Transported - Estimated Harvest - 12% Fallback - 10% pre-spawn mortality.

4.1.4. Hatchery Production

Hatchery production metrics must be monitored to ensure that production goals are met, evaluate the effectiveness of the program, and understand the magnitude of hatchery influence on the natural population. Key monitoring metrics are numbers of salmon harvested, collected for broodstock, and spawned (by origin, age, and sex), smolts released, and salmon returning to the Cowlitz River, Cowlitz Salmon Hatchery, and remaining in nature in the Cowlitz Basin and elsewhere. Using these data, we will be able to calculate and monitor smolt-to-adult survival and return rates and evaluate the effectiveness of the hatchery program.

All hatchery-origin smolts are released directly from Cowlitz Salmon Hatchery and support both the recovery of the Upper Cowlitz Subbasin population and harvest below and above Mayfield Dam. These hatchery-origin salmon are not part of the lower Columbia ESU; however, because this is an endemic hatchery stock derived from the original Upper Cowlitz Subbasin spring Chinook Salmon population, it serves as a temporary gene bank for the reintroduction of spring Chinook Salmon into the Cispus, upper Cowlitz, and Tilton rivers.

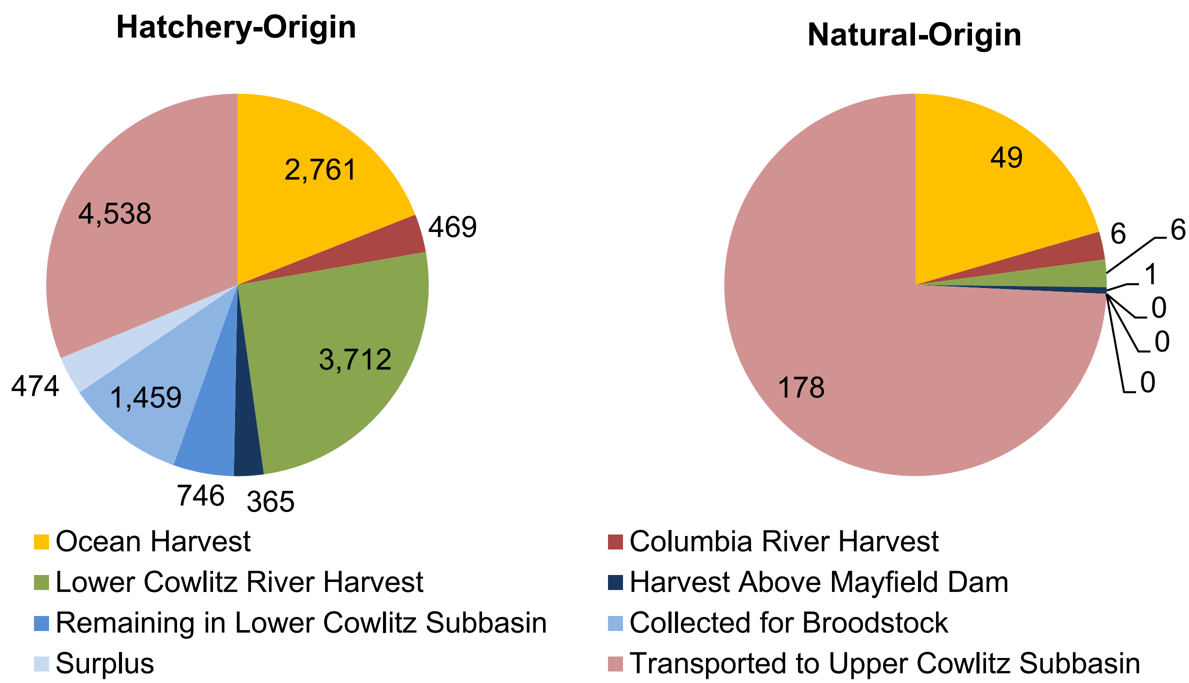


Figure 4.1-3. Mean numbers and proportions of hatchery- and natural-origin adult Upper Cowlitz Subbasin spring Chinook Salmon caught in ocean, Columbia River, or lower Cowlitz River fisheries, or that were transported above Cowlitz Falls Dam (and were harvested or remained in the Upper Cowlitz Subbasin), 2007-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

4.1.4.1. Abundance

From 2007–2017, a mean of 13,998 hatchery-origin spring Chinook Salmon escaped the ocean and Columbia River fisheries and entered the Cowlitz River and 6,458 hatchery-origin salmon returned to Cowlitz Salmon Hatchery. A mean of 4,538 hatchery-origin spring Chinook Salmon were transported to the Upper Cowlitz Subbasin, where we estimate that a mean of 365 were harvested and 3,266 survived to spawn.

4.1.4.2. Harvest

From 2007–2017, annual mean total harvest of hatchery-origin spring Chinook Salmon was 7,306 adult salmon, comprising 52% of the total run, with 38%, 6%, 51%, and 5% of the total harvest occurring in the ocean, Columbia River, lower Cowlitz River, and Upper Cowlitz Subbasin fisheries, respectively (Figure 4.1-3; Table 4.1-1). From 2007–2017, a mean of 29% of the hatchery-origin salmon entering the Cowlitz River were lost to harvest.

4.1.4.3. Disposition

From 2007-2017, a mean of 6,458 hatchery-origin salmon returned to Cowlitz Salmon Hatchery. A mean of 1,459 were collected for broodstock. Hatchery-origin spring Chinook Salmon returning to Cowlitz Salmon Hatchery that are deemed to be in excess of broodstock requirements may be transported above Cowlitz Falls Dam to supplement natural spawning and provide harvest opportunities in the Upper Cowlitz Subbasin or surplused. From 2007-2017, a mean of 4,538 hatchery-origin spring Chinook Salmon were transported to the Upper Cowlitz Subbasin, representing 32% of those returning to the Cowlitz River (Figures 4.1-2 and 4.1-3; Table 4.1-1). Of those, a mean of 365 (8%) were harvested in sport fisheries in the Upper Cowlitz Subbasin. No spawning ground surveys have been conducted to document survival to spawning; however, by using standard fallback (12%) and pre-spawn mortality (10%) rates, we estimate that 3,266 (78%) survived to spawn. A mean of 658 hatchery-origin adult spring Chinook Salmon were surplused each year.

4.1.4.4. Hatchery Spawning

From 2007-2017, an annual mean of 1,459 adult hatchery-origin spring Chinook Salmon were kept for broodstock, comprising 23% of those returning to Cowlitz Salmon Hatchery (Figure 4.1-3; Table 4.1-1). Mean pre-spawn survival was 90% and we spawned a mean of 1,317 adults over those years.

4.1.4.5. Hatchery Rearing

The Upper Cowlitz Subbasin spring Chinook Salmon population is currently in the Recolonization phase and production from the Segregated Hatchery Program supplements the natural population through the transport and release of hatchery-origin adults to spawn naturally in the subbasin. From 2007-2017, a mean of 1,272,801 age-2 (yearling) smolts were released into the lower Cowlitz River, along with 334,540 age-1 (sub-yearling) salmon from 2007-2011. We will rigorously monitor hatchery production by documenting the origin, sex, and age of salmon retained for broodstock and those spawned, fecundity, fertility, and survival between life stages, and the numbers released at all life stages.

4.1.4.6. Hatchery-origin Survival and Productivity

Brood years 2005-2012 (released in 2007-2014) had a mean TSAR of 1.13% and a mean SAR of 0.63%. An annual mean of 4,143 adults returned to Cowlitz Salmon Hatchery from brood years 2007-2011 (the years for which we have a full complement of returns). All data are not available for calculating productivity.

4.1.4.7. Age Composition

As noted above, age composition cannot be completely calculated from the data in ISIT because they are not compiled by age or brood year. Age classes are only characterized as “jacks (<59 cm)” or “adults (>59 cm)” and these data are only available for returns to Cowlitz Salmon Hatchery, not for any other recovery locations. However, the data from CWTs in the RMIS database (www.rmis.org) provide reliable age composition data for the tagged hatchery-origin salmon. These data show that, for the 1999-2012 brood years, a mean of 10% of the hatchery-origin salmon were recovered at age-2, 26% at age-3, 52% at age-4, 11% at age-5, and 0.3% at age-6. In comparison with natural-origin age composition during the 2007-2017 run years (Section 4.1.3.7), a mean of 34% of the hatchery-origin salmon returned as jacks and 66% returned as adults.

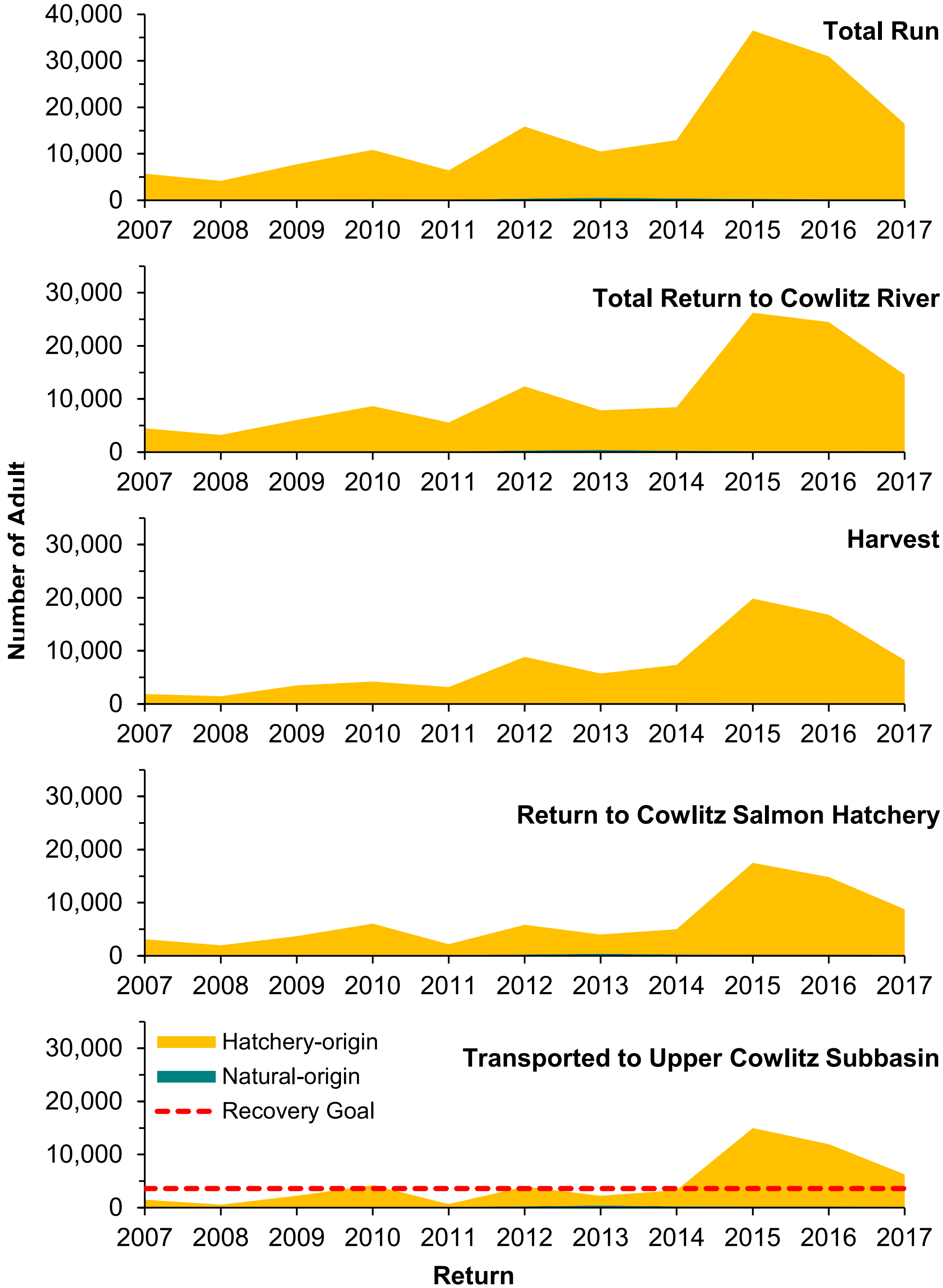


Figure 4.1-4. Estimated total run size for adult natural- and hatchery-origin Upper Cowlitz Subbasin spring Chinook Salmon and the numbers that returned to the Cowlitz River, were harvested, returned to Cowlitz Salmon Hatchery, and were transported above Cowlitz Falls Dam, 2007-2017. Note: numbers of natural-origin adults may be too small to be visible. Data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

4.1.5. Proportionate Natural Influence

PNI is an important metric that is useful for monitoring both hatchery and natural populations. Changes in this metric can indicate an increase or decrease in the effect of hatchery-origin salmon on the natural population.

From 2007-2017, mean pHOS was 0.921 (0.794-0.986), based on the numbers of hatchery- and natural-origin salmon transported above Cowlitz Falls Dam minus the estimated harvest and assumed 10% pre-spawn mortality. The Segregated Hatchery Program uses 100% hatchery-origin salmon for broodstock, so mean pNOB = 0 and, therefore, mean PNI for the Upper Cowlitz Subbasin spring Chinook Salmon population was also 0. HSRG guidelines (HSRG 2009) Primary populations with segregated hatchery programs are that pHOS <0.05. For Primary populations with integrated hatchery programs, pHOS should be <0.3 and pNOB greater than two time pHOS, so that PNI >0.67.

4.1.6. Future

The Upper Cowlitz Subbasin spring Chinook Salmon population is designated as a Primary population for achieving MPG and ESU recovery goals, with a minimum abundance target of 3,600 natural-origin spawners in nature (1,800 in each of the Cispus and upper Cowlitz rivers). Population viability remains at a rating of Very Low, with natural production being supplemented by Segregated Hatchery Program adults being transported to the Upper Cowlitz Subbasin (WDFW and LCFRB 2016). From 2007-2017, the total number of natural-origin spring Chinook Salmon transported to the Upper Cowlitz Subbasin has ranged from 70-397 (mean = 178). Based on harvest estimates and assumed 12% fallback rate and 10% pre-spawn mortality, a mean of 140 of those survived to spawn, so estimated natural-origin spawner abundance has ranged from 55-314 and has not been close to the minimum natural-origin spawner abundance recovery target during any monitoring years. pHOS for this population has also not met the HSRG (2009) standard of pHOS <0.3 in any of the years of monitoring, ranging from 0.794-0.986.

During the period covered by this FHMP we will continue using the existing Segregated Hatchery Program to produce 1.8 million yearling smolts to sustain harvest opportunities downstream of Mayfield Dam, while also continuing the transport and release of hatchery-origin adults above Cowlitz Falls Dam to supplement natural production. Collection efficiency at Cowlitz Falls Dam has greatly improved over the last 2 years, from a mean of 19% from 1996-2016 to 46% in 2017 and 66% in 2018, so we can reasonably expect natural-origin returns to increase. In the first year of the FHMP period, we will develop a plan for beginning to integrate the hatchery program and will implement that plan as soon as the FTC approves it. The long-term goal will be to transition fully to an Integrated Hatchery Program that supports the recovery of populations upstream of Mayfield Dam, as well as harvest both downstream of Mayfield Dam and in the Upper Cowlitz Subbasin.

4.1.6.1. Goals for Conservation and Recovery

Progress toward achieving conservation and recovery goals is evaluated through monitoring of standard fisheries management metrics (Table 4.1-3; Appendix A, Full Big Table). The Upper Cowlitz Subbasin spring Chinook Salmon population had an historical abundance of about 29,800 salmon and has a recovery goal of 3,600 natural-origin adult spawners in nature (Table 4.0-1 in Overview section). In 2016, the abundance and productivity of this population was rated as Very Low (WDFW and LCFRB 2016) and still remains very far from meeting its recovery target (Figure 4.1-3; Table 4.1-1).

Table 4.1-3. Current values (5-year mean) and FHMP period and long-term (Recovery Plan) goals of key monitoring metrics for Upper Cowlitz Subbasin spring Chinook Salmon.

Metric		Current	FHMP Goal	Long-term Goal
Total Adult Abundance		21,628	15,367	19,335
Hatchery-origin		21,155	13,763	13,449
Natural-origin		473	1,603	5,886
Total Adults to Mouth of Cowlitz River		16,431	10,214	14,182
Hatchery-origin		16,083	8,691	8,377
Natural-origin		349	1,522	5,805
Hatchery Broodstock Spawned (adults)		1,645	1,250	1,250
Hatchery-origin		1,645	1,000	0
Natural-origin		0	250	1,250
pNOB (Spawner = spawned; both programs)		0.000	≥0.2	1
Adult Spawners in Nature in Upper Cowlitz Subbasin*		5,497	2,000	5,143
Hatchery-origin		5,309	1,000	1,543
Natural-origin		188	1,000	3,600
pHOS (Spawner = spawners in nature)		0.935	<0.5	<0.3
PNI (Spawner)		0.000	>0.17	>0.67
Smolt Abundance		?	1,860,000	1,980,000
Hatchery-origin (Smolts Released)		1,852,960	1,800,000	1,800,000
Natural-origin (from Upper Cowlitz Subbasin)		? (fall Chinook Salmon present)	60,000	180,000
Smolt Collection Efficiency / Passage Survival		25.9%	65%	75%
Total Smolt-to-Adult Survival (all recoveries; including jacks)				
Hatchery-origin		0.717	1%	1%
Natural-origin (if unavailable, presumed higher than hatchery-origin)		?	2%	2%
Mean Age				
Hatchery-origin		3.7	3.8	4.2
Natural-origin		?	?	4.6
Precocious Maturation Rate				
Hatchery-origin	Mini-jacks	4.6%	5%	5%
	Jacks	27.9%	10%	10%
Natural-origin	Jacks	13.3%	10%	10%
Natural-origin Productivity				
Smolts / spawner		?	>100	≥100
Adults + Jacks / spawner		?	>1	≥1
Total Harvest (from all fisheries)		11,638	?	?
Hatchery-origin		11,501	?	?
Natural-origin		137	?	?
Harvest (% of total adult return)		53.8%	?	?
Hatchery-origin		54.7%	?	?
Natural-origin		25.1%	?	?

* Estimated by subtracting estimated harvest loss and multiplying by standard fallback (12%) and pre-spawn mortality (10%) rates from the numbers transported.

- **Long-term Goals**: The goal for this Primary spring Chinook Salmon population is full recovery in the Upper Cowlitz Subbasin, which would include, but not be limited to:
    - Adult abundance of >3,600 natural-origin adults spawning in nature (1,800 in each of the Cispus and upper Cowlitz river drainages).
    - Supplement with an Integrated Hatchery Program in which pNOB = 1 and pHOS <0.3, such that PNI >0.67.
    - Manage a percentage of the hatchery production for harvest, both below and above Mayfield Dam, to mitigate for lost harvest opportunity.
- **FHMP Goals:** The goals for this program during this FHMP period are attainable steps toward population recovery, focusing on increasing the abundance of natural-origin spring Chinook Salmon in the Upper Cowlitz Subbasin, based on the following:
    - Maximizing the total number of spring Chinook Salmon spawning in the Upper Cowlitz Subbasin by continuing to use the existing Segregated Hatchery Program to supplement natural production.
    - Fish passage survival at Cowlitz Falls Dam is a key limiting factor, so we want to:
        - Improve collection efficiency.
        - Maintain high survival of the collected smolts.
    - Develop a disposition plan during the first year of the FHMP period that:
        - Prioritizes Cowlitz Basin program needs, including both recovery and harvest objectives, over out-of-basin needs.
        - Identifies decision point triggers and objectives for salmon/egg dispositions and harvest.
        - Defines surplus.
        - Balances when salmon and/or their offspring are surplus and no longer critical to Cowlitz Basin restoration needs.
        - Allows for only those salmon or their eggs/offspring that are determined to be surplus to the Cowlitz Basin programs to be exported to meet other State obligations outside of the Cowlitz Basin.
    - Develop a plan for initiating an Integrated Hatchery Program in the first year of the FHMP period, with potentially new or revised Decision Rules (e.g., based on the number of returning adults, the number of natural-origin smolts released at Cowlitz Salmon Hatchery, pHOS, pNOB, PNI, SAR, and/or productivity).
    - Increase and improve monitoring, evaluation, and data collection, including numbers by origin, age, and sex of all recoveries:
        - Returning to Cowlitz Salmon Hatchery.
        - Retained as broodstock.
        - Transported and released upstream of Mayfield Dam.
        - Hatchery surplus.
        - Hatchery strays to/from outside of the Cowlitz Basin.
        - Actual spawners in nature.

        - Natural smolts produced.
    - Reduce the abundance of hatchery surplus by increasing hatchery-origin harvest without a concomitant increase in natural-origin exploitation rate.

4.1.6.2. Management Targets

Reestablishing a self-sustaining population will ultimately require natural spawning by a sufficient number of natural-origin salmon and for their survival to exceed replacement (spawner-to-spawner productivity >1). Currently, low natural-origin abundance, high pHOS, poor smolt production and survival, and natural-origin harvest losses prevent this population from meeting its recovery goals.

- **Natural Production:** The goal of population restoration is to develop self-sustaining, naturally reproducing populations. Efforts to improve downstream smolt collection efficiency and passage survival at Cowlitz Falls Dam have resulted in an increase in collection efficiency in 2017 and 2018, so we are anticipating an increase in natural-origin adult abundance, beginning in 2021. Likewise, the ability to accurately estimate natural production will improve as collection efficiency improves at downstream passage facilities. Counts of salmon transported to the Upper Cowlitz Subbasin are considered to be reliable numbers but harvest estimates are imprecise and pre-spawn mortality (a critical measure for estimating the number of actual spawners) has not been estimated for salmon spawning in nature (neither hatchery- nor natural-origin), so actual pHOS is unknown. As part of this FHMP, Tacoma Power will develop and begin to implement a rigorous monitoring program that is focused on evaluating program effectiveness based on regionally accepted VSP parameters.

  During the current Recolonization phase of recovery, natural production in the Upper Cowlitz Subbasin has relied primarily on spawning by transported hatchery-origin adults. We are accepting the resulting near-term increase in pHOS (>0.3) in order to receive the expected demographic boost that the population needs and, as such, all hatchery production that is not used for Upper Cowlitz Subbasin hatchery production will be used to supplement natural production in the Upper Cowlitz Subbasin during this FHMP period. As natural-origin productivity and abundance increase, reductions in releases of hatchery-origin adults into the Upper Cowlitz Subbasin, reductions in natural-origin exploitation, and/or increased hatchery-origin harvest will also likely be needed to reduce pHOS to an acceptable level (<0.3).

    - **Abundance – Transport and Natural Spawning:** We will focus our monitoring of natural-origin production on documenting the total number of hatchery- and natural-origin salmon released, their respective pre-spawn mortality rates, the number that survive to spawn, and pHOS. These metrics are critical for achieving recovery. The numbers of hatchery- and natural-origin adults transported to the Upper Cowlitz Subbasin will be managed to maximize natural-origin production and minimize pHOS in order to maximize PNI.
    - **Smolts Produced in Nature:** Natural-origin smolt production from the Upper Cowlitz Subbasin is not well known. We will continue to increase collection efficiency at the Cowlitz Falls Fish Facility, which will improve our estimate of natural-origin smolt production and increase the numbers of natural-origin smolts released downstream and, subsequently, of adults returning.
    - **Smolt-to-Adult Survival:** Smolt abundance has been low and uncertain due to poor collection efficiency and, from 2011-2016, our estimates of spring Chinook Salmon

juvenile migrant abundance have been confounded by the presence of juvenile fall Chinook Salmon. Additionally, returns of mature natural-origin salmon have not been documented by age, so SAR cannot be estimated. To monitor this index through our M&E Program, we will collect scale samples from recoveries at all sampling sites.

- **Productivity (Recruits/Spawner):** Productivity (adult natural-origin F_1 recruits / F_0 spawner) is the primary metric for monitoring natural populations, so collection of the necessary data is critical. However, because returns of mature natural-origin salmon have not been documented by age, spawner productivity also cannot be estimated. Productivity can also be calculated as smolts/spawner but the smolt estimate is unreliable, as described for SAR, above. We will monitor this index as the data become available through our M&E Program.
- **Age Composition:** In ISIT, age classes are only characterized as "adults (>49 cm)" or "jacks (<49 cm)" and these data are available only for the returns to Cowlitz Salmon Hatchery; all other abundance data in ISIT (e.g., harvest, spawners in nature, or hatchery broodstock) provide no information about the ages of the salmon included in the number provided. For natural-origin salmon, we have only the incomplete ISIT data, so we can only provide percentages of "jacks" and "adults," as we cannot separate the age-4, age-5, and age-6 adults, and only by run year, not brood year (and only for those that returned in 2007-2017). We will improve our monitoring of this metric by collecting the necessary samples and data so that we can estimate the contribution of each age to the mature returns.
- **Habitat:** Activities by Tacoma Power to protect and enhance habitat in the Upper Cowlitz Subbasin are expected to benefit smolt production and the subsequent return of natural-origin salmon, but it is difficult to monitor these benefits due to a number of confounding factors. Since we cannot estimate smolt production from the Lower Cowlitz Subbasin, we cannot directly evaluate the effectiveness of those efforts.

- **Hatchery Production:** During recovery efforts to date, hatchery influences on the Upper Cowlitz Subbasin spring Chinook Salmon population have consisted of the transport and release of relatively large numbers of hatchery-origin adults to spawn naturally (mean pHOS = 0.921) and there has been no natural-origin salmon in the broodstock, meaning that both pNOB and PNI equal zero. Given the low returns of natural-origin adults and the abundance of hatchery-origin adults released in the subbasin, pHOS consistently exceeds recovery targets and natural influence on the Upper Cowlitz Subbasin population has been minimal.

  To give the population the demographic boost that it needs, we will continue transporting hatchery- and natural-origin adults to the Upper Cowlitz Subbasin over the period of this FHMP. However, we will also initiate a small Integrated Hatchery Program early in this FHMP period to increase the influence of the natural environment on the Upper Cowlitz Subbasin population. Decision Rules will be developed in the Annual Program Review process to implement the Integrated Hatchery Program (Table 4.1-4).

  Over the long-term, as natural-origin abundance increases, the Integrated Hatchery Program will expand and eventually replace the Segregated Hatchery Program. The focus of this hatchery supplementation will be on recovery of the populations upstream of Mayfield Dam and on harvest downstream of Mayfield Dam to mitigate for lost harvest opportunity in the ocean, Columbia River, and Cowlitz Basin (Table 4.1-4). We will also use best management practices for well-managed hatchery programs as a critical component to our strategy (Piper et al. 1982; IHOT 1995; Flagg and Nash 1999;

Wedemeyer 2002; Williams et al. 2003; Campton 2004; Galbreath et al. 2008; HSRG 2004, 2009; 2017).

- **Abundance:** The existing Segregated Hatchery Program for Cowlitz Salmon Hatchery spring Chinook Salmon has a goal of producing an annual run of 17,000 adult hatchery-origin spring Chinook Salmon (WDFW 2014). From 2007-2017, this was only achieved in 2015 (36,223) and 2016 (30,741). As we implement an Integrated Hatchery Program, we will focus our monitoring of hatchery-origin abundance on the numbers that are harvested and that return to the Cowlitz River and to Cowlitz Salmon Hatchery, which are critical for calculating SAR and TSAR, as well as the number that spawn in nature, for monitoring pHOS and PNI. We should also recognize that the observed survival rates may be lower than was anticipated at inception of these programs, especially as ocean conditions fluctuate, and that our hatchery production goals may be insufficient to achieve the expected total return of 17,000 adults.
- **Broodstock Collection and Spawning:** We will collect all broodstock from salmon that return to Cowlitz Salmon Hatchery and will ensure that both natural-origin males and females are incorporated into the broodstock for the Integrated Hatchery Program. The currently low abundance of natural-origin returns will initially constrain natural-origin broodstock collection and spawning decisions.

  We will employ hatchery best management practices for broodstock collection and spawning to ensure that the broodstock represents the entire population in age and run timing and to maximize genetic diversity of the F_1 generation. We will use spawning matrices for all hatchery spawning to maximize genetic diversity. Hatcheries, especially those with a conservation mandate, should use spawning matrices in which the gametes from every individual are mixed (approximately evenly) with those of at least two individuals of the opposite sex (Campton 2004) whenever total spawners are <200. The Integrated Hatchery Program will have at least 50% natural-origin salmon in the broodstock and we will strive to ensure that no hatchery-origin salmon is spawned with another hatchery-origin salmon (HxH cross) in order to minimize the hatchery influence on the F_1 generation and any population that it spawns with.
- **Strays and Spawning in Nature:** Upper Cowlitz Subbasin spring Chinook Salmon that stray could potentially spawn in lower Cowlitz River tributaries or other locations outside the Cowlitz Basin. Likewise, unmarked spring Chinook Salmon originating from the lower Cowlitz River or outside of the Cowlitz Basin could potentially return to Cowlitz Salmon Hatchery, where they would be assumed to have originated from the Upper Cowlitz Subbasin. Spawning surveys, as well as examining CWT data for strays outside of the Cowlitz Basin, will improve our estimates of stray rates and our management of these salmon.
- **Surplus:** As part of the plan for developing the Integrated Hatchery Program, we will identify Decision Rules and triggers for management actions regarding the disposition of hatchery-origin salmon that are caught at Cowlitz Salmon Hatchery but are not needed for broodstock. Surplus will be defined as it applies to these management triggers and these Decision Rules will be based on recovery and harvest objectives in the Cowlitz Basin to determine harvest rates and the disposition of surplus eggs/salmon. For the time being, the additional natural smolt production afforded by hatchery-origin adults spawning in nature in the Upper Cowlitz Subbasin will continue to be prioritized, in order to provide a demographic boost until returns of natural-origin spawners are sufficient to maintain a self-sustaining population.

Table 4.1-4. Recovery phase targets for Upper Cowlitz Subbasin spring Chinook Salmon.

Recovery Designation: Primary

Current Recovery Phase: Recolonization

Target Metric	RECOVERY PHASE Preser-vation	Recolon-ization	Local Adaptation	Fully Recovered	Last 5 Years
Natural Production					
Natural-origin Spawners in Nature	400	900	1,800	3,600	168 [1]
Smolt Abundance (below hatchery)	20,000 [2]	45,000 [2]	90,000 [2]	180,000 [2]	23,982 [3]
Smolt Passage Survival	40%	60%	70%	75%	26%
Productivity (5-year mean)	>1	>1	>1	>1	?
Hatchery Production					
Type of Hatchery Program	Seg	Seg/Int	Int/Seg	Int	Seg
Broodstock to be Collected	1,250	1,250	1,250	1,250	1,825
Integrated Hatchery Program	0	250	625	1,250	0
Hatchery-Origin	0	175	313	0	0
Natural-Origin	0	75	313	1,250	0
Segregated Hatchery Program	1,250	1,000	625	0	1,825
Smolts to be Produced	1,800,000	1,800,000	1,800,000	1,800,000	1,385,715
Integrated Hatchery Program	0	360,000	900,000	1,800,000	0
Segregated Hatchery Program	1,800,000	1,440,000	900,000	0	1,385,715
Total Hatchery Returns	17,000	17,000	17,000	17,000	?
Total Smolt-to-Adult Survival	0.94%	0.94%	0.94%	0.94%	0.717% [4]
Proportionate Natural Influence					
pHOS (<)					
Total	1	0.5	0.3	0.3	0.944
Integrated Hatchery Program	1	0.5	0.3	0.3	NA
Segregated Hatchery Program	1	0.05	0	0	0.944
pNOB (>)	0	0.3	0.6	1	0
PNI (>)	0	0.38	0.67	0.77	0
Max % of Natural-Origin Return to Cowlitz Salmon Hatchery Collected for Broodstock	50%	50%	40%	30%	0%

[1] Adults transported above Cowlitz Falls Dam minus estimated harvest, 12% fallback, and 10% pre-spawn mortality.
[2] Based on 2% SAR.
[3] Caught at Cowlitz Falls Fish Facility and includes some fall Chinook Salmon in 2014-2016.
[4] Brood years 2008-2012.

- **Smolt Production:** Spring Chinook Salmon hatchery-origin smolts will be reared at Cowlitz Salmon Hatchery. The production goals for the hatchery program will be to release 1.8 million age-2 (yearling) smolts, a portion of which will come from the Integrated Hatchery Program. We will develop, test, and evaluate different rearing and release strategies to develop an optimum strategy for this population that will maximize survival, while minimizing the abundance of mini-jacks and jacks and maximizing the abundance of adults of age-5 and older.
- **Smolt-to-Adult Survival and Productivity:** SAR is the primary metric for monitoring hatchery populations, especially those for which return abundance is lower than expected. We will collect scales and/or CWTs from, at least, a sample of recoveries at all collection sites. Additional data needs include the rate of precocious maturation and the sex ratio of hatchery-origin salmon by age. We will monitor this index as the data become available, through our M&E Program.

  Population productivity (the number of F_1 generation recruits that survive to spawn for each F_0 generation spawner) is of less importance, but is still useful, for monitoring hatchery populations, where survival to the smolt stage is unnaturally high. Expanded data collection to include tags and scales at all collection sites will allow us to estimate age and support calculations of productivity and monitoring of this metric over time through our M&E Program.
- **Age Composition:** In ISIT, age classes are only characterized as "adults (>49 cm)" or "jacks (<49 cm)" and these data are available only for the returns to Cowlitz Salmon Hatchery; all other abundance data in ISIT (e.g., harvest, spawners in nature, or hatchery broodstock) provide no information about the ages of the salmon included in the number provided. However, we can use the data from CWTs in the RMIS database (www.rmis.org), which provide reliable age composition data but only for tagged hatchery-origin salmon with CWTs. We will improve our monitoring of this metric by collecting the necessary samples and data so that we can better estimate the contribution of each age to the mature returns at all recovery locations.

  Given the high proportion of hatchery-origin mini-jacks (age-2) and both hatchery- and natural-origin jacks (age-3) and the potential for hatchery production to increase these rates in both the hatchery and in nature, we will more carefully monitor this trend. Samples of scales and tags will be regularly collected at all collection sites to estimate the age of both hatchery- and natural-origin salmon to better characterize each cohort and more clearly understand the age composition of these salmon and the factors influencing their age at maturity. To reverse this trend in hatchery-origin salmon maturing precociously, we will evaluate our hatchery spawning and rearing practices. Large smolts tend to mature at a younger age, so we will develop, implement, and evaluate alternative rearing strategies to decrease the abundance of mini-jacks and jacks and increase the abundance of age-5 and age-6 adults. Additionally, since there is a genetic component to age at maturity, we will consider re-using older (age-5+) males.

- **Harvest:** Although the high level of harvest/exploitation has not yet prevented us from meeting our hatchery production goals, harvest of natural-origin salmon does constrain the ability of managers to minimize pHOS and our progress toward population recovery, which is defined by the numbers of natural-origin adults spawning in nature Therefore, wherever possible, harvest management of the Upper Cowlitz Subbasin spring Chinook Salmon population should focus on minimizing the harvest of natural-origin salmon rather than increasing harvest of hatchery-origin salmon. Hatchery-origin harvest outside of the Cowlitz Basin will be monitored using the CWT recovery and sampling rate data in the RMIS database and robust creel surveys. Harvest in the Cowlitz Basin will be monitored with rigorous creel surveys and analysis of catch cards.

- **Proportionate Natural Influence:** We propose to increase the influence of the natural environment on the Upper Cowlitz Subbasin spring Chinook Salmon population in three ways:
    - Initiate the Upper Cowlitz Subbasin Spring Chinook Salmon Integrated Hatchery Program, while continuing to supplement natural production with all available hatchery production and maintaining total hatchery production of 1.8 million age-2 (yearling) smolts.
    - As natural-origin abundance increases, decrease pHOS by reducing the number of hatchery-origin adults transported to the Upper Cowlitz Subbasin.
    - Increase natural influence on hatchery-origin salmon by increasing the percentage of natural-origin salmon used as broodstock. pNOB for the new Integrated Hatchery Program will be >0.5.

4.1.6.3. Monitoring & Evaluation and Research

<u>Baseline Monitoring</u>

Monitoring and evaluation needs of the Upper Cowlitz Subbasin spring Chinook Salmon population are similar to other populations in the basin and include spawning ground surveys, accurate counts of hatchery releases and returns of both hatchery- and natural-origin salmon, adequate marking, and evaluation of alternative management and hatchery rearing strategies. To support recovery, monitoring programs are needed that are rigorous and that will allow for estimation, with greater confidence, of population abundance, as well as to identify ways to improve survival. Areas of improvement specific to this population include the following:

- Increased monitoring rigor for VSP and hatchery metrics is needed to evaluate recovery status and trends, including, but not limited to:
    - Estimates of total mature salmon abundance, by origin, age, and sex.
    - Estimates of numbers of spawners in nature, strays, and pre-spawn mortalities, by origin, sex, and age.
    - Returns to Cowlitz Salmon Hatchery, by origin, age, and sex.
    - Improved harvest estimates of both hatchery- and natural-origin salmon, by age.
    - Numbers of salmon collected for broodstock and spawned, by origin, age, and sex.
    - Fecundity and fertility rates, survival rates between age classes, disease prevalence, and numbers of smolts produced at Cowlitz Salmon Hatchery.
- Determine hatchery- and natural-origin age at maturity by collecting scales and/or tags from at least a subsample of all recoveries from all recovery locations.
- Document the numbers of actual spawners in nature (by origin, age, and sex) by initiating/improving spawning ground surveys.
- Calculate natural-origin productivity, as estimates of numbers of spawners become available, by origin and age.
- Calculate smolt-to-adult survival and return rates, as estimates of numbers of smolts and spawners become available, by origin and age.

Directed Studies

Directed Studies are designed to diagnose and solve problems associated with achieving FHMP goals and to fill management needs and information gaps in the Big Table (Table 4.1-3; Appendix A). Important areas of study for the Upper Cowlitz Subbasin spring Chinook Salmon population include:

- **Spawning Ground Surveys:** Scales, marks and tags, numbers of actual spawners, pHOS, pre-spawn mortality rates, genetics, spatial distribution (upper extent), and reach-specific adult densities.
- **Freshwater Life History and Natural-origin Juvenile Rearing Studies:** Abundance and life stage-specific survival rates, available habitat, habitat-specific (run/riffle/pool) densities, and carrying capacity.
- **In-river Migratory Survival and Behavior:** Survival of migrating juveniles and movement timing and rates.
- **Hatchery Supplementation Experiments:** Assessing the impact of returning hatchery-origin adults on natural-origin salmon.
- **Hatchery Practices:** Broodstock collection and spawning protocols, in-hatchery growth rate, and examining smolt size and timing of release.
- **Reservoir Survival:** Predation rate and parasite loadings.

4.1.7. Summary

- Although extirpated from upstream habitats following completion of Mayfield Dam, Upper Cowlitz Subbasin population genes were incorporated into the hatchery population, providing the founding stock for recovery.
- Spring Chinook Salmon recovery efforts have focused exclusively on the Upper Cowlitz Subbasin population to avoid conflicting with management activities for restoring fall Chinook Salmon in the Tilton Subbasin.
- Juvenile fish collection and passage survival at Cowlitz Falls Dam are key limiting factors for natural-origin abundance and productivity.
- Providing a demographic boost to the population by increasing the total number of spring Chinook Salmon spawning in the Upper Cowlitz Subbasin is currently the primary management goal.
- Natural-origin smolt abundance will be increased by improving collection efficiency and downstream passage survival at Cowlitz Falls Dam.
- Cowlitz Basin program needs, including both recovery and harvest objectives, will be prioritized over out-of-basin programs by developing a plan to define fish/egg disposition and harvest objectives, hatchery surplus, and associated triggers.
- Over the FHMP period:
    - The existing Segregated Hatchery Program will continue supplementing natural spawning and harvest in the Upper Cowlitz Subbasin.
    - A plan will be developed and implemented early in the FHMP period for initiating an Integrated Hatchery Program using hatchery best management practices.

- The long-term goal is to transition to an Integrated Hatchery Program for all hatchery production. The program will be managed specifically for:
  - Recovery of the Upper Cowlitz Subbasin population.
  - Harvest, both below and above Mayfield Dam, to mitigate for lost harvest opportunity.
  - High pNOB (>0.5).
- Increasing monitoring rigor for VSP and hatchery metrics is needed to evaluate recovery status and trends, including, but not limited to:
  - Hatchery- and natural-origin smolt numbers.
  - Estimates of total mature salmon numbers by origin, age, and sex.
  - Estimates of numbers of spawners in nature, strays, and pre-spawn mortalities, by origin, sex, and age.
  - Returns to Cowlitz Salmon Hatchery by origin, age, and sex.
  - Improved harvest estimates of both hatchery- and natural-origin salmon, by age.
  - Numbers of salmon collected for broodstock and spawned, by origin, age, and sex.
  - Fecundity and fertility rates, survival rates between age classes, disease prevalence, and numbers of smolts produced at Cowlitz Salmon Hatchery.

Intentionally blank page

Population: Tilton Subbasin Spring Chinook Salmon *Oncorhynchus tshawytscha*

Evolutionarily Significant Unit:	Cascade Spring Chinook Salmon stratum Lower Columbia River Chinook Salmon Evolutionarily Significant Unit (ESU) Lower Columbia River Salmon Recovery Region
ESA Listing Status:	Threatened; Listed in 2005, reaffirmed in 2011 and 2016
Population Recovery Designation:	Stabilizing
Population Viability Rating:	
Baseline	Very Low
Objective	Very Low
Recovery Goal:	Proposed 2,000 natural-origin adults spawning in nature in the Tilton Subbasin
Current Recovery Phase:	NA
Current Hatchery Program(s):	None
Proposed Hatchery Program(s):	None under the current FHMP. Future programs may be established, as deemed necessary by the FTC.

4.2. Spring Chinook Salmon: Tilton Subbasin Population

The Tilton Subbasin contained one of the three historical spring Chinook Salmon populations in the Cowlitz Basin (Myers et al. 2006). It was heavily impacted by overharvest, habitat destruction and, ultimately, the construction and operation of Mayfield and Mossyrock dams. Mature salmon were transported above Mayfield Dam until this effort was abandoned in 1968 because smolt production and smolt survival through/around Mayfield Dam were very low, and the population was deemed unlikely to become self-sufficient. At that time, the Tilton Subbasin spring Chinook Salmon population became functionally extinct. However, fisheries managers believe that some of the genetic legacy of the original Tilton Subbasin population remains in the spring Chinook Salmon population that has been maintained at Cowlitz Salmon Hatchery.

Currently, the effort to restore the Tilton Subbasin spring Chinook Salmon population has been delayed so that efforts to restore fall Chinook Salmon to the Tilton Subbasin can be more accurately assessed and better managed. Juvenile spring Chinook Salmon cannot be distinguished from fall Chinook Salmon juveniles, which makes evaluation of restoration programs difficult. Therefore, managers decided to initially focus restoration efforts for fall Chinook Salmon on the Tilton Subbasin and to focus spring Chinook Salmon restoration on the Cispus and upper Cowlitz rivers (Upper Cowlitz Subbasin). Once fall Chinook Salmon have been restored in the Tilton Subbasin, the effort to restore the Tilton Subbasin spring Chinook Salmon population can begin. By that time, it is expected that the effectiveness of the downstream collection facility at Mayfield Dam will be improved to allow for high smolt collection efficiency and survival past the dam. Mature salmon from the Upper Cowlitz Subbasin Spring Chinook Salmon Integrated Hatchery Program will then be transported to the Tilton Subbasin and allowed to spawn in nature. At that time, we anticipate that an integrated hatchery program will be used to supplement natural spawning and harvest in the Tilton Subbasin, but that is beyond the scope of this FHMP (Table 4.2-1).

Table 4.2-1. Recovery phase targets for Tilton Subbasin spring Chinook Salmon.

Recovery Designation:	Stabilizing				
Current Recovery Phase:	NA				
	RECOVERY PHASE				
Target Metric	Preser-vation	Recolon-ization	Local Adaptation	Fully Recovered	Last 5 Years
Natural Production					
Natural-origin Spawners in Nature	250	500	1,000	2,000	NA
Smolt Abundance (below hatchery)	25,000 [1]	50,000 [1]	100,000 [1]	200,000 [1]	NA
Smolt Passage Survival	40%	60%	70%	75%	NA
Productivity (5-year mean)	>1	>1	>1	>1	NA
Hatchery Production					
Type of Hatchery Program	Int	Int	Int	Int	NA
Broodstock to be Collected	1,200	1,200	1,200	1,200	NA
Integrated Hatchery Program	1,200	1,200	1,200	1,200	NA
Hatchery-Origin	0	0	0	0	NA
Natural-Origin	1,200	1,200	1,200	1,200	NA
Segregated Hatchery Program	0	0	0	0	NA
Smolts to be Produced	1,000,000	1,000,000	1,000,000	1,000,000	NA
Integrated Hatchery Program	1,000,000	1,000,000	1,000,000	1,000,000	NA
Segregated Hatchery Program	0	0	0	0	NA
Total Smolt-to-Adult Survival					
Proportionate Natural Influence					
pHOS (<)					
Total	0.5	0.4	0.3	0.3	NA
Integrated Hatchery Program	0.5	0.4	0.3	0.3	NA
Segregated Hatchery Program	NA	NA	NA	NA	NA
pNOB (>)	1	1	1	1	NA
PNI (>)	0.67	0.71	0.77	0.77	NA
Max % of Natural-Origin Return to Cowlitz Salmon Hatchery Collected for Broodstock	30%	30%	30%	30%	NA

[1] Based on 1% SAR.

CHAPTER 5:
COHO SALMON

Coho Salmon *Oncorhynchus kisutch*

ESA Listing

Status:	Threatened Listed in 2005, reaffirmed in 2011 and 2016
Evolutionarily Significant Unit:	Lower Columbia River Coho Salmon
Major Population Group:	Cascade Coho Salmon
Recovery Region:	Lower Columbia River Salmon
Populations, Recovery Designations, and Abundance Targets (natural-origin adults spawning in nature):	• Lower Cowlitz Subbasin – Primary, 3,700 • Upper Cowlitz River drainage – Primary, 2,000 • Cispus River drainage – Primary, 2,000 • Tilton Subbasin – Stabilizing, not established
Current Hatchery Program(s):	• Cowlitz Salmon Hatchery Segregated Hatchery Program (Lower Cowlitz Subbasin); 1.2 million smolts • Cowlitz Salmon Hatchery Integrated Hatchery Program (Upper Cowlitz Subbasin); 1 million smolts
Proposed Hatchery Program(s):	Short-Term Goal: Upper Cowlitz Subbasin Integrated Hatchery Program; 2.2 million age-2 (yearling) smolts Long-Term Goal: Upper Cowlitz Subbasin and Tilton Subbasin Integrated Hatchery Programs; combined production of 2.2 million age-2 (yearling) smolts

5.0. Coho Salmon: Overview

5.0.1. Program Focus

The management focus for Coho Salmon will be population recovery and harvest opportunity. Since the last FHMP (2011), returns of natural-origin adults to spawning grounds both below Cowlitz Salmon Hatchery and above Mayfield Dam have increased and some of these populations are on the verge of meeting their recovery abundance targets. However, hatchery influence on the natural population is high. We will update the recovery phases of each of the Coho Salmon populations and adapt our recovery efforts, appropriately.

The long-term goal for hatchery production of Coho Salmon in the Cowlitz Basin will be to transition to a single Integrated Hatchery Program, derived from the Upper Cowlitz Subbasin. The 2011 FHMP states that “in the future, consideration could be given to converting to an integrated hatchery program to further improve fitness of the natural population.” Additionally, the Washington Department of Fish and Wildlife Hatchery Action Implementation Plans (2009) states that “modify(ing) programs to achieve goals for PNI, pHOS, and pNOB” is a needed improvement action for Cowlitz River hatchery programs. The Lower Columbia Basin Conservation and Sustainable Fisheries Plan (WDFW and LCFRB 2016) recommends that programs “convert from segregated programs to integrated or local brood source.” A single, Upper Cowlitz Subbasin Integrated Hatchery Program will encompass all hatchery production from the current Lower Cowlitz Subbasin Segregated and Upper Cowlitz Subbasin Integrated hatchery programs and will meet all program population supplementation and harvest needs. Moving to a single integrated hatchery program will accomplish the following:

- Prioritizes increasing adult abundance in the Upper Cowlitz Subbasin.
- Prioritizes local adaptation for all populations, particularly those in the larger, more pristine Cispus and upper Cowlitz rivers.
- Helps create a buffer for adult abundances in lower return years.
- Allows for continued harvest at current or higher levels in the Lower Cowlitz Subbasin.
- Creates increased harvest opportunity in the Upper Cowlitz Subbasin.
- Allows for better hatchery M&E and assessment of alternative hatchery strategies.
- Provides the opportunity to align production practices with historical natural run timing for each subbasin by collecting Upper Cowlitz Subbasin broodstock, primarily (but not totally) from the early portion of the run to reconstruct the original run timing of Coho Salmon above Mayfield Dam.
- Presents an opportunity to fill information gaps regarding density dependence, juvenile rearing capacity, and trends toward local adaptation between the Upper Cowlitz and Lower Cowlitz subbasins without negatively impacting the Stabilizing population in the Tilton Subbasin.
- Moves the smaller, more heavily impacted Tilton Subbasin population (a Stabilizing population) toward local adaptation.

This management shift will greatly benefit our efforts to restore the natural Cowlitz Basin Coho Salmon populations and the fisheries that these populations support, so we will develop a plan and transition strategy to accomplish this goal. In the near term, we will also:

- Maintain flexibility to increase hatchery production within FERC licensing and ESA constraints.
- Identify (origin) and monitor pHOS in the mainstem Cowlitz River to assess hatchery influence.
- Develop goals that take into account potential differences in SARs between the Integrated and Segregated Hatchery Programs.
- Develop a transition plan and begin marking natural-origin smolts at the Mayfield Juvenile Bypass System (instead of the Cowlitz Falls Fish Facility) in the next two years.
- Define the disposition/best use of surplus hatchery-origin salmon that return to Cowlitz Salmon Hatchery.

5.0.2. Population Structure

Excluding the Toutle and Coweeman rivers, four historical populations of Coho Salmon have been recognized in the Cowlitz Basin: lower Cowlitz River, Cispus River, upper Cowlitz River, and Tilton River (Myers et al. 2006; Figure 5.0-1; Table 5.0-1). These endemic populations spawned and reared in the tributaries and mainstem of the larger rivers in each basin. Construction of Mayfield Dam (beginning in 1963), the subsequent development and operation of the hatchery programs, the inability to identify the basin of origin of natural-origin salmon, and the sporadic transport of adult salmon above the dams all resulted in the aggregation of the Coho Salmon populations in the Lower Cowlitz, Cispus, Upper Cowlitz, and Tilton subbasins. By the mid-1990s, the Lower Cowlitz Subbasin Coho Salmon population was recognized to be at risk of extinction due to overharvest since the early 1900s, hydroelectric development in the 1960s, and ongoing habitat degradation and hatchery influences (McElhany et al. 2007; LCFRB 2010; Ford et al. 2011). By 2013, the Lower Cowlitz Subbasin Coho Salmon population was not considered to be viable (NMFS 2013) but the Lower Cowlitz Subbasin hatchery population has been the genetic source for Coho Salmon transported above Mayfield Dam. Reintroduction efforts and improved monitoring, since 2011, have enhanced our understanding of Cowlitz Basin Coho Salmon populations and resulted in an apparent increase in their abundance throughout the basin. This led to an improvement in the status of the entire Cowlitz Basin Coho Salmon population from High Risk to Moderate Risk of extinction (NMFS 2016).

With the listing of these populations under the ESA, the management focus was on recovery of the original four populations and conservation was elevated to a higher management priority, resulting in changes in hatchery, harvest, and habitat actions. The Lower Cowlitz Subbasin, Cispus Subbasin, and Upper Cowlitz Subbasin populations are designated as Primary populations and the Tilton Subbasin population is designated as a Stabilizing population in relation to their contribution to recovery of the lower Columbia River ESU (LCFRB 2010). Recovery relies on the extant Lower Cowlitz Subbasin Coho Salmon hatchery population as the founding population for supplementing the three populations above Mayfield Dam. Recovery actions have been undertaken over the past three decades, but delisting cannot occur until all four historical populations have been restored with a probability of persistence that is high or, at a minimum, is consistent with their historical condition. Reintroductions to the Upper Cowlitz Subbasin have provided opportunities for the continued growth and genetic diversification of the entire Cowlitz Basin population.

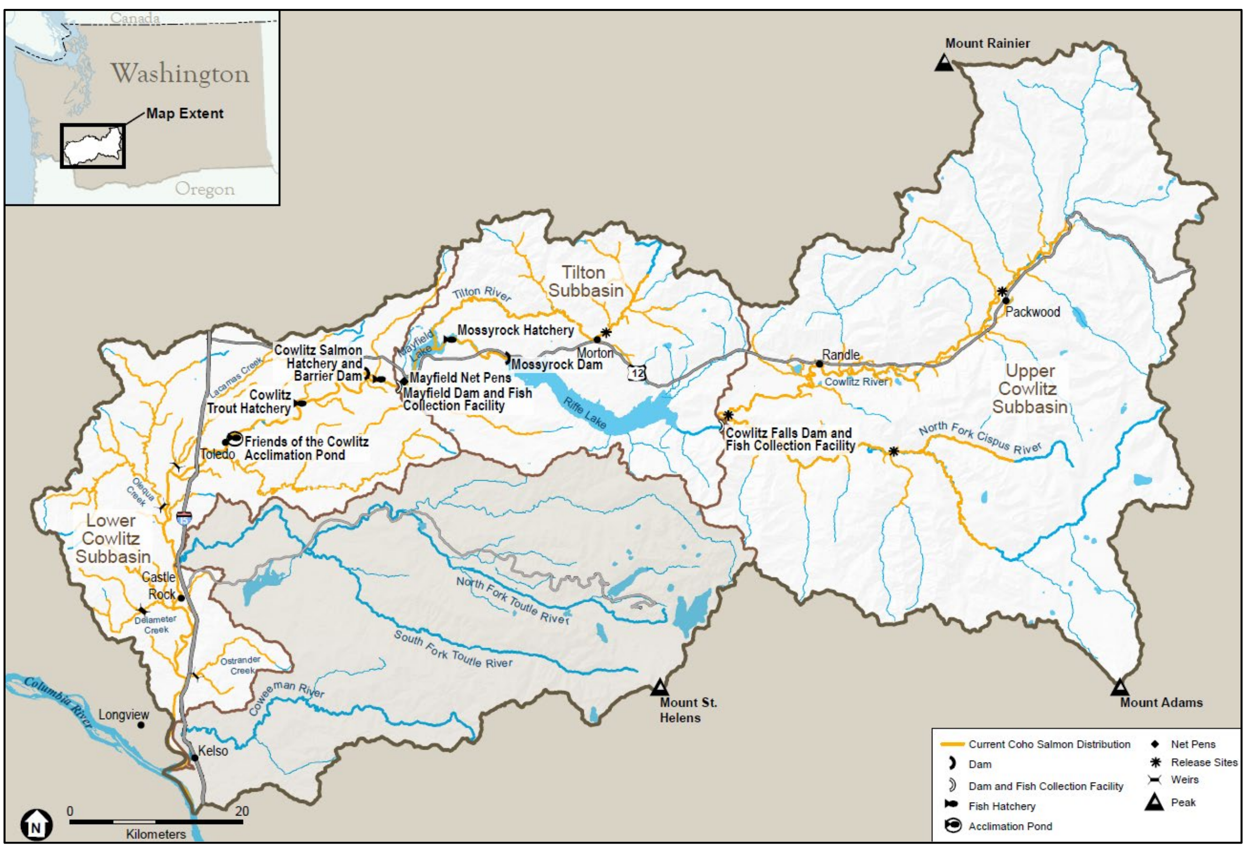


Figure 5.0-1. Distribution of Coho Salmon in the Cowlitz Basin, Washington.

Table 5.0-1. Recovery priority, baseline viability status, viability and abundance objectives, and productivity improvement targets for Cowlitz Basin Coho Salmon populations (from LCFRB 2010; updated from ISIT, WDFW, 28 June 2019).

	Demographically Independent Population			
	Lower Cowlitz Subbasin	Cispus Subbasin[1]	Upper Cowlitz Subbasin[1]	Tilton Subbasin
Run	Late	Early and Late	Early and Late	Early and Late
Recovery Priority Designation[2]	Primary	Primary	Primary	Stabilizing
Abundance				
Historic[3]	18,000	8,000	18,000	5,600
Current (last 5 years)[4]	5,253	2,510		4,237
Target[5]	3,700	2,000	2,000	2000[6]
Baseline Viability[7]				
Abundance & Productivity	Very Low	Very Low	Very Low	Very Low
Spatial Structure	Medium	Medium	Medium	Medium
Diversity	Medium	Low	Low	Low
Net Viability Status	Very Low	Very Low	Very Low	Very Low
Viability Improvement[8]	100%	>500%	>500%	0%[9]
Recovery Viability Objective[7]	High	High	High	Very Low
Proportionate Natural Influence				
pHOS	<0.3	<0.3	<0.3	<0.5
pNOB	>0.6	>0.6	>0.6	>0.9
PNI	>0.67	>0.67	>0.67	>0.6

[1] For current management purposes, the Cispus Subbasin and Upper Cowlitz Subbasin populations are combined into an Upper Cowlitz Subbasin population, with abundances equal to the sum of the two separate populations.
[3] Primary, Contributing, and Stabilizing designations reflect the relative contribution of the population to Major Population Group recovery goals.
[3] Historical population size was mean number, inferred from presumed habitat conditions using EDT Model and NMFS back-of-envelope calculations.
[4] 2013-2017 run years.
[5] Abundance targets were estimated by population viability simulations based on viability goals.
[6] For Stabilizing populations, the current operating conditions were considered adequate to meet conservation goals. No criteria were developed for proportion of effective hatchery-origin spawners (pHOS) or PNI (LCFRB 2010). We propose the value indicated.
[7] Viability status is based on Technical Recovery Team viability rating approach. Viability objective is based on the scenario contribution. Very Low (>60% chance of extinction); Low (26-60% chance of extinction); Medium (6-25% chance of extinction); High (1-5% chance of extinction); Very High (<1% chance of extinction).
[8] Improvement is the relative increase in population abundance and productivity required to reach the prescribed viability goal.

5.0.3. Life History Diversity

Historically, there were two distinct runs of Coho Salmon in the Cowlitz Basin: an early run and a late run (Moore and Clarke 1946). Smolts from the early run (Type S) head south, along the Oregon coast, upon leaving the Columbia River. The early run returned to the Cowlitz River during late August and September and spawned mostly in the upper parts of the watershed, with a spawning peak in late October. Conversely, late run (Type N) smolts head north, along the Washington coast, when they enter the ocean and comprised the majority of the Coho Salmon returning to the Cowlitz River. They entered the Cowlitz River as early as October and as late as March and spawned in all available habitat throughout the watershed (generally in lower reaches), with a spawning peak in late November. Fry and parr of both runs spent their first spring and summer within their natal streams and most smolted in their second spring (age-2 yearlings; typically in May). Smaller pulses of juveniles moved downstream during their first spring of life and, again, the following December (Stockley 1961). However, scale data from returning adults indicate that Coho Salmon reach the ocean during their second spring, so it is thought either that these earlier downstream migrations are movements to rearing habitat in the lower Cowlitz or Columbia rivers, or that these younger migrants do not successfully transition to the ocean (Myers et al. 2006).

The current Cowlitz Basin Coho Salmon population is now a composite population, whose genetic composition has been heavily influenced by past overharvest, the completion of Mayfield Dam in 1963, and hatchery releases. The current run is predominantly Type N, based on early CWT recoveries in ocean fisheries, that came from mostly north of the Columbia River (WDF et al. 1993). However, as a result of the hybridization of the populations, a component of the current population exhibits elements of the upriver early run, as Coho Salmon now enter the Columbia River from August through January (LCFRB 2010). Most of the early run arrives in mid-August through September and spawns in late October. The late run arrives in late September to October and spawns from December through early January. However, Fuss et al. (1998) reported that run timing of hatchery-origin salmon returning to Cowlitz, Washougal, Lewis, and Elochoman hatcheries has been getting later, at a rate of approximately 1.7 days per year. Although this may be because of selection in the hatchery, the authors suggested that timing of in-river harvest could also have caused this effect (Myers et al. 2006). In nature, eggs hatch and fry emerge from January through April, depending on spawn date and water temperature (Sandercock 1991). Variable, weather-related upwelling patterns and the short life cycle of Coho Salmon cause highly variable population cycles.

Recovery of Coho Salmon populations in the Cispus, Upper Cowlitz, and Tilton subbasins is being accomplished using the extant Lower Cowlitz Subbasin Coho Salmon hatchery population as the founding population. Since the inception of the Lower Cowlitz Subbasin Coho Salmon Hatchery Program in 1968, it is likely that individuals from both the early and late returning populations were collected for hatchery broodstock (Myers et al. 2006). The early run genes are probably most beneficial to salmon spawning above Mayfield Dam, so the apparent persistence of some of early run traits in the extant population will be of great benefit to the recovery efforts and should be conserved and promoted in the restored populations above Mayfield Dam.

5.0.4. History

The Cowlitz Basin Coho Salmon population is thought to have been and, although it is now a fraction of its original size, has remained one of the largest in the Lower Columbia Basin. The historical annual Cowlitz Basin Coho Salmon run (combined Lower Cowlitz, Cispus, Upper Cowlitz, and Tilton subbasins) is estimated to have been 40,000-190,000 (LCFRB 2010).

Bryant (1949) described the Cowlitz River as the "greatest silver salmon producing area in the entire Columbia River watershed" and most of those Coho Salmon certainly came from above the Toutle River. However, the combination of overharvest in the early to mid-1900s, habitat alteration and migration blockage due to hydropower development in the 1960s, and the consistent, continuing, and pervasive effects of habitat loss and hatchery supplementation have taken their toll on these populations and resulted in their subsequent listing under the ESA (WDF et al. 1993; Myers et al. 2006; LCFRB 2010).

Hatcheries have been operated on the Cowlitz River for over 100 years (Table 5.0-2). The Tilton River Hatchery released Coho Salmon in the Cowlitz Basin from 1915-1921 and a salmon hatchery operated in the upper Cowlitz River near the mouth of the Clear Fork River until 1949. In 1948, the Washington Department of Fisheries estimated that 77,000 Coho Salmon returned to the Cowlitz Basin, including 24,000 above the future site of Mayfield Dam. Harvest in the 1940s and 1950s was heavy and WDF reported that only 32,500 returned to the basin in the early 1950s. Run size decreased further, and dramatically, when Mayfield Dam blocked access to the Cowlitz Basin above rkm 84 in 1963. In 1968, Mossyrock Dam was completed, Cowlitz Salmon Hatchery and the adjacent Barrier Dam were completed (blocking upstream access at rkm 81), and the volitional trap at Mayfield Dam was closed (NOAA Fisheries 2004). Natural-origin smolts from the Cispus and upper Cowlitz drainages had to traverse an additional dam and reservoir (containing warmwater fish predators), greatly reducing the number of natural-origin smolts that survived to the mouth of the Cowlitz River. As mitigation for this lost production, Cowlitz Salmon Hatchery was designed to release 4.2 million late run Coho Salmon smolts annually, based on an agreement between Tacoma Power and the Washington Department of Fisheries, with a goal of producing enough smolts to maintain annual returns of 25,500 Coho Salmon. The Lower Cowlitz Subbasin and Cowlitz Salmon Hatchery populations absorbed many of the returning adult salmon from the populations above Mayfield Dam, creating aggregated populations from the four original populations. These genes will be important for restoring the populations above Mayfield Dam.

From 1970-1983, total combined harvest of Columbia River Coho Salmon ranged from 70% to >90% of the total run. In 1985, it was estimated that only 5,229 Coho Salmon spawned naturally in the lower Cowlitz River tributaries above the Toutle River and most of those were strays from Cowlitz Salmon Hatchery (LCFRB 2010). Harvest restrictions on ocean fisheries to protect wild coastal Washington Coho Salmon populations began in the mid-1980s. This trend continued into the 1990s, when Canadian Coho Salmon fisheries were severely restricted and Coho Salmon fisheries in the ocean off California and in the Columbia River were closed. Likewise, Coho Salmon ocean fisheries in Oregon and Washington were dramatically reduced in 1993 in response to the Depressed status of Oregon Coast natural Coho Salmon and their subsequent ESA listing. Beginning in 1999, Coho Salmon ocean fisheries in Oregon and Washington moved to mark-selective fishing in response to the continued Depressed status of Oregon Coast natural Coho Salmon.

Cowlitz Falls Dam was completed in 1994 and excess hatchery-origin Coho Salmon from the Lower Cowlitz Subbasin population began to be transported above Mayfield and Cowlitz Falls dams in an effort to reintroduce the historical populations in the Cispus, Upper Cowlitz, and Tilton drainages (Myers et al. 2006). As soon as the natural-origin offspring of these salmon began returning, a combination of hatchery- and natural-origin Coho Salmon were transported, with the desire to produce as many natural smolts as possible and, ultimately, to produce a self-sustaining natural population in each of the three basins above the hydroelectric complex. The transplanted salmon likely have genes from the original populations above Mayfield Dam and these genes will be of great benefit to the restoration effort.

Table 5.0-2. Hatchery releases of Coho Salmon into each demographically independent population (DIP) in the Cowlitz Basin, excluding the Coweeman and Toutle rivers (updated from Myers et al. 2006 using Tacoma Power/Cowlitz Salmon Hatchery data).

Release Location	Release Years	Years[1]	Broodstock Origin	Total Released
			Lower Cowlitz Subbasin	
Lower Cowlitz Subbasin DIP				
Cowlitz River	1954-1966	5	Green River (Puget Sound)[2]	569,724
	1954, 1958, 1990	3	Lewis River Hatchery	249,246
	1956-1957, 1964	3	Big Creek Hatchery (OR)	98,952
	1956-1969	3	Toutle (Type N)	404,785
	1962, 1965	2	Klaskanine Hatchery (OR)	669,756
	1965-1971	3	Kalama Hatchery	1,246,024
	1969-1993	24	Cowlitz River Hatchery	125,520,849
	1974	1	Elochoman Hatchery	31,838
	1995-1999	5	Cowlitz Hatchery (Type N)	28,129,260
	2000-2006	7	Cowlitz Salmon Hatchery	27,842,550
	2007-2016	10	Lower Cowlitz Subbasin (Segregated)[3]	18,728,472
	2009-2016	8	Upper Cowlitz Subbasin (Integrated)	7,278,242
Riffe Lake	1995-1999	5	Cowlitz Hatchery (Type N)	3,035,832
	1982-1992	11	Cowlitz Hatchery	3,110,589
DIP Total				216,916,119
			Upper Cowlitz Subbasin	
Cispus Subbasin DIP				
North Fork Cispus River	1972-1986	7	Cowlitz Hatchery	1,088,985
Iron Creek	1954	1	Toutle River (Type N)	24,050
	1972-1992	20	Cowlitz Hatchery	4,945,686
	1976-1986	9	Cowlitz Hatchery	685,252
DIP Total				6,743,973
Upper Cowlitz Subbasin DIP				
Upper Cowlitz River	1972-1989	17	Cowlitz Hatchery	17,776,163
Ohanapecosh River	1972-1993	23	Cowlitz Hatchery	3,909,445
DIP Total				21,685,608
			Tilton Subbasin	
Tilton Subbasin DIP				
Tilton River	1954-1984	12	Cowlitz Hatchery (Type N)	2,618,815
DIP Total				2,618,815
Grand Total Cowlitz Basin above Toutle River				**247,964,515**

[1] Years is the total number of years that salmon were actually released within the time frame.
[2] Green River is part of the Puget Sound ESU.
[3] The Segregated Program has operated since 1998 (WDFW 2014).

However, the process of building a self-sustaining natural population has been slow. Smolt survival, associated with passage through the reservoirs and dams, has not been historically sufficient to support a self-sustaining population. In 2004, the LCFRB wrote that “current returns (to the lower Cowlitz River) are unknown but assumed to be low,” highlighting the dire straits that the population was in and the lack of effective monitoring. The lower Columbia River Coho Salmon ESU, including the Lower Cowlitz Subbasin population and the Coho Salmon raised at Cowlitz Salmon Hatchery, was subsequently listed as threatened under the ESA in 2005 and that listing was reaffirmed in 2011 and 2016.

In 2015, the Northwest Fisheries Science Center reported generally positive changes in abundance, productivity, diversity, and spatial structure of Cowlitz Basin Coho Salmon populations (NMFS 2016). They noted, however, that these apparent increases were more likely due to improved monitoring and the subsequently improved and more complete data rather than a real change in population metrics. Further improvements in monitoring important population metrics will allow us to better understand and effectively manage these populations.

Additionally, both upstream and downstream fish passage programs are now allowing for the return of relatively large numbers of naturally produced salmon to populations that had been extirpated. Improvements made at the juvenile capture and downstream transport facilities at Mayfield and Cowlitz Falls dams are expected to increase abundance of outmigrants and should help to improve the status of the Tilton Subbasin and Upper Cowlitz Subbasin Coho Salmon populations, respectively. Natural-origin abundance varies widely but is improving. Based on spawning ground surveys in the Lower Cowlitz Subbasin and standard survival rates for adults transported above Mayfield Dam, we estimate that the number of natural-origin spawners in nature has ranged from 3,526-24,837 from 2007-2017 and has exceeded the entire Cowlitz Basin recovery target of 7,700 for 8 of those 11 years. For the entire Cowlitz Basin, land development and increasing human population pressures will likely continue to degrade habitat, especially in lowland areas. Although returns have improved, poor ocean conditions can cause rapid population declines and this ESU is still considered to be at moderate risk (NWFSC 2015).

5.0.5. Distribution

Natural spawning in the Cowlitz Basin occurs in most areas accessible to Coho Salmon, including the mainstem and all accessible tributaries in the Lower Cowlitz Subbasin, as well as those above Mayfield Dam to which Coho Salmon are transported (Figure 5.0-1). Historically important spawning streams for Coho Salmon included Arkansas, Burton, Butter, Kiona, Lake, Lacamas, Ostrander, Silver, and Skate creeks (Bryant 1949). Birtchet and LeMier (1955) counted 329 Coho Salmon entering Arkansas Creek from October 1954 until high flood waters washed out the weir in December. Natural spawning in the Lower Cowlitz Subbasin upstream of the Toutle River now occurs primarily in Blue, Brights, Campbell, Foster, Hill, Lacamas, Mill, Olequa, Otter, and Stillwater creeks, with Olequa Creek being the most productive (LCFRB 2010). It is also possible that Coho Salmon spawn in the mainstem lower Cowlitz River, especially side channels, but this is poorly documented (mostly due to poor survey conditions). Since 1994, returning Coho Salmon have been transported above Mayfield Dam, where they spawn in the Cispus, upper Cowlitz, and Tilton rivers and suitable tributaries, such as the Ohanapecosh and Clear Fork rivers. Habitat in the Upper Cowlitz and Tilton subbasins appears to be productive but this reintroduction effort has been hindered by poor survival of smolts through the dams and associated reservoirs and poor capture efficiency of out-migrating smolts for transport around the dams. However, since 2013, collection efficiency at Cowlitz Falls Fish Facility has exceeded 50% (mean = 73%).

Historically, natural spawning by Coho Salmon (both hatchery- and natural-origin) has not been extensively monitored or managed but, in recent years, both monitoring and management have improved. To reduce the abundance of hatchery-origin strays spawning in Lower Cowlitz Subbasin tributaries, weirs have been installed on Delameter, Lacamas, Olequa, and Ostrander creeks in the Lower Cowlitz Subbasin; only natural-origin salmon are released above the weirs. The weirs provide locations to monitor abundance. In addition, spawning ground surveys are conducted on the streams with weirs and a subsample of other lower Cowlitz River tributaries (but not in the mainstem lower Cowlitz River). In the Tilton and Upper Cowlitz subbasins, where both hatchery- and natural-origin salmon are transported and released, the numbers transported and released are known, but how many survive to spawn is not known, since little or no effort is expended to monitor spawner abundance. We roughly estimate the numbers of spawners by simply using the numbers of hatchery- and natural-origin adults transported multiplied by a standard survival rate, which does not reflect inter-annual variability. So pHOS of the Cowlitz Basin Coho Salmon population is effectively based on numbers transported and harvested, not actual spawners.

5.0.6. Abundance

Mean total run size of all Cowlitz River Coho Salmon (excluding the Toutle River population) from 2007-2017 was 124,607 (37,420-281,143); this estimate includes all hatchery- and natural-origin salmon that can be accounted for from ocean, Columbia River, and lower Cowlitz River fisheries, plus those spawning in the Lower Cowlitz Subbasin or captured at Cowlitz Salmon Hatchery (Figure 5.0-2; Table 5.0-3). The majority (87%) of those salmon were hatchery-origin, with only 13% being natural-origin. A mean of 59% (73,196) of the total combined run was harvested in ocean, lower Columbia River, and Lower Cowlitz, Upper Cowlitz, and Tilton subbasin fisheries, combined. A mean of 62,989 salmon returned to the Cowlitz River, 48,382 returned to Cowlitz Salmon Hatchery, and 21,687 were transported to the Tilton or Upper Cowlitz subbasins.

Productive spawning and rearing habitats still exist above the Cowlitz River Hydroelectric Complex, but reintroduction efforts have been hindered by poor survival of smolts through the dams and associated reservoirs. Downstream migrant traps are operated for juvenile salmon at Mayfield and Cowlitz Falls dams and help to assess the success of the adult releases, but their poor collection efficiency has hindered the recovery efforts in the past. Smolt collection has improved recently and mean collection efficiency at the Cowlitz Fall Fish Facility is 76% over the last 5 years. Total natural-origin smolt production from the Cowlitz Basin is not rigorously monitored because smolt traps in the lower Cowlitz River do not capture an adequate proportion of the smolts passing the trap and we cannot distinguish all of the smolts from the populations above Mayfield Dam from those produced in the Lower Cowlitz Subbasin. As a result, there is much uncertainty regarding the annual production of natural-origin Coho Salmon smolts in the Cowlitz Basin.

Additionally, WDFW supported Remote Streamside Incubation programs, which incubated eggs from the Segregated Hatchery Program for release of the resulting offspring into nature. However, these offspring are not marked, so they cannot be distinguished from natural-origin salmon and, upon any subsequent capture, they are misidentified as natural-origin salmon, which inflates our natural abundance estimates. These programs were discontinued after brood year 2017, and the effects of their programs should diminish after 2021.

5.0.7. Harvest

Harvest is an important management component for Cowlitz Basin Coho Salmon and has great potential for impacting population recovery. Cowlitz River Coho Salmon are an important component of commercial, sport, and tribal harvest and are harvested in ocean, lower Columbia River, and lower Cowlitz River fisheries, as well as in fisheries above both Mayfield and Cowlitz Falls dams (where salmon captured at Cowlitz Salmon Hatchery may be transported). However, creel surveys have been almost nonexistent and much of the harvest information relies heavily on catch record cards, which are notoriously unreliable.

Managing for population recovery would support high harvest rates for hatchery-origin salmon while keeping harvest of the natural-origin salmon as low as possible until the population can support harvest (Paquet et al. 2011). Until recent years, naturally produced Coho Salmon were managed like hatchery salmon and were subjected to similar harvest rates; combined ocean and Columbia River harvest of Columbia River Coho Salmon ranged from 70% to over 90% from 1970-1983. An annual mean of 1,494 Coho Salmon were harvested in the Cowlitz Basin sport fishery from 1986-1990. As noted above, ocean and Columbia River fisheries were reduced in the 1980s and 1990s in California, Oregon, Washington, and Canada to protect several Puget Sound and Washington coastal wild Coho Salmon populations. Natural-origin lower Columbia River Coho Salmon benefitted from these harvest limits and the 1999-2002 harvest of ESA-listed Coho Salmon was less than 15% annually. For the 1994 and 1997 brood years of Cowlitz Salmon Hatchery late Coho Salmon, 36% escaped the fishery, while 64% were captured in fisheries: 55% in the Columbia River, 30% in the Washington ocean, and 15% in the Oregon ocean. Excess hatchery-origin salmon may also be harvested in the Tilton and Upper Cowlitz subbasins, where they are transported for natural production and to support fisheries.

WDFW has established long-term goals for harvest of Cowlitz Basin Coho Salmon in terms of catch numbers, harvest rates, and seasons, by fishery (Tacoma Power 2011). From 2007-2017, a mean of 68,860 hatchery-origin Cowlitz River Coho Salmon were harvested annually, comprising 94% of the total harvest (Table 5.0-3; Figure 5.0-3). Most of hatchery-origin harvest occurred in the ocean (57%), Columbia River (27%), and Lower Cowlitz Subbasin (12%) fisheries, with the remainder harvested in the Tilton or Upper Cowlitz subbasins (4%).

For natural-origin Coho Salmon, mean total harvest from 2007-2017 was 17,848 salmon, 6% of the total harvest of Cowlitz Basin Coho Salmon (Table 5.0-3; Figure 5.0-3). Most of the natural-origin harvest occurred in the ocean (58%) and Columbia River (26%) fisheries, with 10% and 6% being lost to exploitation in the Lower Cowlitz and Tilton/Upper Cowlitz subbasins, respectively.

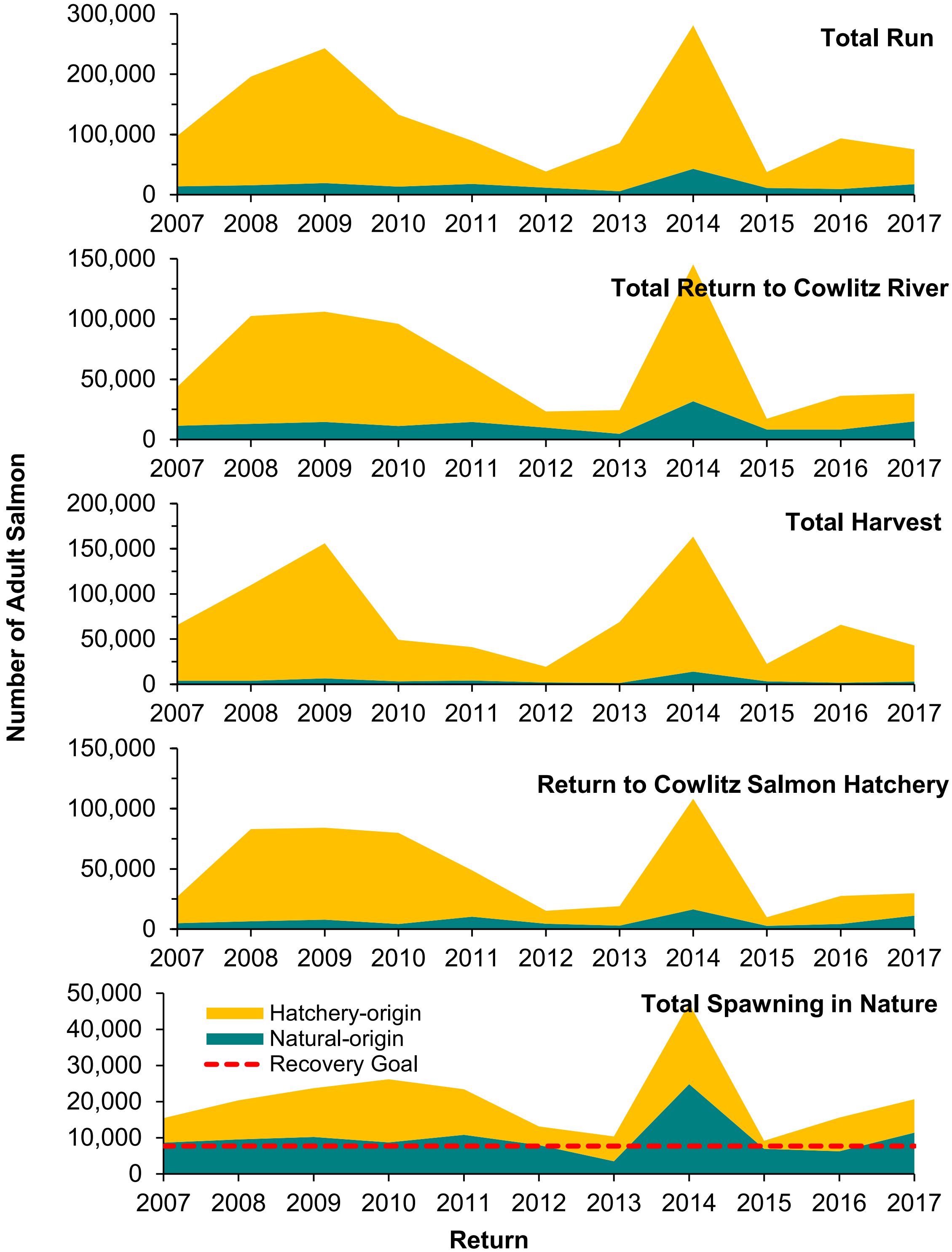


Figure 5.0-2. Estimated total run size for adult hatchery- and natural-origin Coho Salmon and the numbers that returned to the Cowlitz River, were harvested, returned to Cowlitz Salmon Hatchery, and were transported above Cowlitz Falls Dam, 2007-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Table 5.0-3. Mean, minimum, and maximum numbers of all adult hatchery- and natural-origin fall Chinook Salmon from the Cowlitz Basin, excluding the Coweeman and Toutle rivers, that could be accounted for at recovery locations and percentage of total at that recovery location, 2007-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW and may not be complete.

Origin,	Number of Adults		
Recovery Location	Mean	Minimum	Maximum
Hatchery-origin			
Total Run (unique to or below hatchery)[1]	108,413	26,193	238,229
Harvest (total for harvest rate)[2]	68,860	17,169	149,404
Total Return to Cowlitz River [3]	50,037	9,060	113,635
Return to Hatchery	41,525	7,071	91,809
Collected for Broodstock	1,457	689	2,751
Survived to Spawn in Nature[4]	10,577	2,236	22,319
Natural-origin or Integrated Hatchery-origin			
Total Run (unique to or below hatchery)[1]	16,195	5,738	42,915
Harvest (total for harvest rate)[2]	4,335	1,455	14,063
Total Return to Cowlitz River [3]	12,952	4,769	31,714
Return to Hatchery	6,858	2,759	16,391
Collected for Broodstock	630	229	809
Survived to Spawn in Nature[4]	9,891	3,526	24,837
Combined Hatchery- and Natural-origin			
Total Run (unique to or below hatchery)[1]	124,607	37,420	281,143
Harvest (total for harvest rate)[2]	73,196	19,313	163,391
Total Return to Cowlitz River [3]	62,989	17,238	145,349
Return to Hatchery	48,382	9,830	108,200
Collected for Broodstock	2,087	1,383	3,224
Survived to Spawn in Nature[4]	20,469	9,139	47,156

[1] Sum of all harvest below Mayfield Dam, returns to hatchery, and spawning in nature in Lower Cowlitz Subbasin.
[2] Total of harvest in ocean, Columbia River, lower Cowlitz River, and Upper Cowlitz Subbasin fisheries.
[3] Sum of Lower Cowlitz Subbasin harvest, returns to hatchery, and spawning in nature in Lower Cowlitz Subbasin.
[4] Calculated as number transported to the Upper Cowlitz Subbasin minus harvest in the Upper Cowlitz Subbasin, 12% fallback, and 10% pre-spawn mortality.

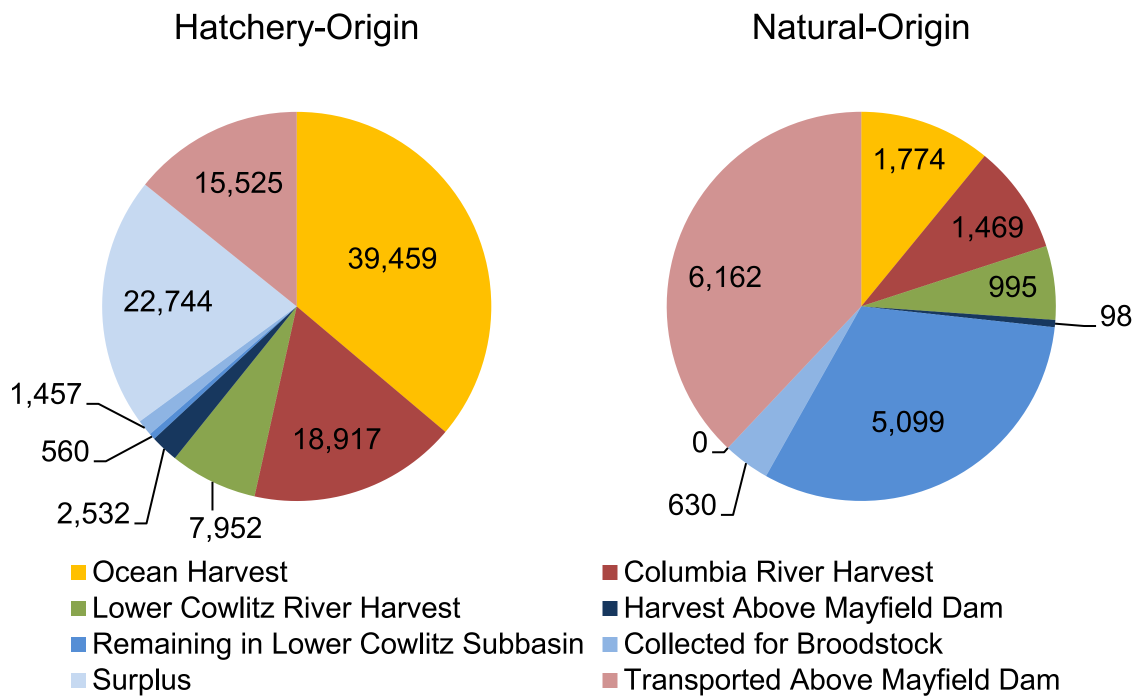


Figure 5.0-3. Percentages and mean numbers of hatchery-origin and natural-origin Cowlitz Basin fall Chinook Salmon harvested, by fishery location, 2011-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

5.0.8. Natural Production

To recover a natural salmon population, it must be self-sustaining. To successfully manage toward population recovery, it is important to know the abundance of the population at important points in their life history. Overall, we need to know (by origin, sex, and age) how many salmon are spawning in nature (F_0 generation) and how many of their offspring (F_1 generation) smolt and leave the Cowlitz River and subsequently survive to produce the next (F_2) generation. Because spawning ground surveys are not conducted in the Upper Cowlitz or Tilton subbasins, any estimates to date of Coho Salmon successfully reproducing on the spawning grounds are based simply on the number transported above the dams; we do not know how many actually survive to spawn. Collections of Coho Salmon smolts at Cowlitz Falls and Mayfield dams offer an important monitoring point and provide a reliable number of smolts transported and released downstream but the accuracy of the actual smolt production estimates has been constrained by poor and variable collection efficiency.

The recovery abundance target for the combined Coho Salmon populations in the Cowlitz Basin is 7,700 natural-origin adults spawning in nature (Table 5.0-1); this target consists of the Primary populations in the Lower Cowlitz (3,700 spawners) and Upper Cowlitz (including the Cispus River drainage) subbasins (4,000 spawners; LCFRB 2010). The Recovery Plan does not establish an abundance target for the Tilton Subbasin population because it is only a Stabilizing population; however, we propose 2,000 natural-origin spawners as a long-term recovery target for the Tilton Subbasin population. This brings the combined Cowlitz Basin Coho Salmon recovery target to at least 9,700 natural-origin adults spawning in nature.

From 2007-2017, estimated natural-origin abundance on the spawning grounds in the Primary populations (Lower Cowlitz and Upper Cowlitz subbasins) exceeded the target in 8 of 11 years, ranging from 3,526 in 2013 to 24,83 in 2014, with a mean of 9,891. Over that same period, the Primary Upper Cowlitz Subbasin population achieved its recovery target of 4,000 natural-origin adults spawning in nature for 7 of the 11 years (mean = 2,851), and the Stabilizing Tilton Subbasin population achieved 2,000 natural-origin adults spawning in nature twice, with a mean of 1,941.

Although natural spawning of hatchery-origin salmon is not directly credited toward meeting natural production targets, hatchery-origin adults are currently transported to the Upper Cowlitz and Tilton subbasins to spawn naturally as part of the recovery program. Ultimately, the goal is to greatly reduce or eliminate natural spawning of hatchery-origin salmon once natural-origin abundance targets are met.

5.0.8.1. Adult Transport / Natural Spawning

Currently, Coho Salmon smolts captured at the Cowlitz Falls Fish Facility are marked with a CWT, so they are identifiable when they return at maturity to Cowlitz Salmon Hatchery. However, the natural-origin salmon from the Lower Cowlitz and Tilton subbasins cannot be distinguished from each other. All unmarked natural-origin returns to the hatchery are assumed to have originated from the Tilton Subbasin and are transported there. For the 2007-2017 run years, a mean of 3,650 natural-origin adults were transported and released into the Upper Cowlitz Subbasin, while a mean of 2,512 natural-origin adults were transported and released into the Tilton Subbasin. Collectively, this represented 38% of the total natural-origin run and 48% of those returning to the Cowlitz River.

5.0.8.2. Smolt Production / Transport

Natural-origin smolt production from the Lower Cowlitz Subbasin is unknown and cannot be estimated at present. Smolt monitoring in the Lower Cowlitz Subbasin is conducted using a screw trap in the mainstem Cowlitz River and is difficult because of the large size of the river. Further confounding these estimates is the presence of Coho Salmon smolts from the Tilton and Upper Cowlitz subbasins, many of which cannot be discerned from those from the Lower Cowlitz Subbasin.

Smolt production of natural-origin Coho Salmon from the Tilton and Upper Cowlitz subbasins is not well known due to historically poor and variable collection efficiencies at Mayfield and Cowlitz Falls dams. However, collection efficiency at Cowlitz Falls Fish Facility has greatly improved and we will continue to increase collection efficiency at both dams to improve our estimate of natural-origin smolt production. From 2007-2017, a mean of 86,968 Coho Salmon smolts from the Upper Cowlitz Subbasin were captured at Cowlitz Falls Dam and a mean of 34,115 Tilton Subbasin smolts were captured at Mayfield Dam. All of these smolts were transported to Cowlitz Salmon Hatchery, where they were released into the lower Cowlitz River to continue their migration.

5.0.9. Artificial Production

A Coho Salmon hatchery program was initiated at Cowlitz Salmon Hatchery in 1967 (WDFW 2014). The program was integrated by default because the hatchery-origin Coho Salmon were not 100% marked until 1998 and, because only a fraction of the hatchery-origin salmon was marked at all, the integration rates were unknown. A truly segregated program began in 1998 when 100% of the hatchery-origin salmon were adipose fin-clipped and managers could be certain about the origin of the salmon collected for broodstock. The Segregated Hatchery Program for the Lower Cowlitz Subbasin Coho Salmon population currently has a production goal of 1,200,000 age-2 smolts but may vary, depending on factors such as the projected return of natural-origin salmon and the size of the Upper Cowlitz Subbasin Integrated Hatchery Program.

The Upper Cowlitz Subbasin Coho Salmon Integrated Hatchery Program at Cowlitz Salmon Hatchery was initiated in 2007 with pNOB = 1 and a goal of producing 978,000 smolts annually that are marked (CWT and adipose clip) as the F_1 progeny of natural-origin broodstock from the Upper Cowlitz Subbasin. These fish are reared at Cowlitz Salmon Hatchery and directly released into the Lower Cowlitz River to avoid the loss due to low fish passage survival at Cowlitz Falls Dam.

Moving forward in the near term, we will develop a plan and transition strategy to move to a single Integrated Hatchery Program derived from the Upper Cowlitz Subbasin that meets all program supplementation and harvest needs. This single, Upper Cowlitz Subbasin Integrated Hatchery Program will encompass all hatchery production from the current Lower Cowlitz Subbasin (Segregated) and Upper Cowlitz Subbasin (Integrated) hatchery programs, with an annual production target of 2.2 million age-2 (yearling) smolts. Hatchery broodstock will be collected primarily (but not totally) from the early portion of the run to reconstruct the original run timing of Coho Salmon above Mayfield Dam. The result is that we will continue to meet all program supplementation and harvest needs:

- Total hatchery production of Coho Salmon in the Cowlitz Basin will not change.
- Fisheries will continue to be supported both below Mayfield Dam and in the Tilton and Upper Cowlitz subbasins.
- The Cowlitz Basin Coho Salmon population will be supplemented with hatchery-origin salmon with at least one natural parent (reducing domestication of the hatchery population).
- Hatchery-origin salmon spawning in nature will have at least one natural parent (reducing the detrimental effect on the natural population of hatchery-origin salmon spawning in nature).
- We will begin the local adaptation process for the populations above Mayfield Dam by protecting natural-origin salmon to the best of our abilities through management and new infrastructure.

In the longer term, we will continue with additional steps toward encouraging local adaptation of the three separate populations above Mayfield Dam.

Hatchery best management practices will be used for all facets of hatchery production and hatchery production metrics will be monitored to ensure that production goals are met, as well as to understand the magnitude of hatchery influence on the natural population that it is supplementing. Key monitoring metrics are the numbers of salmon collected and spawned (by origin, age, and sex), green eggs, eyed eggs, fry, parr, smolts released, and of mature hatchery-origin salmon returning to the Cowlitz River and Cowlitz Salmon Hatchery (by age and sex). Using these data, we also calculate and monitor hatchery effectiveness metrics and smolt-to-adult survival and return rates.

5.0.9.1. Overall Hatchery Program Goals

The overall goals of the Coho Salmon hatchery program within the Cowlitz Basin are to:

1) Promote the recovery of populations in the Cowlitz Basin.
2) Provide harvest opportunities for commercial, recreational, and tribal fisheries.
3) Support educational and research opportunities.

To achieve these goals, specific and quantifiable objectives for the hatchery program are described in detail within the respective sections for each of the Cowlitz Basin Coho Salmon populations (see Sections 5.1, 5.2, and 5.3).

In the nearer term, the duration of this FHMP, our goals are to:

1) Develop a plan and transition strategy to move to one hatchery program derived from the Upper Cowlitz Subbasin that meets all program and harvest needs. This single, Upper Cowlitz Subbasin Integrated Hatchery Program will encompass all hatchery production from the current Lower Cowlitz River Integrated and Segregated Hatchery Programs.
2) Maintain flexibility to increase production within FERC licensing and ESA constraints.
3) Identify the origin of spawners and monitor pHOS in the mainstem lower Cowlitz River.
4) Develop goals that take into account any difference in survival between hatchery-origin salmon from the Integrated and Segregated Hatchery Programs.
5) Develop a transition plan and begin marking natural-origin salmon collected at Mayfield Dam, instead of Cowlitz Falls Dam, in the next 2 years.
6) Define the disposition/best use of surplus salmon (returns to the hatchery that are not used for broodstock or transported upstream).

5.0.9.2. Existing Hatchery Program

Salmon that are captured at Cowlitz Salmon Hatchery may be hatchery-origin salmon, natural-origin salmon that are attempting to migrate above the hydroelectric dams, or natural-origin salmon from the Lower Cowlitz Subbasin that strayed upstream and entered the hatchery trap. From 2003-2017, a mean of 48,382 adult Coho Salmon returned to Cowlitz Salmon Hatchery, of which 41,525 (86%) were hatchery-origin while 6,858 (14%) were natural-origin. From 2007-2017, a mean total of 1,716 Coho Salmon were spawned at Cowlitz Salmon Hatchery, 1,163 (68%) of which were hatchery-origin and 553 (32%) were natural-origin. Those salmon produced a mean of 2,564,120 age-2 (yearling) smolts, of which 1,804,727 (70%) came from the Segregated Hatchery Program and 759,393 (30%) from the Integrated Hatchery Program.

5.0.9.3. Adult Transport and Natural Spawning

The existing hatchery program also involves the transport of salmon collected at the hatchery to habitats above Mayfield Dam. From 2007-2017, a mean of 21,687 adult Coho Salmon were transported above Mayfield Dam to either the Tilton Subbasin or the Upper Cowlitz Subbasin to provide for fisheries and natural spawning. Of those, means of 15.525 (72%) were hatchery-origin and 6,162 (28%) were natural-origin Coho Salmon.

From 2007-2017, a mean of 20,469 Coho Salmon spawned in nature, 10,577 (52%) of which were hatchery-origin and 19,891 (48%) were natural-origin. From 1994-2016, the salmon that spawned above Mayfield Dam produced an annual mean of 138,604 smolts that were captured for transport to Cowlitz Salmon Hatchery (migration years 1996-2018), where they were released into the lower Cowlitz River to continue their migration to the ocean. A mean of 33,018 smolts were captured at the Mayfield Dam Collection Facility (Tilton Subbasin) and 105,586 smolts were captured at the Cowlitz Falls Fish Facility (Upper Cowlitz Subbasin).

5.0.10. Survival and Productivity

Based on the CWT data in the RMIS database, the mean total smolt-to-adult return (TSAR) rate for coded-wire-tagged hatchery-origin Coho Salmon for the 2005-2014 brood years was 1.61. Natural-origin Coho Salmon smolts captured at Cowlitz Falls Dam have been coded-wire-tagged since 2013 (brood year ~2011). Mean smolt-to-adult return rate (to Cowlitz Salmon Hatchery, since natural-origin Coho Salmon are rarely checked for CWTs anywhere else) for Coho Salmon tagged as juveniles from 2013-2015 was 8.53%. For comparison, hatchery-origin TSAR (which includes harvest) over that same period was 0.64%.

Mean productivity (adult recruits that returned to Cowlitz Salmon Hatchery or spawned in nature/spawning parent; R/S) cannot be estimated, as all data are not yet available. We will monitor this index as the data become available through our M&E Program.

5.0.11. Proportionate Natural Influence and Age Composition

PNI is an index of the influence that hatcheries have on salmon populations as a whole. PNI is calculated using two proportions: the proportion of spawners in nature that are hatchery-origin (pHOS) and the proportion of the hatchery broodstock that is comprised of natural-origin salmon (pNOB). HSRG recommendations for Primary populations with integrated hatchery programs are that pHOS <0.3 and that pNOB should be greater than twice pHOS (so that PNI >0.67). For Primary populations with a segregated hatchery program, the HSRG recommends pHOS <0.05.

Because of the large proportions of hatchery-origin salmon transported Upper Cowlitz and Tilton subbasins and the low numbers of natural-origin salmon spawning in Lower Cowlitz Subbasin tributaries, mean pHOS for the Cowlitz Basin from 2007-2017 was 0.506. Mean pNOB for all Coho Salmon spawned at Cowlitz Salmon Hatchery was 0.315, mostly because the Integrated Hatchery Program usually uses 100% hatchery-origin salmon for its broodstock. As a result, mean PNI for the Coho Salmon population in the Cowlitz Basin was 0.374 from 2007-2015.

Age composition cannot be completely calculated from the ISIT data because they are not compiled by age or brood year. Age classes are only characterized as “jacks (<42 cm)” or “adults (>42 cm)” and these data are only available for returns to Cowlitz Salmon Hatchery, not for any other recovery locations. Mean age composition of mature Coho Salmon that returned to Cowlitz Salmon Hatchery from 2007-2017 was 28% age-2 (jacks) and 72% ages-3-4 (adults) for hatchery-origin salmon. However, age composition is more informative when examined by brood year. Data from coded wire tagged hatchery-origin salmon from RMIS indicate that, for the 2005-2014 brood years, 20% of the hatchery-origin Coho Salmon were recovered at age-2 (jacks) and 73% and 7% at ages-3 and -4 (adults), respectively. ISIT combines natural-origin and Integrated Hatchery Program returns to the hatchery, so the frequency of natural-origin jacks cannot be estimated. We will begin collecting age data by origin and hatchery program and will monitor this index as the data become available through our M&E Program.

5.0.12. Marking and Tagging

Identifying the origin and/or release group to which a salmon belongs is crucial to effective monitoring and evaluation (Table 5.0-4). All hatchery-origin Coho Salmon are marked with an adipose fin clip. We will apply other types and locations of various marks and tags to all or a sufficient portion of all hatchery release groups so that we can adequately monitor and evaluate the programs. Additionally, we will switch from tagging natural-origin smolts captured at the Cowlitz Falls Fish Facility to those captured at the Mayfield Dam Juvenile Bypass Facility so that each can be differentiated upon any later recapture (those from the Upper Cowlitz Subbasin will be identified by the absence of a tag). Marking and tagging schemes may differ from year to year, especially for hatchery-origin releases, which may also include experimental groups. Marking and tagging schemes for each group, within each brood year, will be set by the Monitoring and Evaluation subgroup, approved by the FTC, and documented in each year's Annual Operating Plan.

Table 5.0-4. Current and proposed hatchery programs, smolt production, and marking/ tagging for Coho Salmon.

Origin & Stock	Hatchery Program	Juvenile Production		Mark / Tag	
		Current	Proposed	Current	Proposed
Hatchery					
Lower Cowlitz Subbasin	Integrated	1,000,000	None	Adipose Fin Clip	NA
	Segregated	1,200,000	None	100% Ad + CWT	NA
Upper Cowlitz Subbasin	Integrated	None	2,200,000	NA	Ad + CWT
Natural					
Lower Cowlitz Subbasin	None	Unknown	50,000	None	None
Upper Cowlitz Subbasin	None	50,000-200,000		CWT	None
Tilton Subbasin	None	20,000-70,000		None	CWT

5.0.13. Summary

- The continued genetic exchange among Coho Salmon in the hatchery and those spawning naturally in the Lower Cowlitz Subbasin since 1963 has caused Cowlitz Basin Coho Salmon to functionally become a single population.
- Although the ESA framework identifies distinct Coho Salmon populations in the Cispus and upper Cowlitz rivers, returning adults cannot be differentiated. Thus, these populations are managed as a combined "Upper Cowlitz Subbasin" population.
- Recovery efforts for Coho Salmon will focus on increasing the abundance of natural-origin adults spawning in nature in the Lower Cowlitz, Upper Cowlitz, and Tilton subbasins.
- In the near-term, we will develop a plan and transition strategy to move to a single Integrated Hatchery Program, derived from the Upper Cowlitz Subbasin, that will meet all program supplementation and harvest needs. This single, Upper Cowlitz Subbasin Integrated Hatchery Program will have a production target of 2.2 million age-2 (yearling) smolts, which will replace all current hatchery production from the Lower Cowlitz Subbasin (Segregated) and Upper Cowlitz Subbasin (Integrated) Hatchery Programs.
- We will continue to evaluate the appropriate program structure to manage for individual populations and local adaptation.

Population: Lower Cowlitz Subbasin Coho Salmon
Oncorhynchus kisutch

<u>**ESA Listing**</u>

Status:	Threatened Listed in 2005, reaffirmed in 2011 and 2016
Evolutionarily Significant Unit:	Columbia River Coho Salmon
Major Population Group:	Cascade Coho Salmon
Recovery Region:	Lower Columbia River Salmon
Population Recovery Designation:	Primary
Population Viability Rating:	
Baseline	Very Low
Objective	High
Recovery Target:	3,700 natural-origin adults spawning in nature in the Lower Cowlitz Subbasin
Current Recovery Phase:	Local Adaptation
Current Hatchery Program(s):	Cowlitz Salmon Hatchery Segregated Hatchery Program, 1.2 million age-2 (yearling) smolts
Proposed Hatchery Program(s):	None; production will transfer to the Upper Cowlitz Subbasin Integrated Hatchery Program

5.1. Coho Salmon: Lower Cowlitz Subbasin Population

5.1.1. Purpose

This section describes the current status of the Lower Cowlitz Subbasin Coho Salmon population based on recent and available data. In addition, we identify VSP metrics needed to evaluate the status of this population with regard to reaching recovery targets under ESA guidelines. Where appropriate, we propose changes to both hatchery and monitoring programs to better evaluate progress toward population recovery. Although the Lower Cowlitz Subbasin Coho Salmon population is on the verge of meeting its recovery abundance target, hatchery influence on the natural population is high. During the period covered by this FHMP, we begin working toward reducing hatchery influence on the natural-origin population, with a short-term goal of transitioning hatchery production from the Lower Cowlitz Subbasin Segregated Hatchery Program to a single Upper Cowlitz Subbasin Integrated Hatchery Program of 2.2 million smolts, which would continue to provide fisheries both below and above Mayfield Dam. We will continue to evaluate the hatchery program and fisheries management and will make refinements or adjustments, as described in this FHMP, to effectively manage the Lower Cowlitz Subbasin Coho Salmon population.

5.1.2. Population Description

The Lower Cowlitz Subbasin Coho Salmon population includes all natural-origin Coho Salmon that occupy the Cowlitz River and all tributaries, excluding the Toutle and Coweeman rivers, from the mouth of the Cowlitz River up to the Barrier Dam (rkm 81), as well as those from the current Segregated Hatchery Program at Cowlitz Salmon Hatchery (Figure 5.1-1). The Coho Salmon population is the sole extant population of the original four Coho Salmon populations above the Toutle River. It was found to be "Depressed" (WDFW 1993) and was listed in 2005 as threatened under the ESA, and reaffirmed in 2011 and 2016. This population is classified as a Primary population for contributing to recovery of the lower Columbia River ESU and must attain its recovery and viability goals for the ESU to be considered recovered (WDFW and LCFRB 2016).

The Lower Cowlitz Subbasin Coho Salmon population is currently supplemented by hatchery production. The combined hatchery- and natural-origin Lower Cowlitz Subbasin population is relatively abundant and is the source population for restoring populations above Mayfield Dam (Figure 5.1-1). The most recent 5-year means for total run size, returns to the Lower Cowlitz Subbasin, total harvest, and spawners in nature for hatchery- and natural-origin salmon have exceeded the recovery/management goals for the population. Hatchery-origin broodstock spawned and smolts produced have not consistently achieved their goal, but this may be due to hatchery production goals being lower in some years. Natural smolt abundance has not been estimated.

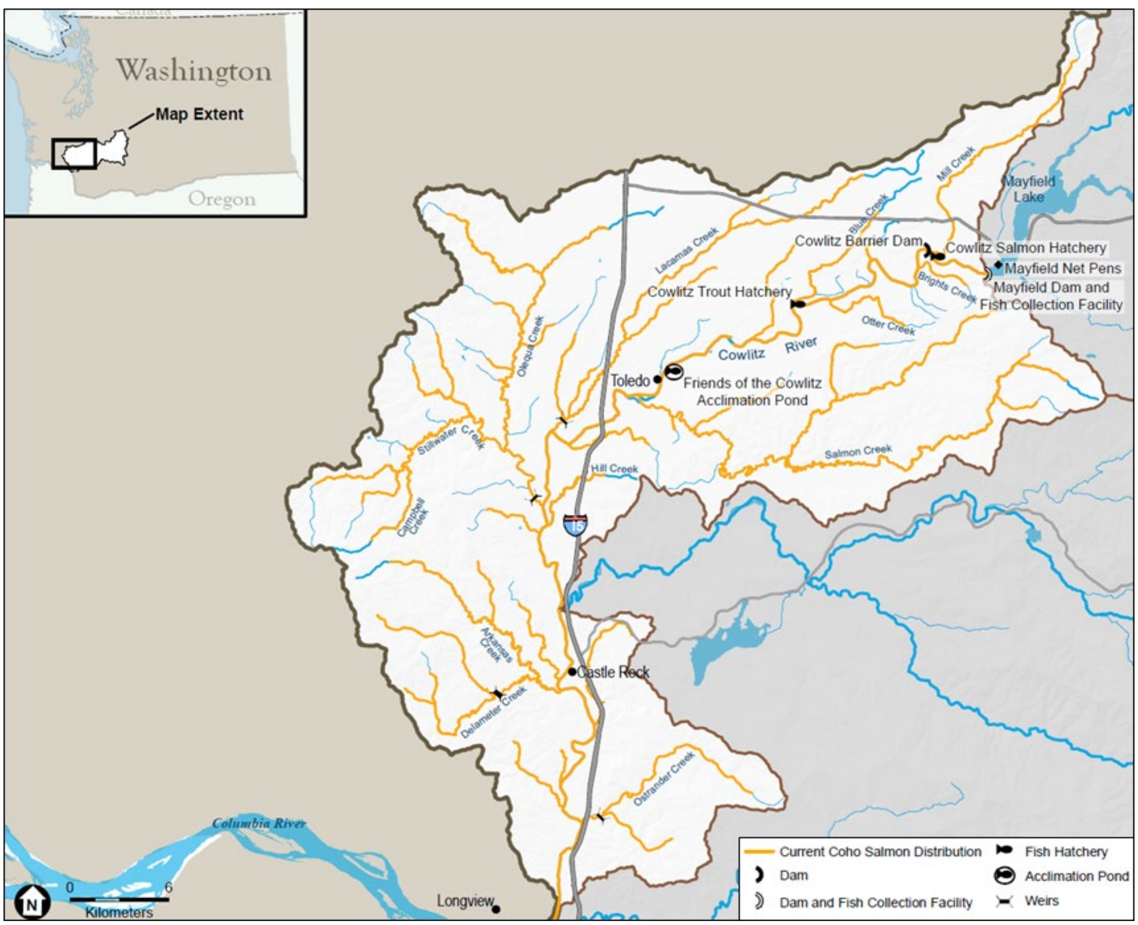


Figure 5.1-1. Distribution of Coho Salmon in the Lower Cowlitz Subbasin.

Table 5.1-1. Mean, minimum, and maximum numbers of all hatchery- and natural-origin adult Coho Salmon from the Lower Cowlitz Subbasin population accounted for at recovery locations, and percentage of total at each recovery location, 2010-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

	Number of Adults		
Origin, Recovery Location	Mean	Minimum	Maximum
Hatchery-origin			
Total Run[1]	27,703	16,115	48,856
Harvest[2]	18,588	7,106	30,456
Ocean harvest	10,897	2,761	22,246
Columbia River harvest	4,860	2,178	11,823
Lower Cowlitz River harvest	1,776	1,017	4,031
Above Mayfield Dam harvest	1,054	162	1,922
Total Return to Cowlitz River[3]	11,945	6,221	23,304
Remain in Lower Cowlitz Subbasin	560	20	1,094
Return to Cowlitz Salmon Hatchery	9,609	4,015	18,646
Collected for Broodstock	1,323	689	2,086
Transported Above Mayfield Dam	4,163	1,512	6,206
Spawners Above Mayfield Dam[4]	2,348	823	4,223
Natural-origin			
Total Run[1]	7,484	2,442	20,482
Harvest[2]	2,385	826	7,821
Ocean harvest	996	304	2,978
Columbia River harvest	826	94	3,341
Lower Cowlitz River harvest	564	100	1,502
Above Mayfield Dam harvest	0	0	0
Total Return to Cowlitz River[3]	5,663	1,819	14,163
Remain in Lower Cowlitz Subbasin	5,099	1,565	12,661
Return to Cowlitz Salmon Hatchery	0	0	0
Collected for Broodstock	0	0	0
Transported Above Mayfield Dam	0	0	0
Spawners Above Mayfield Dam[4]	0	0	0
Combined Hatchery- and Natural-origin			
Total Run[1]	35,187	18,557	69,338
Harvest[2]	20,973	7,932	38,277
Ocean harvest	11,893	3,065	25,224
Columbia River harvest	5,686	2,272	15,164
Lower Cowlitz River harvest	2,340	1,117	5,533
Above Mayfield Dam harvest	1,054	162	1,922

Origin, Recovery Location	Number of Adults Mean	Minimum	Maximum
Total Return to Cowlitz River[3]	17,608	8,040	37,467
Remain in Lower Cowlitz Subbasin	5,659	1,585	13,755
Return to Cowlitz Salmon Hatchery	9,609	4,015	18,646
Collected for Broodstock	1,323	689	2,086
Transported Above Mayfield Dam	4,163	1,512	6,206
Spawners Above Mayfield Dam[4]	2,348	823	4,223

[1] Sum of all harvest below Mayfield Dam, remaining in the Lower Cowlitz Subbasin, and returns to Cowlitz Salmon Hatchery.
[2] Total of harvest in ocean, Columbia River, lower Cowlitz River, and above Mayfield Dam.
[3] Sum of lower Cowlitz River harvest, remaining in the Lower Cowlitz Subbasin, and returns to Cowlitz Salmon Hatchery.
[4] Estimated by subtracting estimated harvest loss and multiplying by standard fallback (12%) and pre-spawn mortality (10%) rates from the numbers transported.

Table 5.1-2. Mean, minimum, and maximum hatchery and natural spawning metrics and proportionate natural influence for Lower Cowlitz Subbasin Coho Salmon, 2007-2015 spawn/brood years. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Spawning Location, Metric	2007-2015 Spawn/Brood Years Mean	Minimum	Maximum
Hatchery			
Adults Collected	1,311	689	2,086
Hatchery-origin	1,311	689	2,086
Natural-origin	0	0	0
Pre-spawn Survival Rate	0.895	0.801	0.956
Adults Spawned	1,158	600	1,760
Hatchery-origin	1,158	600	1,760
Natural-origin	0	0	0
Total Green Eggs	1,716,343	909,186	2,710,393
Mean Fecundity	3,000	1,300	4,123
Total Eyed Eggs		data unavailable	
Smolts Released	1,477,266	810,085	2,349,911
Green Egg-to-Smolt Survival	86%	73%	97%
Smolt Productivity (smolts / spawner)	1,329	621	1,838
Nature			
Spawners	5,990	1,585	13,730
Hatchery-origin	525	20	1,069
Natural-origin	5,465	1,565	12,661
Smolts Produced		data unavailable	
Smolt Productivity (smolts / spawner)		data unavailable	
Proportionate Natural Influence			
pNOB	0.000	0.000	0.000
pHOS	0.086	0.013	0.150
PNI	0.000	0.000	0.000

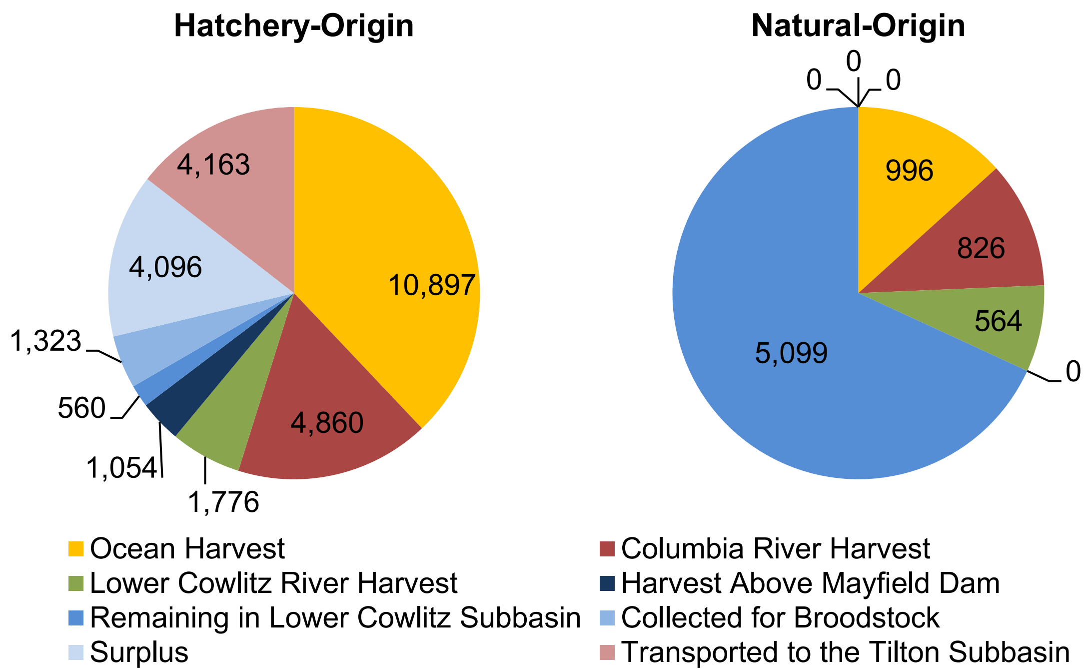


Figure 5.1-2. Mean numbers and proportions of hatchery- and natural-origin Lower Cowlitz Subbasin fall Chinook Salmon caught in ocean, Columbia River, or lower Cowlitz River fisheries, or that were transported above Cowlitz Falls Dam (and were harvested or remained in the Upper Cowlitz Subbasin), 2007-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

5.1.3. Natural Production

Two critical monitoring metrics for salmon management are the numbers that return at maturation and their disposition (Table 5.1-1; Figures 5.1-2 and 5.1-3). Lower Cowlitz Subbasin Coho Salmon that survive to begin their spawning migration may be harvested in commercial, sport, or tribal fisheries in the ocean, Columbia River, or Cowlitz River. Those escaping harvest may return to Cowlitz Salmon Hatchery or natural spawning grounds, where they may be recovered and counted. They may also die from predation or disease at any time and not be recovered. Monitoring these metrics allows us to evaluate population health, productivity, and progress toward recovery; however, these data, which are critical to monitoring the Lower Cowlitz Subbasin Coho Salmon population, have been only sporadically collected and are incomplete, making population trends difficult to discern at this time.

5.1.3.1. Abundance

The recovery goal for the Lower Cowlitz Subbasin Coho Salmon population is an annual abundance of 3,700 natural-origin salmon spawning in nature (LCFRB 2010). From 2007-2017, means of total run sizes were 7,484 natural-origin Coho Salmon (Figures 5.1-2 and 5.1-3; Table 5.1-1). A mean of 5,663 natural-origin salmon entered the Cowlitz River (32% of the total return to the Cowlitz River) and 5,099 natural-origin Coho Salmon remained on the spawning grounds in the Lower Cowlitz Subbasin.

Juvenile production of Coho Salmon in the Lower Cowlitz Subbasin includes smolts released from Cowlitz Salmon Hatchery plus natural production. Estimates of natural production for juvenile Coho Salmon are not available.

5.1.3.2. Harvest

Harvest is an important component of the management of Lower Cowlitz Subbasin Coho Salmon and has the potential to impact population recovery. Lower Cowlitz Subbasin Coho Salmon contribute to important commercial and recreational fisheries in the Pacific Ocean, lower Columbia River, and Lower Cowlitz Subbasin. From 2007-2017, 32% (2,385) of the Lower Cowlitz Subbasin natural-origin population run was harvested (Figures 5.1-2 and 5.1-3; Table 5.1-1). Most (42%) of the natural-origin harvest was in the ocean, while 35% were harvested in the lower Columbia River, and 24% in the Lower Cowlitz Subbasin.

5.1.3.3. Disposition

By definition, no natural-origin Coho Salmon from the Lower Cowlitz Subbasin arrived at Cowlitz Salmon Hatchery. Therefore, there are no dispositions of natural-origin Lower Cowlitz Subbasin Coho Salmon to discuss.

5.1.3.4. Spawning in Nature

The Lower Cowlitz Subbasin Coho Salmon population recovery goal of 3,700 natural-origin salmon spawning in nature was exceeded during four of the eight years for which data are available in ISIT (mean = 5,099 from 2010-2017; Figures 5.1-2 and 5.1-3; Table 5.1-1). From 2007-2017, a mean of 5,663 natural-origin Coho Salmon from the Lower Cowlitz Subbasin population returned to the Cowlitz River. Of those, 10% were harvested, and 90% remained in nature. No Lower Cowlitz Subbasin Coho Salmon were recorded as having returned to Cowlitz Salmon Hatchery because all unmarked natural-origin salmon captured there are assumed to have come from the Tilton Subbasin.

Transport to the Tilton Subbasin of natural-origin Coho Salmon caught at Cowlitz Salmon Hatchery likely reduces the documented abundance of natural-origin Lower Cowlitz Subbasin Coho Salmon, as well as the actual number spawning in nature and their subsequent juvenile production in the Lower Cowlitz Subbasin. On the other hand, it is also likely that some Tilton Subbasin natural-origin salmon remain in the Lower Cowlitz Subbasin to spawn. No effort is currently conducted to identify the true origin of salmon returning to Cowlitz Salmon Hatchery, so the effect of these adult returns spawning out of location on actual adult natural-origin abundance is uncertain but should be considered in the future to facilitate effective management of populations both above and below Mayfield Dam.

5.1.3.5. Smolt Production

No estimate of Coho Salmon smolt abundance is available for the Lower Cowlitz Subbasin population. A smolt trap is operated on the lower Cowlitz River, but any juveniles captured may be from the Lower Cowlitz, Upper Cowlitz, or Tilton subbasins, so the data are confounded. Additionally, production from tributaries downstream from the smolt trap is not sampled. We will monitor this index as the data become available, through our M&E Program.

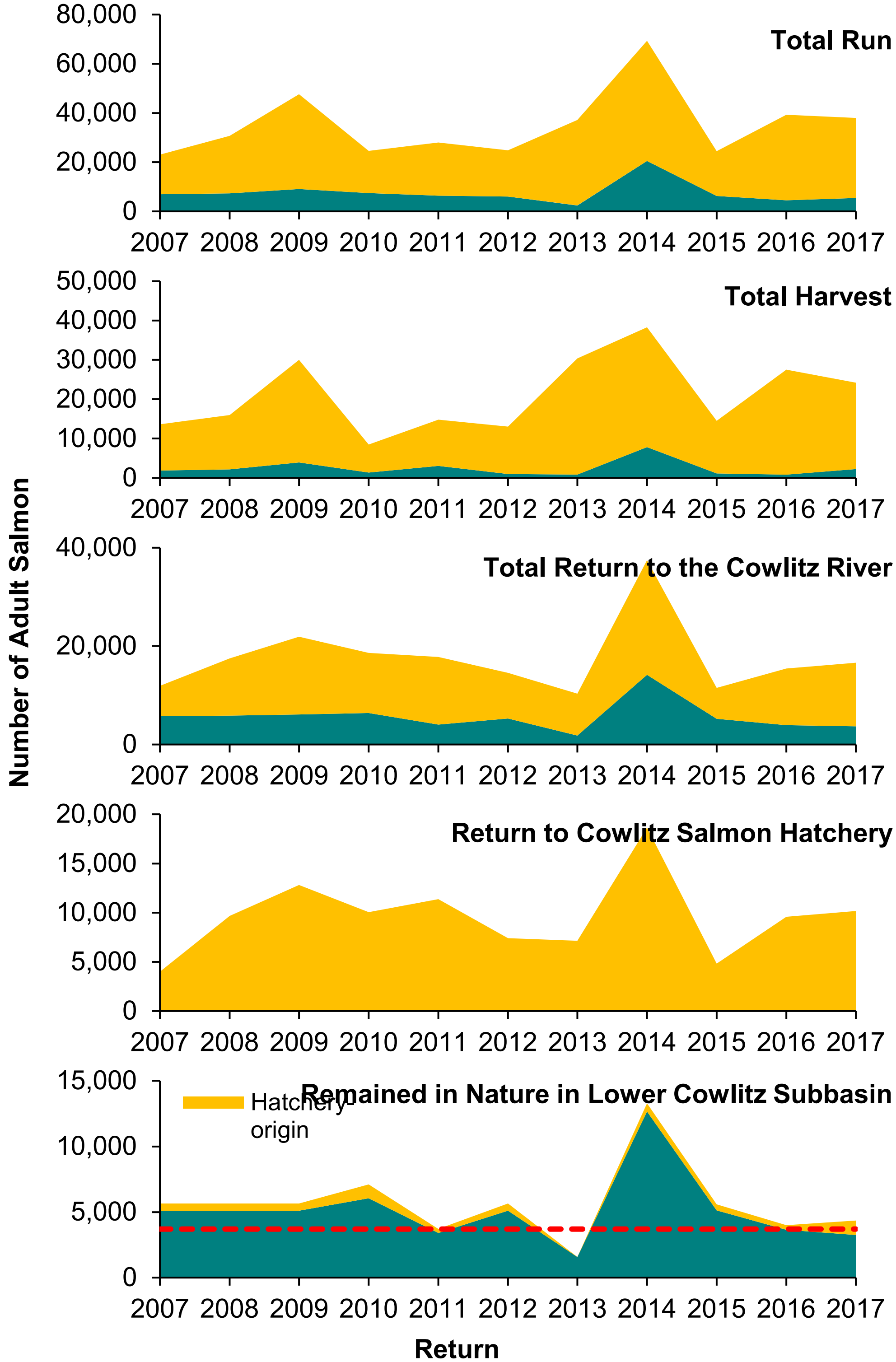


Figure 5.1-3. Estimated total run size for natural- and hatchery-origin (Segregated Hatchery Program) adult Lower Cowlitz Subbasin Coho Salmon and the numbers that returned to the Cowlitz River, were harvested, returned to Cowlitz Salmon Hatchery, or returned to Lower Cowlitz Subbasin spawning grounds, 2007-2017. Note: Numbers of natural-origin adults may be too small to be visible. Data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

5.1.3.6. Natural-origin Survival and Productivity

Survival and productivity are key metrics for monitoring populations. However, neither SAR, TSAR, nor smolts/spawner can be calculated for the Lower Cowlitz Subbasin Coho Salmon population because smolt abundance in the Lower Cowlitz Subbasin is not monitored, nor is age of returning mature salmon. For reference, mean smolt-to-adult return rate (to Cowlitz Salmon Hatchery) for Coho Salmon coded-wire-tagged as smolts at Cowlitz Falls Dam from 2013-2015 was 8.53%. We will monitor this index for the Lower Cowlitz Subbasin population as the data become available, through our M&E Program.

If we can develop a good estimate of smolt numbers, we will also monitor smolt productivity. Smolts produced/spawner provides an indication of the productivity of the freshwater rearing habitat but this metric is less valuable for overall population monitoring, as it is affected by freshwater rearing density and survival from smolt to maturation can vary widely.

5.1.3.7. Age Composition

Age composition cannot be completely calculated from the data in ISIT because they are not compiled by age or brood year. Age classes are only characterized as "jacks (<42 cm)" or "adults (>42 cm)," and these data are only available for returns to Cowlitz Salmon Hatchery, not for any other recovery locations. Because natural-origin returns to the hatchery are assumed to originate from populations above Mayfield Dam, no natural-origin Lower Cowlitz Subbasin Coho Salmon are handled at the hatchery; thus, ISIT does not provide an estimate of the ratio of natural-origin. We will monitor this index as the data become available, through our M&E Program.

5.1.4. Hatchery Production

Hatchery production metrics must be monitored to ensure that production goals are met, to evaluate the effectiveness of the program, and to understand the magnitude of hatchery influence on the natural population that it is supplementing. Key monitoring metrics are the numbers of salmon harvested, collected, and spawned (by origin, age, and sex); smolts released; and salmon returning to the Cowlitz River and Cowlitz Salmon Hatchery, as well as remaining in nature in the Cowlitz Basin and elsewhere. Using these data, we also calculate and monitor smolt-to-adult survival and return rates.

Cowlitz Salmon Hatchery initiated a Coho Salmon hatchery program in 1967 (WDFW 2014). The program was integrated by default because the hatchery-origin Coho Salmon were not 100% marked until 1998 and because only a fraction of the hatchery-origin salmon was marked at all, the integration rates were unknown. A truly segregated program began in 1998 when the hatchery-origin salmon were 100% adipose fin-clipped and managers could be certain about the origin of the salmon collected for broodstock. The Segregated Hatchery Program for the Lower Cowlitz Subbasin Coho Salmon population currently has a production goal that varies from 1,200,000 to 2,400,000, depending on factors such as the projected return of natural-origin salmon and the size of the Upper Cowlitz Subbasin Integrated Hatchery Program.

5.1.4.1. Abundance

From 2007-2017, the mean total run size of hatchery-origin Coho Salmon was 27,703 (Figures 5.1-2 and 5.1-3; Table 5.1-1). A mean of 11,945 hatchery-origin Coho Salmon entered the Cowlitz River, 9,609 returned to Cowlitz Salmon Hatchery, and 560 remained on the spawning grounds in the Lower Cowlitz Subbasin.

5.1.4.2. Harvest

From 2007-2017, 67% (18,588) of the Lower Cowlitz Subbasin hatchery-origin (Segregated Hatchery Program) population run was harvested (Figures 5.1-2 and 5.1-3; Table 5.1-1). From 2007-2017, 59% (10,897) of the total hatchery-origin harvest was in the ocean, 26% (4,860) was in the Columbia River, 10% (1,776) in the Lower Cowlitz Subbasin, and 6% (1,054) in the Tilton Subbasin (salmon that were transported upstream).

5.1.4.3. Disposition

From 2007-2017, a mean of 9,609 adult Coho Salmon from the Segregated Hatchery Program returned to Cowlitz Salmon Hatchery. Of those, a mean of 1,323 were collected for broodstock and 1,163 were spawned. A mean of 4,163 were transported to the Tilton Subbasin to provide harvest opportunities and to supplement natural spawning. The remaining 4,096 were deemed to be surplus.

5.1.4.4. Hatchery-origin Returns

The Cowlitz Salmon Hatchery Segregated Hatchery Program has a goal of producing an annual run of 25,500 hatchery-origin Coho Salmon. That goal was exceeded for 5 of the 11 years from 2007-2017 (mean = 27,703; Figure 5.1-3; Table 5.1-1). From 2007-2017, a mean of 11,945 hatchery-origin Coho Salmon returned to the Cowlitz River, where 15% (1,776) were harvested, 80% (9,609) returned to Cowlitz Salmon Hatchery, and 5% (560) remained in nature.

5.1.4.5. Hatchery Rearing

From 2007-2015, a mean of 1,311 mature hatchery-origin Coho Salmon were collected for broodstock in the Segregated Hatchery Program (Table 5.1-2). Mean pre-spawn survival was 90% and a mean of 1,158 of those collected were spawned, of which a mean of 52% were females. The Segregated Hatchery Program uses only mature salmon from the Segregated Hatchery Program for broodstock, so pNOB = 0 for all years.

From 2007-2015, an estimated mean of 1,716,343 green eggs were collected for the Segregated Hatchery Program at Cowlitz Salmon Hatchery from a mean of 602 females (Table 5.1-2). Mean fecundity was 3,000 green eggs, mean green egg-to-smolt survival was 87%, and 1,477,266 smolts were released.

Some eggs and/or fry were provided to RSI programs. However, juvenile production from these programs is unknown. Additionally, these offspring were not marked, so mature production is also unknown.

5.1.4.6. Hatchery-origin Survival and Productivity

We cannot calculate separate survival estimates for the Segregated and Integrated Hatchery Programs, as only one of those groups had CWTs and that information is not available in ISIT or RMIS. However, we see little reason for survival to differ substantially between the programs.

Based on the CWT data in the RMIS database, the mean total smolt-to-adult return (TSAR) rate for coded-wire-tagged hatchery-origin Coho Salmon for the 2005-2014 brood years was 1.61. Mean productivity (adult recruits that returned to Cowlitz Salmon Hatchery/spawned parent; R/S) cannot be estimated, as all data are not yet available. We will monitor this index as the data become available through our M&E Program.

5.1.4.7. Age Composition

Age composition cannot be completely calculated from the data in ISIT because they are not compiled by age or brood year. Age classes are only characterized as “jacks (<42 cm)” or “adults (>42 cm),” and these data are only available for returns to Cowlitz Salmon Hatchery, not for any other recovery locations. For hatchery-origin salmon, mean age composition of mature Coho Salmon that returned to Cowlitz Salmon Hatchery from 2007-2017 was 5% age-2 (jacks) and 95% age-4 (adults). CWT data show that, for the 2000-2013 brood years, means of 20%, 73%, and 7% of the hatchery-origin Coho Salmon returned at age-2, age-3, and age-4, respectively.

5.1.5. Proportionate Natural Influence

PNI is a useful metric for monitoring both hatchery and natural populations. Changes in PNI can indicate an increase or decrease in the effect of hatchery-origin salmon on the natural population.

From 2007-2017, a mean of 5,659 Coho Salmon spawned in the Lower Cowlitz Subbasin other than the Toutle and Coweeman rivers (Figures 5.1-2 and 5.1-3; Table 5.1-1). Of those, a mean of 560 were hatchery-origin (Segregated Hatchery Program) and 5,099 were natural-origin. Mean estimated spawner pHOS was 0.101 and ranged from 0.013-0.252. Because the Segregated Hatchery Program uses only hatchery-origin salmon for broodstock, pNOB is always equal to 0, so PNI = 0, as well.

However, this pHOS estimate is likely lower than the true value because ISIT lists only salmon from the Segregated Hatchery Program as having strayed into spawning tributaries in the Lower Cowlitz Subbasin. It is highly unlikely that some Coho Salmon from the Upper Cowlitz Subbasin Integrated Hatchery Program did not also stray into these streams, which would increase pHOS.

No natural-origin salmon were collected because the Segregated Hatchery Program uses only hatchery-origin salmon for broodstock. Therefore, the natural-origin escapement was not mined to support the hatchery program.

5.1.6. Future Management

The Lower Cowlitz Subbasin Coho Salmon population is designated as a Primary population for contribution to MPG and ESU recovery goals, with a minimum abundance target of 3,700 natural-origin spawners in nature. Population viability was rated as Very Low (LCFRB 2010, WDFW and LCFRB 2016) but natural-origin abundance has improved and the minimum abundance target was exceeded in 2010, 2014, and 2015 (ranging from 1,565-12,661). While the target was not met in 2011, 2013, 2016, or 2017 (ranging from 1,565-3,654), the most-recent (2013-2017) 5-year mean was 5,253 so this population may be meeting its minimum natural-origin spawner abundance goal of 3,700. However, this population is not meeting the HSRG standard of pHOS <0.05 for hatchery influence in a Primary population with a segregated hatchery program. The 2011 FHMP (Tacoma Power 2011) noted that “better information about spawner abundance and composition is required” and monitoring effectiveness has improved since that time and will continue to do so. Additionally, the Lower Cowlitz Subbasin Coho Salmon population will benefit (as will the entire Cowlitz Basin population) from shifting hatchery production from the current Segregated Hatchery Program to a single Upper Cowlitz Subbasin Integrated Hatchery Program, also recommended in the 2011 FHMP.

5.1.6.1. Goals for Conservation and Recovery

Progress toward achieving conservation and recovery goals is evaluated through monitoring of standard fisheries management metrics (Table 5.1-3; Appendix A, Full Big Table). The Lower Cowlitz Subbasin Coho Salmon population had an historical abundance of about 18,000 salmon and has a recovery goal of 3,700 natural-origin spawners in nature. In 2010, abundance and productivity of this population were rated as Very Low (LCFRB 2010). Today, it is on the verge of meeting its recovery goal (Figure 5.1-3; Table 5.1-1).

- **Long-term Goals:** The goal for this Primary Coho Salmon population is full recovery, which would include, but not be limited to:
  - Maintaining natural-origin spawner abundance >3,700 in the Lower Cowlitz Subbasin (Table 5.1-4).
  - pHOS <0.1. There will be no hatchery supplementation for this population, so PNI cannot be calculated. Hatchery supplementation for the entire basin will be shifted to a single program for the Upper Cowlitz Subbasin that will have a high pNOB (>0.6). The Lower Cowlitz Subbasin is the only place where there will be unregulated pHOS, so we will use pHOS <0.1, which is a conservative compromise between the two HSRG recommendations (pHOS <0.05 or <0.3).
  - A harvestable population of natural-origin Coho Salmon in the Lower Cowlitz Subbasin.
- **FHMP Goals:** The goals for the Lower Cowlitz Subbasin Coho Salmon population for the duration of this FHMP are to achieve attainable steps toward population recovery by:
  - Maintaining natural-origin spawner abundance >3,700 in the Lower Cowlitz Subbasin.
  - Developing a plan and transition strategy to move to one Integrated Hatchery Program derived from the Upper Cowlitz Subbasin that meets all program supplementation and harvest needs. This single, Upper Cowlitz Subbasin program will encompass all hatchery production from the current Lower Cowlitz Subbasin (Segregated) and Upper Cowlitz Subbasin (Integrated) Hatchery Programs, with the continued total production of 2.2 million age-2 smolts.
  - Define the disposition of surplus salmon and management strategies for high and low return years.
  - Emphasize as key population monitoring metrics:
    - Numbers returning to the Cowlitz River.
    - Relative numbers of natural- and hatchery-origin salmon spawning in nature in the Lower Cowlitz Subbasin.
  - Keep pHOS below <0.1.
  - Expand monitoring of natural spawning in the Lower Cowlitz Subbasin.

- Increase and improve monitoring, evaluation, and data collection, including numbers and age, sex, and origin of all recoveries:
    - Harvested in fisheries in the ocean, Columbia River, and Cowlitz River.
    - Returning to Cowlitz Salmon Hatchery.
    - Retained as broodstock.
    - Transported and released upstream of Mayfield Dam.
    - Hatchery surplus.
    - Hatchery strays to/from outside of the Cowlitz Basin.
    - Actual spawners in nature.
    - Natural smolts produced.
- Eliminate RSI programs or ensure that those salmon are identifiable.
- Emphasize natural-origin spawners in nature and hatchery-origin return to Cowlitz Salmon Hatchery as key population metrics for Coho Salmon.
- Reduce the abundance of hatchery surplus by increasing hatchery-origin harvest without a concomitant increase in natural-origin exploitation rate.
- Maintain flexibility to increase production within FERC licensing and ESA constraints. Additional returning hatchery adults will require increased harvest management in order to manage for high return years.

5.1.6.2. Management Targets

The factors that inhibit progress toward conservation goals for this population are high pre-terminal exploitation rates and proportions of hatchery-origin salmon spawning in nature. In recent years, harvest of this population has occurred primarily in ocean and mainstem Columbia River fisheries. This exploitation of the natural-origin population directly reduces natural spawning. Likewise, the abundance of hatchery-origin adults and jacks increases the likelihood of natural spawning and, subsequently, introgression of hatchery traits into the natural-origin population.

- **Natural Production:** The goal of population restoration is to develop self-sustaining, naturally reproducing populations. Activities by Tacoma Power to protect and enhance habitat in the Lower Cowlitz Subbasin are expected to benefit smolt production and the subsequent return of natural-origin salmon, but the current monitoring program is insufficient to evaluate the effectiveness of those efforts. Counts of salmon returning to the hatchery are reliable, while estimates of harvest, returns to spawning grounds, and spawners in nature have unacceptably wide variances because of low sampling rates, when estimated at all. In addition, pre-spawn mortality, a critical measure for estimating natural production, has not been estimated for spawning in nature, so actual pHOS is unknown. As part of this FHMP, Tacoma Power will develop and begin to implement a rigorous monitoring program focused on evaluating program effectiveness based on regionally accepted VSP parameters.

Table 5.1-3. Current values (5-year mean) and FHMP and long-term (recovery) goals for key monitoring metrics for Lower Cowlitz Subbasin Coho Salmon. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Metric	Current	FHMP Goal	Long-Term
Total Adult Abundance	41,650	33,643	33,643
Hatchery-origin	33,816	26,478	26,478
Natural-origin	7,834	7,164	7,164
Total Adult Abundance to Mouth of Cowlitz River	18,278	10,272	10,272
Hatchery-origin	12,511	5,085	5,085
Natural-origin	5,767	5,186	5,186
Hatchery Broodstock Spawned (adults)	1,241	0	0
Hatchery-origin	1,241	0	0
Natural-origin	0	0	0
pNOB (Spawner = spawned)	0	NA	NA
Adult Spawners in Nature in Lower Cowlitz Subbasin	5,760	3,700	3,700
Hatchery-origin	508	1,586	1,586
Natural-origin	5,253	3,700	3,700
pHOS (Spawner = spawners in nature)	0.096	<0.3	<0.3
PNI (Spawner)	0	NA	NA
Smolt Abundance	1,234,982	370,000	370,000
Hatchery-origin (Smolts Released)	1,234,982	0	0
Natural-origin	data unavailable	370,000	370,000
Smolt Collection Efficiency / Passage Survival	NA	NA	NA
Smolt-to-Adult Survival (to hatchery / spawning grounds; excluding Jacks)			
Hatchery-origin	0.64%	NA	NA
Natural-origin (if unavailable, presumed higher than hatchery-origin)	data unavailable	?	?
Mean Age (by Run Year)			
Hatchery-origin	2.9	NA	NA
Natural-origin	data unavailable	?	?
Precocious Maturation Rate (by Run Year)			
Hatchery-origin Jacks	29%	<10%	<10%
Natural-origin Jacks	6%	5%	5%
Natural-origin Productivity (assume 1% Smolt-to-Adult Return to hatchery)			
Smolts / spawner	data unavailable	>100	≥100
Adults + Jacks / spawner	data unavailable	>1	≥1
Total Harvest (from all fisheries)	26,969	?	?
Hatchery-origin	24,388	NA	NA
Natural-origin	2,581	?	?
Harvest (% of total adult return)		?	?
Hatchery-origin	72%	NA	NA
Natural-origin	33%	?	?

Table 5.1-4. Recovery phase targets for Lower Cowlitz Subbasin Coho Salmon. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Species:	Coho Salmon
Population Name:	Lower Cowlitz Subbasin
Recovery Designation:	Primary
Current Recovery Phase:	Local Adaptation

	RECOVERY PHASE				
Target Metric	Preser-vation	Recolon-ization	Local Adaptation	Fully Recovered	Last 5 Years
Natural Production					
Natural-origin Spawners in Nature	400	900	1,800	3,700	5,253
Smolt Abundance (below hatchery)	?	?	?	?	?
Smolt Passage Survival	N/A	N/A	N/A	N/A	N/A
Productivity (5-year mean)	>1	>1	>1	>1	?
Hatchery Production					
Type of Hatchery Program	Int/Seg	Int/Seg	Int	Int	Seg
Broodstock to be Collected	1,340	675	670	670	1,393
Integrated Hatchery Program	330	340	500	670	0
Hatchery-Origin	165	170	165	0	0
Natural-Origin	165	170	335	670	0
Segregated Hatchery Program	1,010	335	170	0	1,393
Smolts to be Produced	2,400,000	1,200,000	1,200,000	1,200,000	1,182,149
Integrated Hatchery Program	600,000	600,000	900,000	1,200,000	0
Segregated Hatchery Program	1,800,000	600,000	300,000	0	1,182,149
Total Smolt-to-Adult Survival					
Proportionate Natural Influence					
pHOS (<)					
Total	0.5	0.4	0.2	0.1	0.479
Integrated Hatchery Program	0.5	0.4	0.2	0.1	
Segregated Hatchery Program	0.1	0.1	0.1	N/A	0.479
pNOB (>)	0.2	0.3	0.5	1	0
PNI (>)	0.3	0.55	0.7	0.9	0
Max % of Natural-Origin Return to Cowlitz Salmon Hatchery Collected for Broodstock	50%	40%	30%	30%	0%

- **Abundance – Natural Spawning:** Recent data indicate that the Lower Cowlitz Subbasin Coho Salmon population may have achieved its recovery goal of 3,700 natural-origin spawners in nature. This achievement is supported by the recent (5-year mean) total natural-origin harvest rate of 22%. If exploitation remains at or below the current level, the population may be able to maintain itself above 3,700. Exploitation in the Lower Cowlitz Subbasin is low, with only 9% of the total harvest-related mortality of natural-origin salmon occurring there; only 2.5% of the natural-origin salmon entering the Cowlitz River die due to the fishery. We will focus our monitoring of abundance on documenting the total number of hatchery- and natural-origin spawners, their respective pre-spawn mortality rates, and pHOS. These metrics are critical for achieving recovery and the number of spawners is used to calculate recruits/spawner.

  Two issues may confound accurately estimating abundance of the Lower Cowlitz Subbasin Coho Salmon population. First, some salmon spawning in nature are missed because not all tributaries are surveyed, and no surveys are conducted in the mainstem Cowlitz River, where some Coho Salmon likely spawn (especially in side channels). Secondly, we cannot determine the origin of unmarked salmon returning to the Cowlitz River; specifically, we cannot distinguish between those from the Lower Cowlitz, Tilton, and Upper Cowlitz subbasins or any other source of unmarked Coho Salmon. For management purposes, all unmarked/untagged (assumed to be natural-origin) salmon that are captured at Cowlitz Salmon Hatchery are considered to be from the Tilton Subbasin because they have swum past the spawning reaches in the Lower Cowlitz Subbasin. While many of them likely did come from the Tilton Subbasin, we cannot know for certain and it is very likely that some originated in the Lower Cowlitz Subbasin (and simply wandered a little too far upstream while exploring suitable spawning areas) or strayed from some other location. It is also likely that some Tilton Subbasin salmon remain below Cowlitz Salmon Hatchery. Although these scenarios provide a source of genetic diversity, they compromise our ability to evaluate recovery and may preclude the ability of populations to adapt to local conditions.

- **Smolts Produced in Nature:** Natural-origin smolt production from the Lower Cowlitz Subbasin is unknown and cannot be estimated at present. Smolt monitoring in the Lower Cowlitz Subbasin is conducted using a screw trap in the mainstem Cowlitz River and is difficult due to the large size of the river. Additionally, the presence of Coho Salmon smolts from the Tilton and Upper Cowlitz subbasins, which cannot be discerned from those from the Lower Cowlitz Subbasin, further confounds these estimates. Increasing collection efficiency at Cowlitz Falls and Mayfield dams will help to distinguish production from the Lower Cowlitz Subbasin. Given the challenges of monitoring the mainstem Cowlitz River, estimating smolt production from the Lower Cowlitz Subbasin would require capturing smolts as they leave the tributaries, but monitoring individual tributaries is logistically daunting due to the number of tributaries that would have to be monitored.

- **Smolt-to-Adult Survival:** Because smolt abundance is not estimated and returns are not documented by age, SAR cannot be estimated. This metric is important but less critical for monitoring natural populations than for hatchery populations. We will monitor this index as the data become available, through our M&E Program.

- **Productivity (Recruits/Spawner):** Because returns are not documented by age, productivity also cannot be estimated. Productivity (mature natural-origin F_1 recruits/F_0 spawner) is the primary metric for monitoring natural populations, so collection of the necessary data is critical. We will monitor this index as data become available through our M&E Program.

- **Hatchery Production:** The Lower Cowlitz Subbasin natural-origin population is approaching its recovery goal and does not appear to need supplementation. Therefore, we will terminate the Segregated Hatchery Program. However, fisheries are supported by the Segregated Hatchery Program, so that hatchery production will be shifted to a single Upper Cowlitz Subbasin Integrated Hatchery Program.
  - **Abundance:** The Cowlitz Salmon Hatchery Coho Salmon Program is expected to produce an annual run of 25,500 hatchery-origin Coho Salmon (WDFW 2014), which was exceeded for all return years from 2007-2017 (mean = 108,413). Indeed, the Segregated Hatchery Program, alone exceeded 25,500 for 5 of the 11 years (mean = 27,703). We will focus our monitoring of abundance on the numbers that are harvested and that return to the Cowlitz River and to Cowlitz Salmon Hatchery (which are critical for calculating SAR and TSAR), as well as the number that remain to spawn in nature (used for pHOS and PNI calculations).
  - **Broodstock Collection and Spawning:** No hatchery-origin salmon will be produced to supplement the Lower Cowlitz Subbasin.
  - **Smolt Production:** No hatchery-origin salmon will be produced to supplement the Lower Cowlitz Subbasin.
- **Smolt-to-Adult Survival:** SAR is the primary metric for monitoring hatchery populations, especially those for which return abundance is lower than expected. However, because returns are not documented by age, SAR cannot currently be estimated. To support calculations of SAR, rigorous estimates of the returns of hatchery-origin salmon by age class are needed. To do so, we will collect scales and/or CWTs from at least a sample of recoveries at all collection sites. Additional data needs include the rate of precocious maturation and the sex ratio of hatchery-origin salmon by age. We will monitor this index as the data become available, through our M&E Program.
- **Productivity:** Population productivity (number of F_1 generation recruits that survive to spawn for each F_0 generation spawner) is of less importance, but is still useful, for monitoring hatchery populations, where survival to the smolt stage is unnaturally high. For the Cowlitz River Segregated Hatchery Program, an R/S ratio of 34 is needed for 750 spawners to achieve the 25,500 annual return goal. Expanded data collection to include age at all collection sites will support calculations of productivity and monitoring of this metric over time through our M&E Program.
- **Strays and Spawning in Nature:** Only about 4% of the total hatchery-origin run (about 2% of those entering the Cowlitz River) are recovered on the natural spawning grounds. This estimate is based only on hatchery-origin salmon identified as having spawned in monitored streams in the Lower Cowlitz Subbasin, so it is likely a low estimate for three reasons. First, an unknown number of hatchery-origin Coho Salmon are captured and removed at weirs on Delameter, Lacamas, Olequa, and Ostrander creeks. The ultimate destination of these salmon, had they not been captured, is unknowable, but it is likely that some would have remained to spawn in nature and are strays. Second, other tributaries to the Lower Cowlitz Subbasin are not monitored, where hatchery-origin strays have likely spawned. The number of natural-origin and hatchery-origin salmon spawning in these streams is also unknown, but the proportion may be similar to that of those captured and removed from the weirs. Lastly, there has been no accounting for hatchery-origin salmon that stray to other spawning locations, outside of the Cowlitz Basin. For an

accurate estimate of the true stray rate, these salmon (probably a small number, but we do not know) must also be accounted for. Conversely, hatchery-origin salmon that spawn in Mill Creek (which passes through the grounds of Cowlitz Salmon Hatchery) or immediately below the hatchery ladder are also considered to be strays. Implementation of expanded spawning surveys, as well as examining CWT data for strays outside of the Cowlitz Basin, will improve data collection and rigor for estimating stray rates and our understanding of the biology and management of these salmon.

- **Surplus:** A surplus of hatchery-origin salmon returning to the Cowlitz River can affect the viability of the natural-origin population if a sufficient number of them remain to spawn in nature and increase pHOS. Our goal is to maximize the harvest of hatchery-origin salmon but, if hatchery-origin salmon do spawn in nature, we prefer that they are from an integrated program (hence the priority to advance that program).
- **Harvest:** A mean of 60% of the combined Lower Cowlitz Subbasin Coho Salmon run is harvested each year, including 32% of natural-origin salmon. A mean of 50% of the combined run is harvested in the ocean and Columbia River fisheries (40% of the hatchery-origin and 13% of the natural-origin runs). Conversely, only 7% of the run (6% of the hatchery-origin and 8% of the natural-origin runs) is harvested in the Lower Cowlitz Subbasin. An additional 4% of the Lower Cowlitz Subbasin Coho Salmon hatchery-origin run is harvested in the Tilton Subbasin, after being transported there from Cowlitz Salmon Hatchery. However, even with this high level of exploitation natural-origin salmon, the population appears to be achieving its recovery goal. Given that population productivity appears to be above replacement, we expect the population to continue to grow. As natural-origin abundance increases, losses due to fisheries will be even less critical.

  Far too many hatchery-origin salmon escape the fishery and return to Cowlitz Salmon Hatchery. Therefore, harvest management of the Lower Cowlitz Subbasin Coho Salmon population should focus on increasing the harvest of hatchery-origin Coho Salmon, especially in the Lower Cowlitz Subbasin. Spawning in nature by hatchery-origin salmon appears to be fairly low but not all streams are monitored and only four streams have weirs to manage straying by hatchery-origin salmon. Increasing the harvest of hatchery-origin salmon in all fisheries would decrease the potential for them to remain in the river to spawn in nature. However, this will likely result in an increase in the natural-origin catch and subsequent mortality (exploitation).

  Hatchery-origin harvest outside of the Cowlitz Basin will be monitored using the CWT recovery and sampling rate data in the RMIS and robust creel surveys. Harvest in the Cowlitz Basin will be monitored with rigorous creel surveys.
- **Proportionate Natural Influence:** We propose to increase the influence of the natural environment on the Lower Cowlitz Subbasin Coho Salmon population in two ways:
  - We will increase pNOB by replacing hatchery production from the Lower Cowlitz Subbasin Coho Salmon Segregated Hatchery Program (pNOB = 0) with an integrated hatchery program (pNOB = 0.6) in the Upper Cowlitz Subbasin.
  - We will decrease pHOS by increasing monitoring of natural spawning in the mainstem Lower Cowlitz Subbasin and its tributaries. We will try to maintain pHOS <0.1. This will also allow for increased flexibility to allow more hatchery-origin salmon to spawn in nature and, hopefully, increase natural production.

  Additionally, by switching all hatchery production to an integrated hatchery program, those hatchery-origin salmon that spawn in nature will have some natural influence and will not be as detrimental to the natural populations.

PNI cannot be calculated for the Lower Cowlitz Subbasin population because pNOB for the Segregated Hatchery Program = 0. However, although mean pHOS exceeds the 0.05 limit for Primary populations with segregated hatchery programs, it appears to be fairly low (0.101), and only 2% of the Segregated Hatchery Program salmon entering the Cowlitz River are recovered on the natural spawning grounds. Weirs are operated on Delameter, Lacamas, Olequa, and Ostrander creeks, where all hatchery-origin salmon captured are removed. Spawning ground surveys are conducted on these and a set of other streams in the basin, but not all streams (including the mainstem Cowlitz River) are surveyed and not all surveyed streams are surveyed extensively. Therefore, hatchery- and natural-origin return and spawner abundances are almost certainly greater than reported, and pHOS is likely to be as well. Also, in early years, pHOS may exceed 0.3, but we expect that, with increased natural production and collection efficiency and survival rates at the smolt collection facilities on Cowlitz Falls and Mayfield dams, we can quickly increase natural-origin abundance and subsequently reduce the numbers of hatchery-origin salmon released above those dams.

- **Age Composition:** A mean of 20% of the hatchery-origin salmon that returned to Cowlitz Salmon hatchery matured at age-3 (jacks). Because natural-origin returns to the hatchery are assumed to originate from populations above Mayfield Dam, no natural-origin Lower Cowlitz Subbasin Coho Salmon are handled at the hatchery; thus, ISIT does not estimate the ratio of jacks for natural-origin Lower Cowlitz Subbasin Coho Salmon. However, as long as we can keep pHOS low, the natural-origin population will likely produce a lower percentage of jacks.

  A high rate of precocious maturation is common for hatchery production, but it can be mitigated. Decreasing the number of mini-jacks will increase the mean age at maturation and should also increase the abundance of adults. We will increase the age at maturation of the hatchery-origin salmon using two strategies. First, by transitioning to an integrated hatchery program with 100% pNOB, only about 10% of the males used in the hatchery broodstock will be jacks, thereby reducing the heritable portion of the tendency to mature earlier. Secondly, we will evaluate rearing strategies to reduce growth, especially during the late summer and fall, when rapid growth induces precocious male maturation. This will produce smaller smolts, which are less likely to mature at age-2 or age-3. We will target the release of smolts at a size that is similar to that of natural salmon.

  A potential drawback to releasing small smolts is that the early mortality rate may increase, and the subsequent survival can be lower than for larger smolts. However, this can be mitigated by releasing a greater number of smaller smolts; we can produce a greater number of small smolts than large smolts in each raceway. The resulting release groups will be of similar total weight (kg/pond), but the ponds with smaller smolts will have more fish/pond. Releasing smaller smolts can increase adult returns. If the increase in mortality rate does not exceed the increase in smolt production numbers, then more mature salmon will return with the smaller smolts than with the larger smolts. Also, the higher mortality rate may be compensated for by lower rates of jacks, resulting in a greater number of adults.

5.1.6.3. Monitoring and Evaluation (M&E) and Research

Baseline Monitoring

Monitoring and evaluation needs of the Upper Cowlitz Subbasin Coho Salmon population are similar to other populations in the basin and include spawning ground surveys, accurate counts of hatchery releases and returns of both hatchery- and natural-origin salmon, adequate marking, and evaluation of alternative management and hatchery rearing strategies. To support recovery, monitoring programs need to be rigorous and allow for estimation, with greater confidence, of population abundance, as well as to identify ways to improve survival. Areas of improvement that are specific to this population include the following:

- Estimating harvest rates of hatchery- and natural-origin salmon in all fisheries.
- Estimating hatchery- and natural-origin escapement to the Lower Cowlitz Subbasin.
- Controlling hatchery-origin escapement to Lower Cowlitz Subbasin spawning areas.
- Estimating hatchery- and natural-origin escapement to Lower Cowlitz Subbasin spawning areas, spawners in nature, and pre-spawning mortality.
- Documenting hatchery- and natural-origin returns to Cowlitz Salmon Hatchery.
- Documenting numbers of salmon collected for hatchery broodstock and spawned.
- Estimating pHOS, pNOB, and PNI.
- Estimating natural-origin population productivity (spawner-to-spawner).
- Estimating hatchery-origin smolt production and SAR.

Directed Studies

Directed Studies are designed to diagnose and solve problems associated with achieving FHMP goals, and to fill management needs and information gaps in the Big Table (Table 5.1-3; Appendix A). Important areas of study for the Lower Cowlitz Subbasin Coho Salmon population include the following:

- **Upper basin creel survey:** Exploitation rate and hatchery-/natural-origin handling ratio.
- **Spawning ground survey:** Scales, hatchery-/natural-origin ratio, pre-spawn, genetics, spatial distribution (upper extent), and reach specific adult densities (sub-sample).
- **Juvenile rearing capacity studies**: Available habitat and habitat-specific (run/riffle/pool) densities.
- **Hatchery program studies:** Size at release, time of release, growth rates, broodstock collection, and spawning protocols.
- **Early life stage survival studies:** Egg to fry, fry to parr, and parr-to-smolt survival.
- **In-river migratory survival and behavior:** Survival of migrating juveniles and movement rates.
- **Reservoir survival:** Predation rate and parasite loadings.
- **Hatchery supplementation experiments**: Assessing the impact of returning hatchery-origin adults.

- **Hatchery practices**: Examining the size and timing of release, growth rate in hatchery, broodstock collection techniques, and spawning protocols.

5.1.7. Summary

- The Lower Cowlitz Subbasin Coho Salmon population is the only remaining population of the original four Coho Salmon populations above the Toutle River.
- A Coho Salmon hatchery program has supported the population since 1967, operating as a fully segregated hatchery program since 1998, when mass-marking allowed for all al hatchery-origin salmon to be differentiated.
- Natural-origin spawner abundance in the Lower Cowlitz Subbasin is approaching the recovery/management goal of 3,700. However, mean pHOS=0.1 and the population is not meeting the HSRG standard of pHOS <0.05 for hatchery influence in a Primary population with a segregated hatchery program.
- The long-term goal for the population is to develop a plan and transition strategy to move to one Integrated Hatchery Program derived from the Upper Cowlitz Subbasin that meets all program supplementation and harvest needs. This single, Upper Cowlitz Subbasin program will encompass all hatchery production from the current Lower Cowlitz Subbasin (Segregated) and Upper Cowlitz Subbasin (Integrated) Hatchery Programs.
- Goals for the period covered by this FHMP are to:
    - Define the disposition of surplus salmon and management strategies for high and low return years.
    - Develop goals that account for integrated vs. segregated SARs.
    - Identify and monitor pHOS in the mainstem lower Cowlitz River.
    - Maintain flexibility to increase production within FERC licensing and ESA constraints. Additional returning hatchery adults will require increased harvest management in order to manage for high return years.

Population: Upper Cowlitz Subbasin Coho Salmon
Oncorhynchus kisutch

Evolutionarily Significant Unit:	Cascade Coho Salmon Columbia River Coho Salmon Evolutionarily Significant Unit (ESU) Lower Columbia River Salmon Recovery Region
ESA Listing Status:	Threatened; Listed in 2005, reaffirmed in 2011 and 2016
Population Recovery Designation:	Primary
Population Viability Rating:	
Baseline	Very Low
Objective	High
Recovery Goal:	4,000 natural-origin salmon spawning in the Upper Cowlitz Subbasin (2,000 in each of the Cispus and upper Cowlitz rivers)
Current Recovery Phase:	Recolonization
Current Hatchery Program(s):	Cowlitz Salmon Hatchery Integrated Hatchery Program, 1 million age-2 (yearling) smolts
Proposed Hatchery Program(s)	Cowlitz Salmon Hatchery Integrated Hatchery Program, 2.2 million age-2 (yearling) smolts

5.2. Coho Salmon: Upper Cowlitz Subbasin Population

5.2.1. Purpose

This section describes the current status of the Upper Cowlitz Subbasin Coho Salmon population, based on recent and available data. We identify VSP metrics needed to evaluate the status of this population with regard to recovery targets under ESA guidelines. Where appropriate, we propose changes to both hatchery and monitoring programs to better evaluate progress toward population recovery. The Upper Cowlitz Subbasin Coho Salmon population is currently in the Recolonization phase of recovery. During the period covered by this FHMP, we will terminate the Lower Cowlitz Subbasin Segregated Hatchery Program and increase production from the Upper Cowlitz Subbasin Integrated Hatchery Program to produce 2.2 million smolts. This program will support all of the harvest that the present two hatchery programs support and will supplement the Tilton Subbasin, as well. We will also continue to release mature hatchery-origin salmon from this program upstream of Cowlitz Falls Dam. As downstream passage survival improves and numbers of returning natural-origin adults increases, we will reduce the number of hatchery-origin adults released above Cowlitz Falls Dam to reduce hatchery influence on the natural-origin population. We will continue to evaluate the hatchery program and fisheries management and make refinements or adjustments, as described in this FHMP, to effectively supplement and manage the Upper Cowlitz Subbasin Coho Salmon population.

5.2.2. Population Description

The Upper Cowlitz Subbasin Coho Salmon population includes all natural-origin Coho Salmon that occupy the Cowlitz River and its tributaries upstream of Cowlitz Falls Dam (upper Cowlitz and Cispus river basins; Figure 5.2-1). Closure of Mayfield Dam in 1963 and the subsequent termination of transport of mature salmon above the dams in 1968 resulted in the extirpation of the Coho Salmon populations in the Cispus and upper Cowlitz rivers and the aggregation of their genes into the existing Lower Cowlitz Subbasin population. These upper river populations are now considered to be functionally extinct or at Very High Risk of extinction (LCFRB 2010).

The lower Cowlitz River Coho Salmon population has persisted and has been used as the genetic source for reintroductions of Coho Salmon to the Upper Cowlitz Subbasin (Cispus and upper Cowlitz rivers) since transport of mature Coho Salmon to the Upper Cowlitz Subbasin resumed in 1994. The Upper Cowlitz Subbasin Coho Salmon population was found to be “Depressed” (LCFRB 2010) and, as part of the lower Columbia River ESU, was listed as threatened under the ESA in 2005. The reintroductions and improved monitoring, since 2011, have increased the abundance of Coho Salmon throughout the Cowlitz Basin. In turn, greater abundance has led to an improvement in the status of the overall Cowlitz River Coho Salmon population, including upper river populations, from a High to Moderate risk of extinction, but they were reaffirmed as threatened under the ESA in 2011 and 2016 (NMFS 2016). Because this population is classified as a Primary population for recovery of the lower Columbia River ESU, it must attain its recovery and viability goals for the ESU to be considered recovered (LCFRB 2010).

The Upper Cowlitz Subbasin Coho Salmon population is currently supplemented by the Integrated Hatchery Program, which is managed separately from the Lower Cowlitz River Segregated Hatchery Program. The Upper Cowlitz Subbasin Integrated Hatchery Program releases age-2 (yearling) smolts directly from Cowlitz Salmon Hatchery into the lower Cowlitz River each spring. In addition, both hatchery- and natural-origin adults and jacks are transported and released above Cowlitz Falls Dam to spawn naturally. Currently, spawning by Coho Salmon in the Upper Cowlitz Subbasin occurs in the mainstem and tributaries of the upper Cowlitz and Cispus rivers (LCFRB 2010, WDFW 2014a).

5.2.3. Natural Production

Two critical monitoring metrics for salmon management are the numbers that return at maturation and their disposition (Figures 5.2-2 and 5.2-3; Table 5.2-1). Upper Cowlitz Subbasin Coho Salmon that survive to maturity may be harvested in commercial, sport, or tribal fisheries in the ocean, lower Columbia River, or lower Cowlitz River. Those escaping harvest may return to Cowlitz Salmon Hatchery or remain on the natural spawning grounds in the Lower Cowlitz Subbasin. Natural-origin Coho Salmon from the Upper Cowlitz Subbasin that are caught at Cowlitz Salmon Hatchery may be retained for broodstock or transported to above Cowlitz Falls Dam for release (along with some hatchery-origin salmon), where they may be harvested, die prior to spawning from predation or disease, or survive to spawn naturally. Monitoring these dispositions allows us to evaluate population health, productivity, and progress toward recovery.

The Upper Cowlitz Subbasin Coho Salmon population had an historical abundance of about 26,000 salmon (18,000 in the upper Cowlitz River and 8,000 in the Cispus River). The recovery goal for this population is an annual abundance of 4,000 natural-origin adults spawning in nature; 2,000 in each of the Cispus and Upper Cowlitz rivers (LCFRB 2010). Only natural-origin Coho Salmon that were released into the Upper Cowlitz Subbasin and survive to spawn are counted toward the recovery goal.

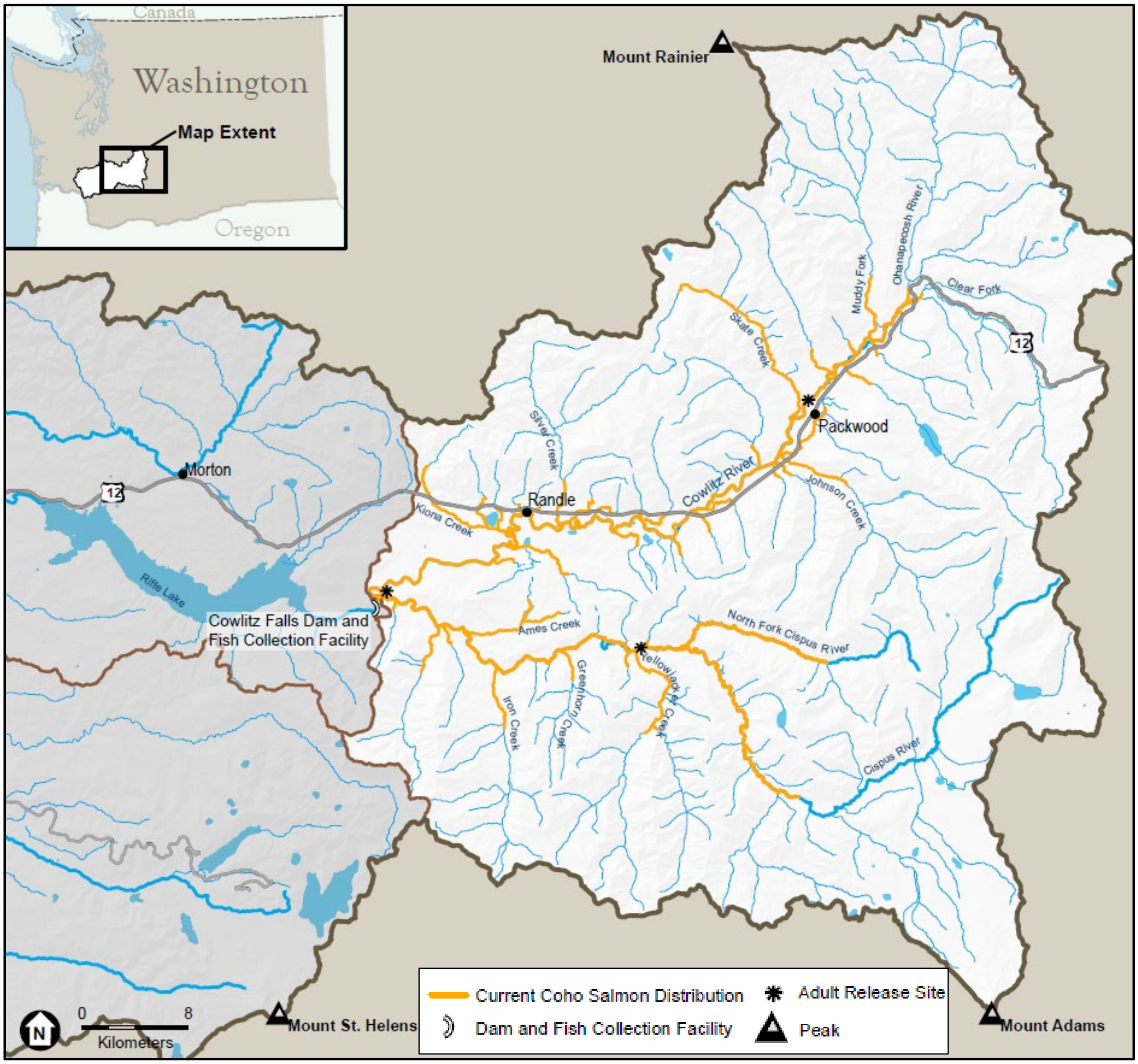


Figure 5.2-1. Distribution of Coho Salmon in the Upper Cowlitz Subbasin.

5.2.3.1. Abundance

Critical data for monitoring the natural-origin Upper Cowlitz Subbasin Coho Salmon population have not been consistently collected and are incomplete. ISIT presents the numbers of Upper Cowlitz Subbasin Coho Salmon returning to Cowlitz Salmon Hatchery in terms of Segregated Hatchery Program hatchery-origin and the combined natural-origin and Integrated Hatchery Program hatchery-origin salmon. Therefore, any estimates of abundance at or below Cowlitz Salmon Hatchery are confounded. Collection of outmigrants at the Cowlitz Falls Fish Facility offers some indication of natural-origin smolt production, specifically the numbers collected and released downstream. However, collection efficiency has not been as high as desired and has ranged widely, which precludes accurate estimates of total natural-origin juvenile Coho Salmon production. The monitoring program has improved and will continue to do so.

Table 5.2-1. Mean, minimum, and maximum numbers of all hatchery- and natural-origin adult Coho Salmon from the Upper Cowlitz Subbasin population that could be accounted for at recovery locations, and percentages of total at each recovery location, 2007-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Origin, Recovery Location	Number of Adults Mean	Minimum	Maximum
Hatchery-origin			
Total Run[1]	82,773	8,827	192,930
Harvest[2]	50,012	5,380	122,889
Ocean harvest	29,363	3,539	78,412
Columbia River harvest	14,429	1,143	46,689
Lower Cowlitz River harvest	6,176	517	17,168
Above Mayfield Dam harvest	44	0	108
Total Return to Cowlitz River[3]	38,982	3,053	92,027
Remain in Lower Cowlitz Subbasin	383	12	929
Return to Cowlitz Salmon Hatchery	32,423	2,383	74,352
Collected for Broodstock	135	0	866
Transported to Upper Cowlitz Subbasin	11,362	953	25,435
Spawners in Upper Cowlitz Subbasin[4]	8,959	751	20,081
Natural-origin			
Total Run[1]	7,064	1,527	17,854
Harvest[2]	2,829	1,273	10,438
Ocean harvest	1,186	529	3,948
Columbia River harvest	964	143	4,429
Lower Cowlitz River harvest	635	246	1,991
Above Mayfield Dam harvest	44	0	108
Total Return to Cowlitz River[3]	4,915	606	9,477
Remain in Lower Cowlitz Subbasin	0	0	0
Return to Cowlitz Salmon Hatchery	4,280	231	8,358
Collected for Broodstock	630	229	809
Transported to Upper Cowlitz Subbasin	3,650	2	7,633
Spawners in Upper Cowlitz Subbasin[4]	2,851	2	5,948
Combined Hatchery- and Natural-origin			
Total Run[1]	89,837	12,832	210,783
Harvest[2]	52,840	6,907	128,578
Ocean harvest	30,548	4,443	79,716
Columbia River harvest	15,393	1,502	51,118
Lower Cowlitz River harvest	6,811	770	19,159
Above Mayfield Dam harvest	88	0	216
Total Return to Cowlitz River[3]	43,897	4,373	101,504
Remain in Lower Cowlitz Subbasin	383	12	929
Return to Cowlitz Salmon Hatchery	36,703	3,450	81,838
Collected for Broodstock	765	341	1,339
Transported to Upper Cowlitz Subbasin	15,012	1,547	32,131
Spawners in Upper Cowlitz Subbasin[4]	11,810	1,217	25,322

[1] Sum of all harvest below Mayfield Dam, remaining in the Lower Cowlitz Subbasin, and returns to Cowlitz Salmon Hatchery.
[2] Total of harvest in ocean, Columbia River, lower Cowlitz River, and Upper Cowlitz Subbasin fisheries.
[3] Sum of lower Cowlitz River harvest, remaining in the Lower Cowlitz Subbasin, and returns to Cowlitz Salmon Hatchery.
[4] Estimated by subtracting estimated harvest loss and multiplying by standard fallback (12%) and pre-spawn mortality (10%) rates from the numbers transported.

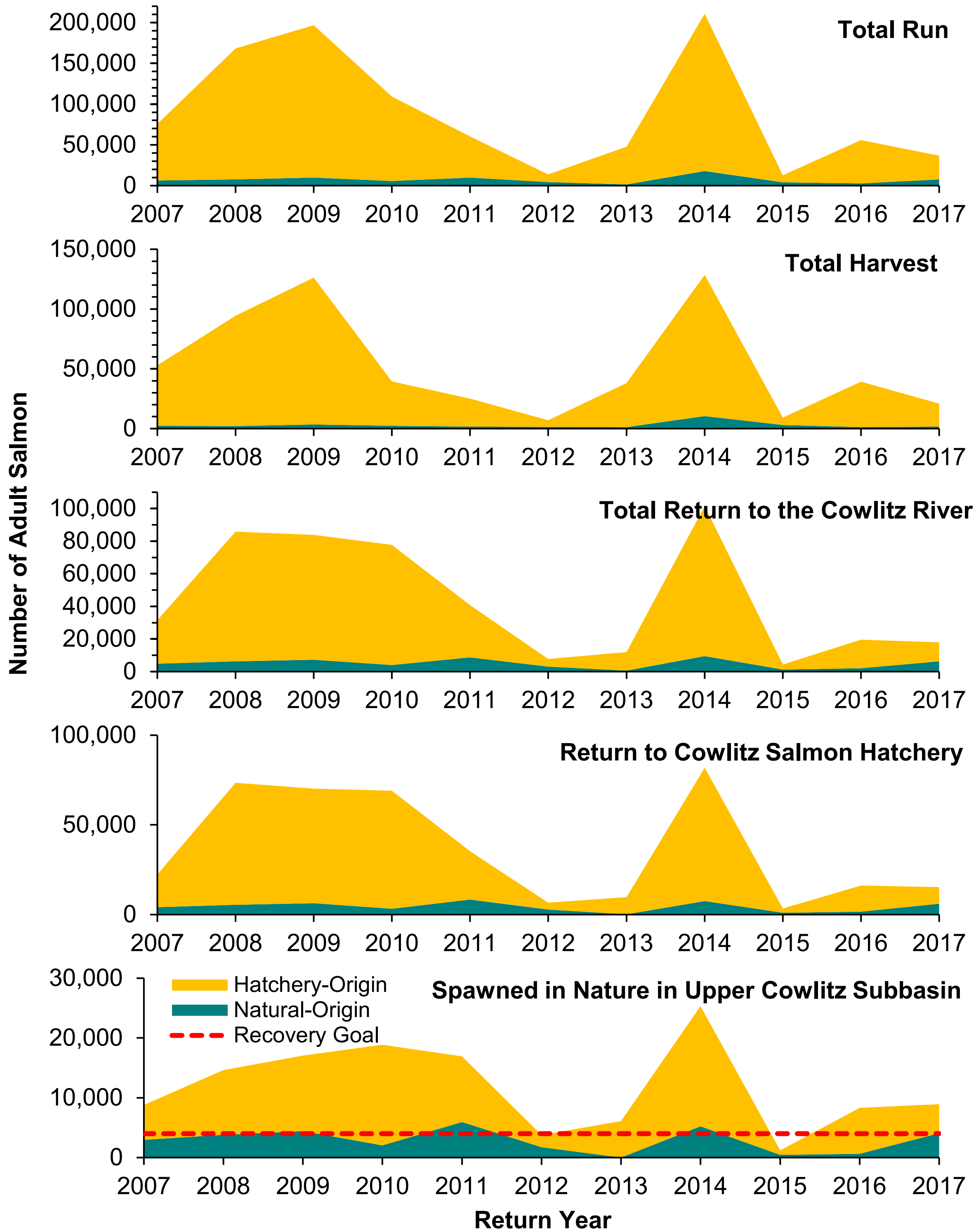


Figure 5.2-2. Total run size of hatchery- (Segregated Hatchery Program) and natural-origin / combined natural-origin and Integrated Hatchery Program Upper Cowlitz Subbasin Coho Salmon and numbers that returned to the Cowlitz River, were harvested, returned to the Cowlitz Salmon Hatchery, or were transported upstream of Cowlitz Falls Dam, 2007-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

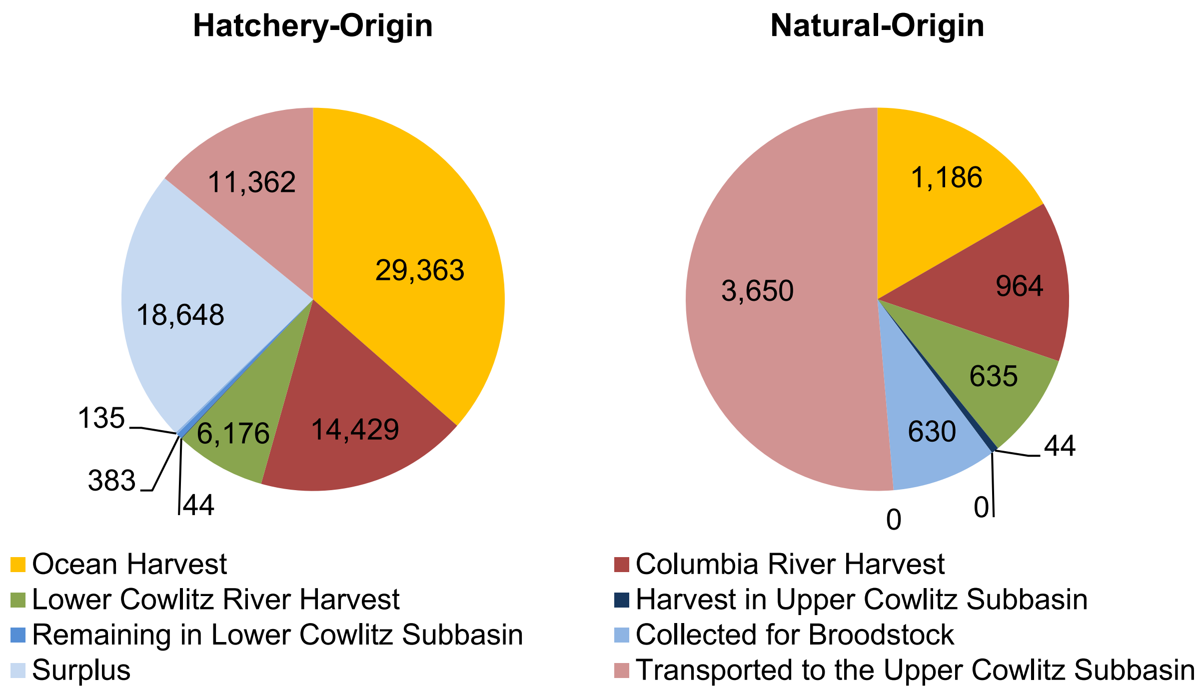


Figure 5.2-3. Mean numbers and proportions of hatchery- and natural-origin Upper Cowlitz Subbasin Coho Salmon caught in ocean, Columbia River, or lower Cowlitz River, or returned to Cowlitz Salmon Hatchery (including Upper Cowlitz Subbasin harvest, Upper Cowlitz Subbasin spawning grounds, hatchery broodstock, and hatchery surplus) and those that were transported to the Upper Cowlitz Subbasin, from 2007-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

From 2007-2017, a mean of 7,064 Upper Cowlitz Subbasin natural-origin Coho Salmon returned to Cowlitz Salmon Hatchery or were harvested on their way back (Figures 5.2-2 and 5.2-3; Table 5.2-1). A mean of 4,915 natural-origin Upper Cowlitz Subbasin Coho Salmon escaped the ocean and Columbia River fisheries and entered the Cowlitz River. Of those salmon reaching the Cowlitz River, a mean of 4,280 returned to Cowlitz Salmon Hatchery, and 3,650 were transported and released upstream of Cowlitz Falls Dam where they were available for harvest or to spawn naturally in the Upper Cowlitz Subbasin.

5.2.3.2. Harvest

Upper Cowlitz Subbasin Coho Salmon contribute to important commercial, sport, and tribal fisheries in the Pacific Ocean, lower Columbia River, and within the Cowlitz Basin. From 2007-2017, mean total harvest of the natural-origin run of Upper Cowlitz Subbasin Coho Salmon was 2,829 adults (40% of the total run; Table 5.2-1). Of the total harvest, 42% were in the ocean, while 34% were harvested in the lower Columbia River, 22% in the lower Cowlitz River, and 2% in the Upper Cowlitz Subbasin.

Although a large percentage of Coho Salmon were caught in the ocean and Columbia River fisheries, of those that returned to the Cowlitz River, most escaped harvest and arrived at the hatchery (Table 5.2-1). From 2007-2017, the lower Cowlitz River fishery harvested a mean of only 13% (635) of all natural-origin Upper Cowlitz Subbasin Coho Salmon that entered the

Cowlitz River. Of those transported upstream, a mean of 1% (44) were harvested in the Upper Cowlitz Subbasin fishery.

5.2.3.3. Disposition

No effort is currently conducted to identify the true origin of natural-origin salmon returning to Cowlitz Salmon Hatchery; all natural-origin returns to the hatchery are assumed to have originated from above Mayfield Dam and are either kept for broodstock or transported to the Upper Cowlitz Subbasin. For the 2007-2017 run years, a mean of 630 adults were collected for broodstock in the Integrated Hatchery Program. A mean of 3,650 natural-origin adult Upper Cowlitz Subbasin Coho Salmon were transported and released into the Upper Cowlitz Subbasin, representing 52% of the natural-origin total adult run and 74% of those returning to the Cowlitz River (Figures 5.2-2 and 5.2-3; Table 5.2-1).

5.2.3.4. Spawning in Nature

The Upper Cowlitz Subbasin Coho Salmon population has a recovery goal of 4,000 natural-origin salmon spawning in nature: 2,000 in each of the Cispus and upper Cowlitz rivers (Table 5.2-2). Estimating the numbers of salmon that survive to spawn in the Upper Cowlitz Subbasin is confounded by the fact that no spawning ground surveys are conducted in the Upper Cowlitz Subbasin, so the fallback (over Cowlitz Falls Dam) and pre-spawn mortality rates are assumed and constant. Additionally, harvest is estimated by angler self-reporting and an assumed rate of hooking mortality (Table 5.2-1). We roughly estimated the numbers of spawners in the Upper Cowlitz Subbasin by subtracting the estimates of exploitation, fallback (12%), and pre-spawn mortality (10%) from the numbers transported and released into the subbasin.

Of the 3,650 natural-origin adults from the Upper Cowlitz Subbasin population that were transported to the Upper Cowlitz Subbasin, a mean of 1% (44) were removed by sport fisheries in the Upper Cowlitz Subbasin, and we assume that 12% (438) fell-back over Cowlitz Falls Dam and 10% (317) died prior to spawning. That left a mean of 2,851 (78% of those transported and 40% of the entire run) to spawn in the Upper Cowlitz Subbasin.

5.2.3.5. Smolt Production

From 2009-2017, a mean of 90.457 age-2 (yearling) Coho Salmon were captured at Cowlitz Falls Fish Facility, which is located at Cowlitz Falls Dam and captures juveniles emigrating from the Upper Cowlitz Subbasin. Mean collection efficiency was estimated to be 50.8%, so we estimated that 188,918 age-2 Coho Salmon smolts were produced from the Upper Cowlitz Subbasin.

5.2.3.6. Natural-origin Survival and Productivity

Survival and productivity are the key metrics for monitoring populations. However, currently neither SAR nor productivity can be calculated for the Upper Cowlitz Subbasin Coho Salmon population because smolt abundance estimates are impractical/imprecise, and returns are not documented by age in ISIT, so a full run reconstruction of each brood year is not possible.

Table 5.2-2. Mean, minimum, and maximum hatchery and natural spawning metrics for Upper Cowlitz Subbasin Coho Salmon, 2007-2015 spawn/brood years. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

	2007-2015 Run Years		
Spawning Location, Metric	Mean	Minimum	Maximum
Hatchery Spawning			
Adults Collected	755	341	1,339
Hatchery-origin	163	0	866
Natural-origin	592	229	790
Adults Spawned	88.3%	80.0%	95.1%
Hatchery-origin	654	328	1,139
Natural-origin	150	0	782
Pre-spawn Survival Rate	504	128	748
Total Green Eggs	1,068,190	573,813	1,269,034
Mean Fecundity	3,357	2,181	4,406
Smolts Released	928,147	472,248	1,079,002
Green Egg-to-Smolt Survival	87%	82%	97%
Smolt Productivity (smolts / spawner)	1,478	944	1,900
Natural Spawning			
Adult Spawners in Upper Cowlitz Subbasin	12,519	1,217	25,322
Hatchery-origin	2,961	2	5,948
Natural-origin	12,519	1,217	25,322
Smolts Produced	188,918	36,032	393,545
Smolt Productivity (smolts / spawner)	20.0	3.1	30.6

5.2.3.7. Age Composition

Only returns to Cowlitz Salmon Hatchery offer an indication of age composition, where they are characterized as being “<42 cm” (presumably age-3 jacks) or “>42 cm” (presumably age-4 and -5 adults). For natural-origin salmon, jacks comprised a mean of 13% and adults comprised a mean of 87% of the 2007-2017 return years.

Age composition is more informative when examined by brood year, but those data are not available at present. We will collect the necessary data/samples and estimate and report this index as the data become available through our M&E Program.

5.2.4. Hatchery Production

Hatchery production metrics must be monitored to ensure that production goals are met, to evaluate the effectiveness of the program, and to understand the magnitude of hatchery influence on the natural population. Key monitoring metrics are numbers of salmon harvested, collected for broodstock, and spawned (by origin, age, and sex); smolts released; salmon returning to the Cowlitz River, Cowlitz Salmon Hatchery; and remaining in nature in the Cowlitz Basin and elsewhere. Using these data, we can calculate and monitor smolt-to-adult survival and return rates and evaluate the effectiveness of the hatchery program.

The Coho Salmon Integrated Hatchery Program at Cowlitz Salmon Hatchery was initiated in 2007 with a goal to produce 978,000 smolts annually, using 100% natural-origin salmon for broodstock (pNOB = 1). Smolts from the Integrated Hatchery Program are reared at Cowlitz Salmon Hatchery, marked (CWT and adipose clip), and released directly into the lower Cowlitz River to avoid the loss from low fish passage survival at Cowlitz Falls Dam.

5.2.4.1. Abundance

From 2007-2017, mean total run size was 82,773 adult hatchery-origin (Integrated Hatchery Program) Coho Salmon that returned to Cowlitz Salmon Hatchery or were harvested on their way back (Figures 5.2-2 and 5.2-3; Table 5.2-1). Means of 38,982 hatchery-origin adults escaped the ocean and Columbia River fisheries and entered the Cowlitz River. Of those salmon reaching the Cowlitz River, a mean of 32,423 hatchery-origin Coho Salmon returned to Cowlitz Salmon Hatchery, and 11,362 were transported and released upstream of Cowlitz Falls Dam, where they were available for harvest or to spawn naturally in the Upper Cowlitz Subbasin.

5.2.4.2. Harvest

From 2007-2017, mean total harvest of Integrated Hatchery Program Upper Cowlitz Subbasin Coho Salmon was 50,012 adults (60% of the total hatchery-origin run; Table 5.2-1). Of the total harvest, 59% were in the ocean, while 29% were harvested in the lower Columbia River, 12% in the lower Cowlitz River, and <1% in the Upper Cowlitz Subbasin.

5.2.4.3. Disposition

Hatchery-origin Coho Salmon returning to Cowlitz Salmon Hatchery are either kept for broodstock, transported to the Upper Cowlitz Subbasin to supplement natural spawning and provide harvest opportunities, or surplused. Of the mean 32,423 Integrated Hatchery Program hatchery-origin Coho Salmon adults that returned to Cowlitz Salmon Hatchery, a mean of 135 were kept for broodstock for the Integrated Hatchery Program (Figures 5.2-2 and 5.2-3; Table 5.2-1). A mean of 11,362 were transported and released into the Upper Cowlitz Subbasin from 2007-2017, representing 14% of the total hatchery-origin run and 29% of those returning to the Cowlitz River. A mean of 18,648 were surplused to food banks.

5.2.4.4. Hatchery Spawning

A mean of 32,423 Integrated Hatchery Program Coho Salmon adults returned to Cowlitz Salmon Hatchery from 2007-2017, of which a mean of 135 were kept for broodstock and 124 were spawned in the Integrated Hatchery Program, along with a mean of 553 natural-origin adults. Mean pNOB for the Integrated Hatchery Program was 0.861.

5.2.4.5. Hatchery Rearing

From 2007-2015, an estimated mean of 1,068,190 green eggs were collected for the Integrated Hatchery Program from a mean of 331 females (Table 5.2-2). Mean fecundity was 3,357 green eggs. Mean green egg-to-smolt survival was 87%, and a mean of 928,147 smolts were released in 2009-2017.

5.2.4.6. Hatchery-origin Survival and Productivity

Mean total smolt-to-adult (TSAR) survival of coded-wire-tagged hatchery-origin Coho Salmon from brood years 2000-2014 was 1.67%, and the mean smolt-to-adult return (to Cowlitz Salmon Hatchery) rate was 0.75%. Age composition data are currently insufficient to calculate productivity, but we will begin collecting the data/samples necessary to calculate this index through our M&E Program.

5.2.4.7. Age Composition

Only returns to Cowlitz Salmon Hatchery offer an indication of age composition, where they are characterized as being "<42 cm" (presumably age-3 jacks) or ">42 cm" (presumably age-4 and -5 adults). Based on these meager data, jacks and adults comprised means of 23% and 77%, respectively, of hatchery-origin returns for the 2007-2017 return years (Table 5.2-2).

Age composition is more informative when examined by brood year, but those data are not available at present. We will collect the necessary data/samples and estimate and report this index as the data become available through our M&E Program.

5.2.5. Proportionate Natural Influence

PNI is a useful metric for monitoring both hatchery and natural populations. Changes in PNI can indicate an increase or decrease in the effect of hatchery-origin salmon on the natural population. This program strives to reduce the effect of hatchery supplementation on the natural population that it supplements. To do so, we try to maximize the number and percentage of natural-origin salmon in the hatchery broodstock and minimize the number and percentage of hatchery-origin salmon spawning in nature.

The Upper Cowlitz Subbasin Coho Salmon Integrated Hatchery Program generally uses 100% natural-origin salmon for its broodstock (pNOB = 1). However, natural-origin returns were low in 2 years, so 571 and 782 hatchery-origin salmon were incorporated into the broodstock in 2013 and 2015-2017, respectively, to support the Integrated Hatchery Program, and small numbers of hatchery-origin salmon were used as broodstock in 2016 (3) and 2017 (13). Overall, a mean of 135 hatchery-origin salmon were used as broodstock from 2007-2017. Mean pNOB from 2007-2017 was 0.861, but pNOB was 0.183 in 2013 and 0.313 in 2015.

Based on the numbers transported to the Upper Cowlitz Subbasin, our estimates of harvest, and the constant fallback and pre-spawn mortality rates, we estimate that means of 8,959 hatchery-origin and 2,851 natural-origin Coho Salmon spawned in the Upper Cowlitz Subbasin from 2007-2017. Mean pHOS from 2007-2017 was 0.736, and the resulting mean PNI was 0.523, ranging from 0.155-0.650.

5.2.6. Future Management

The Upper Cowlitz Subbasin Coho Salmon population is designated as a Primary population for achieving MPG and ESU recovery goals, with a minimum abundance target of 4,000 natural-origin adult spawners in nature, which is the combined abundance targets of 2,000 spawners in each of the Upper Cowlitz and Cispus rivers. Although population viability was rated as Very Low in the Recovery Plan (LCFRB 2010), a minimum goal of High viability was established for this population (WDFW and LCFRB 2016). Following initiation of reintroduction in 1996, and since the Recovery Plan was drafted in 2010, natural-origin spawner abundance (based on number transported and harvest estimates) has exceeded the 4,000 spawner target in 4 of the 11 years (2009, 2011, 2014, and 2017). However, other years have seen dramatically lower abundance, such as 2012 (649), 2015 (466), and 2013 (2). Estimates of pHOS have exceeded the HSRG standard of <0.3 every year from 2007-2017.

The Integrated Hatchery Program primarily used natural-origin broodstock, so pNOB was 1.0 in most years from 2007-2017. However, abundant hatchery-origin spawners in the Upper Cowlitz Subbasin still meant that pNOB was typically less than twice pHOS, failing to meet that HSRG standard. As a Primary population supported by an integrated hatchery program, HSRG standards dictate that pNOB should be greater than pHOS by at least a factor of two. Consequently, the mean PNI (0.523) from 2007-2017 was less than the minimum HSRG threshold of PNI ≥0.67.

5.2.6.1. Goals for Conservation and Recovery

The Upper Cowlitz Subbasin Coho Salmon population was identified as a High recovery priority (LCFRB 2010) and will play a primary role in the recovery of the lower Columbia River Coho Salmon ESU. Progress toward achieving conservation and recovery goals and identification of factors that limit recovery are evaluated through monitoring of standard fisheries management metrics (Table 5.2-3; Appendix A, Full Big Table). The Upper Cowlitz Subbasin Coho Salmon population had an historical abundance of about 26,000 salmon (18,000 in the upper Cowlitz River and 8,000 in the Cispus River) and has a recovery target of 4,000 natural-origin adult spawners in nature. In 2010, the abundance and productivity of this population was rated as Very Low, with less than 50 in of the Upper Cowlitz and Cispus river subpopulations (LCFRB 2010). Due to improved management and monitoring, natural-origin spawner abundance has increased dramatically, to a mean of 3,168 from 2007-2017 and as high as 5,948 in 2011. However, an over-abundance of hatchery-origin salmon released into the Upper Cowlitz Subbasin has kept pHOS well above the target of <0.3 (Figure 5.2-3; Tables 5.2-1 and 5.2-2).

- **Long-term Goals:** The overarching goal for this Primary Coho Salmon population is full recovery, which would include, but not be limited to:
  - Adult abundance of >4,000 adult natural-origin salmon spawning in nature; 2,000 in each of the Cispus River and upper Cowlitz River (Table 5.2-4).
  - pHOS <0.3 (HSRG 2009).
  - pNOB more than two times pHOS, such that PNI ≥0.67
  - Harvestable population of natural-origin Coho Salmon.
- **FHMP Goals:** The goals for the Upper Cowlitz Subbasin Coho Salmon population for the duration of this FHMP are to achieve attainable steps toward population recovery by:
  - Developing a plan and transition strategy to move to one Integrated Hatchery Program derived from the Upper Cowlitz Subbasin that meets all program supplementation and harvest needs. This single, Upper Cowlitz Subbasin program will encompass all hatchery production from the current Lower Cowlitz Subbasin (Segregated) and Upper Cowlitz Subbasin (Integrated) Hatchery Programs, with the continued total production of 2.2 million age-2 smolts.
  - Define the disposition of surplus salmon and management strategies for high and low return years.
  - Emphasize as key population monitoring metrics:
    - Numbers returning to the Cowlitz River.

    - Numbers of natural-origin salmon returning to the hatchery trap.
    - Relative numbers of mature natural- and hatchery-origin salmon transported and released in the Upper Cowlitz Subbasin.
    - Relative numbers of natural- and hatchery-origin salmon spawning in nature in the Upper Cowlitz Subbasin.
  - Maintain natural-origin spawner abundance >4,000 and begin monitoring natural spawning in the Upper Cowlitz Subbasin.
  - Develop a transition plan and begin marking natural-origin salmon collected at Mayfield Dam, instead of Cowlitz Falls Dam, in the next 2 years.
  - Effectively monitor pre-spawn mortality and actual spawner pHOS, and keep pHOS below 0.3 (HSRG 2009). Reduce the abundance of hatchery-origin spawners in the Upper Cowlitz Subbasin either by:
    - Reducing the number transported and released upstream, and/or
    - Increasing hatchery-origin harvest without a concomitant increase in the natural-origin exploitation rate.
  - Increase and improve monitoring, evaluation, and data collection, including numbers and age, sex, and origin of all recoveries:
    - Harvested in fisheries in the ocean, Columbia River, and Cowlitz River.
    - Returning to Cowlitz Salmon Hatchery.
    - Retained as broodstock.
    - Transported and released upstream of Mayfield Dam.
    - Hatchery surplus.
    - Hatchery strays to/from outside of the Cowlitz Basin.
    - Actual spawners in nature.
    - Natural smolts produced.
    - Document strays from outside of the Cowlitz Basin and Cowlitz River strays at sites outside the Cowlitz Basin.
  - Eliminate RSI programs or ensure that those salmon are identifiable.
  - Continue to support fisheries at current levels.
  - Reduce the abundance of hatchery surplus by increasing hatchery-origin harvest without a concomitant increase in the natural-origin exploitation rate.
  - Maintain flexibility to increase production within FERC licensing and ESA constraints. To manage for high return years, additional returning hatchery adults will require increased harvest management.

Table 5.2-3. Current values (5-year mean) and FHMP and long-term (recovery) goals for key monitoring metrics for Upper Cowlitz Subbasin Coho Salmon. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Metric	Current	FHMP Goal	Long-term Goal
Total Adult Abundance	72,767	56,174	56,174
Hatchery-origin	65,967	46,551	46,551
Natural-origin	6,801	9,623	9,623
Total Adults to Mouth of Cowlitz River	31,050	14,457	14,457
Hatchery-origin	27,082	7,666	7,666
Natural-origin	3,968	6,790	6,790
Hatchery Broodstock (adults spawned)	829	1,572	1,572
Hatchery-origin	274	629	629
Natural-origin	556	943	943
pNOB (Effective = adults spawned)	0.695	>0.6	>0.6
Adult Spawners in Nature*	9,977	5,714	5,714
Hatchery-origin	7,894	1,714	1,714
Natural-origin	2,084	4,000	4,000
pHOS (Effective = adult spawners in nature)	0.775	<0.3	<0.3
PNI (Effective)	0.442	>0.67	>0.67
Smolt Abundance (in Lower Cowlitz River)	1,082,396	2,392,461	2,392,461
Hatchery-origin	958,815	2,200,000	2,200,000
Natural-origin	123,581	192,461	192,461
Smolt Collection Efficiency	72%	75%	75%
Smolt-to-Adult Survival (adults to hatchery / spawning grounds)			
Hatchery-origin	0.96%	>1%	>1%
Natural-origin	8.82%	>5%	>5%
Mean Age			
Hatchery-origin	data	?	?
Natural-origin	unavailable	?	?
Precocious Maturation Rate			
Hatchery-origin Jacks	23%	<10%	<10%
Natural-origin Jacks	13%	5%	5%
Natural-origin Productivity			
Smolts / spawner	23	>48	>48
Adults / spawner	?	≥1	≥1
Total Harvest (adults from all fisheries)	47,248	?	?
Hatchery-origin	43,702	?	?
Natural-origin	3,546	?	?
Harvest (% of total adult return)	59%	?	?
Hatchery-origin	60%	?	?
Natural-origin	40%	?	?

* Estimated by subtracting estimated harvest loss and multiplying by standard fallback (12%) and pre-spawn mortality (10%) rates from the numbers transported.

Table 5.2-4. Recovery phase targets for Upper Cowlitz Subbasin Coho Salmon.

Species: Coho Salmon
Population Name: Upper Cowlitz Subbasin
Recovery Designation: Primary
Current Recovery Phase: Recolonization

Target Metric	RECOVERY PHASE Preser-vation	Recolon-ization	Local Adaptation	Fully Recovered	Last 5 Years
Natural Production					
Natural-origin Spawners in Nature	500	1,000	2,000	4,000	2,084
Smolt Abundance (below hatchery)	10,000	20,000	40,000	80,000	123,581
Smolt Passage Survival	40%	60%	70%	75%	72%
Productivity (5-year mean)	>1	>1	>1	>1	?
Hatchery Production					
Type of Hatchery Program	Seg/Int	Int	Int	Int	Int
Broodstock to be Collected	780	780	780	780	915
Integrated Hatchery Program	NA	NA	NA	NA	NA
Hatchery-Origin	624	390	195	0	135
Natural-Origin	156	390	585	780	630
Segregated Hatchery Program	0	0	0	0	0
Smolts to be Produced	1,000,000	1,000,000	1,000,000	1,000,000	958,815
Integrated Hatchery Program	500,000	1,000,000	1,000,000	1,000,000	958,815
Segregated Hatchery Program	500,000	0	0	0	NA
Total Smolt-to-Adult Survival					
Proportionate Natural Influence					
pHOS (<)					
Total	0.5	0.4	0.3	0.2	0.775
Integrated Hatchery Program					0.775
Segregated Hatchery Program	0.1	NA	NA	NA	NA
pNOB (>)	0.2	0.5	0.75	1	0.695
PNI (>)	0.3	0.55	0.7	0.8	0.442
Max % of Natural-Origin Return to Cowlitz Salmon Hatchery Collected for Broodstock	50%	40%	30%	30%	43%

5.2.6.2. Management Targets

The factors that inhibit progress toward conservation goals for this population are downstream fish passage survival at Cowlitz Falls Dam and high pHOS. To minimize pHOS, only hatchery-origin salmon that are positively identified as from the Upper Cowlitz Subbasin Integrated Hatchery Program will be transported to the Upper Cowlitz Subbasin. No Lower Cowlitz Subbasin Coho Salmon will be released above Cowlitz Falls Dam.

In most years, the current hatchery program uses 100% natural-origin salmon for broodstock. The juveniles produced are reared and released from Cowlitz Salmon Hatchery to avoid the loss due to low fish passage survival at Cowlitz Falls Dam. Moving forward, the challenge for this population will be to provide fishing opportunity in the Upper Cowlitz Subbasin without exceeding a pHOS of 0.3. Meeting this pHOS target will require a combination of increased fish passage survival (FPS), increased harvest on hatchery-origin salmon, and/or limiting the number of hatchery-origin salmon that are transported to the Upper Cowlitz Subbasin.

- **Natural Production:** The goal of population restoration is to produce self-sustaining natural-origin populations. We will develop monitoring programs that are rigorous and will allow us to estimate, with greater confidence, the abundance of salmon in these populations, when populations have become self-sustaining, as well as to identify areas where we can improve survival. Efforts to improve downstream fish passage survival continue and recruitment from natural production will increase with the success of these efforts. Likewise, the ability to accurately estimate natural production will improve as collection efficiency at downstream passage facilities improves. Tacoma Power's efforts to protect and enhance habitat in the Upper Cowlitz Subbasin are expected to benefit smolt production and the subsequent return of mature salmon, but the current monitoring program is insufficient to know whether those efforts are successful. Counts of salmon returning to the hatchery and Upper Cowlitz Subbasin are reliable numbers, while estimates of harvest, returns to spawning grounds, and the number of spawners in nature have wide variances because of low sampling rates, when estimated at all. Pre-spawn mortality (largely due to senescence) does not seem to be estimated (or is inconsistently estimated) for spawners in nature.
    - **Abundance – Transport and Natural Spawning:** The recovery goal for the Upper Cowlitz Subbasin Coho Salmon population is 4,000 natural-origin spawners, which has been met intermittently during recent years. However, the target of pHOS <0.3 has not been met. The likelihood of meeting the pHOS target could be increased by the following approaches, either individually or in combination:
        - Reduce the number of hatchery-origin spawners in the Upper Cowlitz Subbasin by:
            - Reducing the number of hatchery-origin adults transported upstream and released in the Upper Cowlitz Subbasin, or
            - Increasing harvest of hatchery-origin adults in the Upper Cowlitz Subbasin.
        - Increase the abundance of natural-origin spawners in the Upper Cowlitz Subbasin by:
            - Reducing harvest of natural-origin adults in the Upper Cowlitz Subbasin,
            - Reducing harvest of natural-origin adults in pre-terminal fisheries,
            - Increasing natural production in the Upper Cowlitz Subbasin, or
            - Increasing FPS for naturally-produced downstream migrants.

    To meet recovery goals, the number of returning natural-origin spawners must increase and the proportional contribution of hatchery-origin salmon spawning in the Upper Cowlitz Subbasin must decrease. We will focus our monitoring of abundance on the numbers of hatchery- and natural-origin Coho Salmon that return to the Cowlitz Salmon Hatchery that are transported to the Upper Cowlitz Subbasin, and that spawn in nature each year. These metrics are critical for achieving recovery.

- **Smolts Produced in Nature:** Although natural-origin smolts are collected at the Cowlitz Falls Fish Facility and reported in ISIT, actual natural-origin smolt production from the Upper Cowlitz Subbasin is not comprehensive and cannot be estimated with sufficient precision until collection efficiencies of downstream passage facilities improve.
- **Smolt-to-Adult Survival:** Because accurate estimates of smolt abundance are not currently feasible, neither SAR nor TSAR can be estimated. These metrics are important but less critical for monitoring natural populations than for hatchery populations. We will monitor these indices as means to do so become available, which will require a comprehensive and robust M&E Program.
- **Productivity (Recruits/Spawner):** Population productivity (number of F_1 generation recruits that survive to spawn for each F_0 generation spawner; "spawner-to-spawner") is the primary monitoring metric for any population, especially natural populations. It provides an overall view of population performance and trajectory, where:
    - If productivity >1, the population is increasing.
    - If productivity <1, the population is declining.

  Given the current difficulty in estimating smolt abundance and origin, deriving productivity estimates remains a challenge and a significant data gap.

- **Hatchery Production:** The Upper Cowlitz Subbasin Integrated Hatchery Program was initiated in 2007 and uses up to 30% of the natural-origin returns to the hatchery as broodstock (WDFW 2014c). All of the resulting hatchery progeny of these broodstock receive an adipose fin-clip and a CWT so that they can be distinguished from the Segregated Hatchery Program upon their return as mature salmon. Up to 25,000 of these hatchery-origin returns from the integrated program (i.e., F_1 progeny) are transported and released upstream of Cowlitz Falls Dam. Natural-origin returns to the hatchery carrying a blank wire or CWT that exceed broodstock needs are also transported upstream. Up to 978,000 smolts from the integrated program are released in the Cowlitz River during the spring (May) as yearlings at a targeted mean weight of 30 g.

  We will develop and implement a rigorous sampling and monitoring program, along with a database for the hatchery program, to allow the managers to better evaluate and manage the hatchery programs. The numbers of broodstock to be collected, by week, origin, age class, and sex, will be set at the Annual Action Plan meeting. The collection schedule will be based on the smolt production needs of each program, and the most recent 5-year means of pre-spawn mortality, fecundity, fertility, hatching rates, and survival rates from hatching-to-swim-up fry, fry-to-parr (at marking), and parr-to-smolt survival rates. Improved monitoring of returns will also be needed to estimate stray and smolt-to-adult survival and return rates and evaluate the hatchery programs.

  The Upper Cowlitz Subbasin population is currently in the Recolonization phase of recovery and releases of hatchery-origin adults and jacks from the Integrated Hatchery Program into the Upper Cowlitz Subbasin at pHOS levels greater than 0.3 will constrain efforts to achieve recovery goals, which require pHOS <0.3 and PNI >0.67. Notably though, hatchery-origin spawners in the Upper Cowlitz Subbasin during this time will be F_1 generation progeny of 100% natural-origin broodstock originating from the Upper Cowlitz Subbasin.

    - **Abundance:** The combined Segregated and Integrated Hatchery Programs have a goal of producing annual returns of up to 25,000 hatchery-origin Coho Salmon (WDFW 2014c, WDFW and LCFRB 2016). For return years 2007-2017, the mean total run size of hatchery-origin salmon from the Integrated Hatchery Program was 82,773, well above the goal. We will focus our monitoring of abundance on the numbers of hatchery-origin Coho Salmon that return to the Cowlitz River and to Cowlitz Salmon Hatchery, which are critical for calculating SAR and TSAR.

- **Broodstock Collection and Spawning:** While the goal of the Integrated Hatchery Program is to use 100% natural-origin broodstock, hatchery-origin salmon were used to supplement broodstock in 2013 and 2015-2017, years in which pNOB was less than 1. Based on the mean pre-spawn survival rate, fecundity, green egg-to-smolt survival rate, and sex ratio, in order to produce the target of 978,000 smolts, 752 mature salmon (380 females) must be collected and 664 must be spawned (335 females).

  We will employ hatchery best management practices for broodstock collection and spawning to ensure that the broodstock represents the entire population in age and run timing in order to maximize genetic diversity of the F_1 generation. Whenever $\leq$100 females are spawned in a specific group, hatcheries (especially those with a conservation mandate) should use spawning matrices in which the gametes from every individual are mixed (approximately evenly) with those of at least two individuals of the opposite sex (Campton 2004; Busack and Knudsen 2007; Bartron et al. 2018). We will also strive to ensure that there are no HxH crosses in order to minimize the hatchery influence on the F_1 generation and any population that it spawns with.

- **Smolt Production:** The Settlement Agreement (Section 6.1.5), states that, "The hatchery complex will be designed with flexibility so managers can employ innovative rearing practices, low densities, and replication of historic fish out-migration size and timing." It is clear that the intent of the SA is to rear the salmon so that they are as similar, in both appearance and performance, to natural-origin salmon as possible. So, we will begin developing and evaluating novel rearing and release strategies (e.g., smaller, natural-sized Coho Salmon smolts) to improve program performance by decreasing the rates of precocious maturation (jacks and mini-jacks) and straying, and increasing in-hatchery survival, smolt-to-adult survival, and smolt-to-adult return rates. This will further minimize the hatchery influence on the F_1 generation and any population that it spawns with.

- **Smolt-to-Adult Survival:** SAR and total smolt-to-adult survival are the primary indices for monitoring a hatchery program. SAR indicates the success of the program in producing salmon that survive in nature and return to the hatchery; a sufficient number is needed to support hatchery broodstock (for segregated or partially integrated programs) or for release into nature to support natural spawning. TSAR is indicative of the overall success of a hatchery program to support all aspects that hatchery salmon may support: commercial, tribal, and/or recreational fisheries in the ocean, Columbia River, and the Cowlitz River and/or its tributaries, hatchery broodstock, and/or natural spawning. We will monitor these indices by all means available and it will be necessary to estimate abundances at all locations, which will require a comprehensive and robust M&E Program.

- **Productivity:** Population productivity (the number of F_1 generation recruits that survive to spawn for each F_0 generation spawner; "spawner-to-spawner") is the primary monitoring metric for any population, especially natural populations. However, this metric is of less importance to hatchery-origin populations, where population productivity should be well above replacement (R/S = 1) because of the huge pre-smolt survival advantage afforded by rearing in a hatchery. Therefore, recruits/spawner (smolt recruits or mature recruits) is less important for monitoring hatchery populations.

- **Strays and Spawning in Nature:** Because all mature Coho Salmon reaching the Upper Cowlitz Subbasin are sorted for transport, and because only F_1 progeny hatchery-origin Coho Salmon (i.e., marked with both ad-clip and CWT) are transported and released into the Upper Cowlitz Subbasin, the risk of hatchery-origin strays from outside the integrated program spawning naturally in the subbasin is low.

  While it is likely that stray rates to out-of-basin locations are low, it is reasonably certain that Cowlitz River hatchery-origin salmon do stray into other streams such as the Toutle, Coweeman, Kalama, Lewis, or Willamette rivers, and that Coho Salmon from other basins stray into the Cowlitz River. The magnitude of both forms of straying is not known, as the data are either not collected or not reported. This will need to change to accurately evaluate the effectiveness of these hatchery programs.

- **Surplus:** The Integrated Hatchery Program Hatchery allows for flexibility in dealing with hatchery returns that exceed broodstock needs because hatchery-origin salmon can be transported upstream of Cowlitz Falls Dam to advance the restoration of Coho Salmon to the Upper Cowlitz Subbasin, and support harvest opportunities in the subbasin; in some cases, surplus salmon are sent to food banks or a fish buyer. However, an excess of hatchery-origin salmon returning to Cowlitz Salmon Hatchery can have indirect effects on the viability of the natural-origin population. An overabundance of hatchery-origin salmon could result in overcrowding in the Upper Cowlitz Subbasin if holding areas are limited. Although it is far preferable for a surplus of hatchery-origin salmon to return to the hatchery than to remain in nature to spawn in the lower Cowlitz River or be transported upstream, in reality, excessive hatchery surplus is likely to also correspond with increased hatchery-origin spawners and, consequently, increased pHOS.

- **Harvest:** A mean of 59% of the combined Upper Cowlitz Subbasin Coho Salmon run is harvested each year, including 40% of natural-origin salmon. Although this level of exploitation does not prevent meeting hatchery egg-take and smolt production goals, harvest of natural-origin salmon does constrain the ability of managers to minimize pHOS. While the abundance of hatchery-origin spawners can be effectively regulated by controlling the numbers transported upstream, the production provided by hatchery-origin spawning is still required until returns of natural-origin spawners are sufficient to maintain a self-sustaining population. Given the ability to control numbers of hatchery-origin salmon transported upstream, harvest management of the Upper Cowlitz Subbasin Coho Salmon population should focus on minimizing the harvest of natural-origin salmon rather than increasing harvest on hatchery-origin salmon.

  The hatchery-origin harvest will be monitored using the CWT recovery and sampling rate data in RMIS and robust creel surveys. Natural-origin harvest and exploitation rates will be monitored in terms of the following metrics:

  - Pre-terminal Exploitation Rate
  - Terminal Harvest Rate
  - Expected Catch
  - Terminal Catch

Decreasing the harvest of natural-origin salmon would incrementally increase potential natural spawning abundance. However, given the already low harvest rates, particularly in the Cowlitz River, reducing harvest rates further may be an impractical means of substantially increasing natural-origin abundance.

- **Proportionate Natural Influence:** We plan to increase the influence of the natural environment on the Upper Cowlitz Subbasin Coho Salmon population by maintaining a high pNOB through the continued use of as close to 1 natural-origin salmon as possible for broodstock as part of the Integrated Hatchery Program. We will also explore means of decreasing pHOS by increased harvest of hatchery-origin salmon and/or decreased transport of hatchery-origin salmon upstream of Cowlitz Falls Dam as natural production increases. We will use the HSRG guidelines for pHOS and PNI by maintaining PNI >0.67 and trying to maintain pHOS <0.3. In early years of the Integrated Hatchery Program, pHOS has consistently exceeded 0.3 (pHOS was 0.54 or greater for all but one year from 2007-2015), but as FPS increases, we expect that both natural-origin abundance and natural production will quickly increase.

  Despite high pNOB values that are typically 1, from 2007-2017, PNI has never met the ≥0.67 target. This reflects the high pHOS upstream of Cowlitz Falls Dam. As annual transports of natural-origin Coho Salmon to the Upper Cowlitz Subbasin consistently approach levels sufficient to support a self-sustaining population (i.e., 4,000 natural-origin spawners), we plan to allow for increased influence of the natural environment on the Upper Cowlitz Subbasin Coho Salmon population by progressively decreasing the number of hatchery-origin adults that are released in the Upper Cowlitz Subbasin. As FPS increases, the numbers of natural-origin adults should also increase, and fewer hatchery-origin adults will be released above Cowlitz Falls Dam.

- **Age Composition:** Only returns to Cowlitz Salmon Hatchery offer an indication of age composition; they are characterized as being "<42 cm" (presumably age-3 jacks) or ">42 cm" (presumably age-4 and -5 adults). Based on these meager data, jacks comprised a mean of 23% and 13%, respectively, of hatchery- and natural-origin returns from 2007-2017 (Table 5.2-2). We will collect the necessary samples and data to completely reconstruct every brood year, including all major recovery locations, through our M&E Program.

5.2.6.3. Monitoring and Evaluation (M&E) and Research

<u>Baseline Monitoring</u>

Baseline studies are required to adequately monitor a population so that we can effectively manage it. Baseline monitoring is conducted annually to track the population's trajectory and variability and includes the basic data required to operate a one-stage or two-stage life cycle model. Because smolt abundance cannot be reliably monitored for the natural-origin Upper Cowlitz Subbasin Coho Salmon population until the collection efficiency of the Cowlitz Falls Fish Facility improves, year-class abundance is more accurately determined based on the latter returns of mature salmon; until collection efficiency improves, baseline studies for this population will likely focus on mature salmon returns.

Current M&E work for Upper Cowlitz Subbasin Coho Salmon is focused on addressing monitoring needs, such as:

- Estimating harvest rates of hatchery- and natural-origin salmon in all fisheries.
- Estimating hatchery- and natural-origin pre-spawn mortality, spawning areas, and natural spawning in the Upper Cowlitz Subbasin.

- Identifying the source of natural-origin returns to the hatchery trap.
- Estimating pHOS.
- Estimating natural-origin population productivity (spawner-to-spawner).
- Quantifying the number of smolts produced in the Upper Cowlitz Subbasin.
- Identifying the ability to differentiate Coho Salmon smolts naturally produced in the Upper Cowlitz Subbasin from those naturally produced in the Tilton River.

Some of these efforts are incomplete (e.g., spawner escapement is not differentiated from the number of adults transported upstream of Cowlitz Falls Dam, and data are not entered into ISIT for all fisheries each year), so, while metrics can be calculated, they are inaccurate. Expanded monitoring should include collecting data and samples to enable the runs to be further characterized by age and sex, where appropriate, to enable complete run reconstruction.

Critical factors are those that are most likely to affect a population, positively or negatively, and its progress toward recovery, as well as those metrics that are most important for monitoring the progress of a population toward recovery and our management of that population. For natural populations, population productivity (“spawner-to-spawner” - the number of F_1 generation recruits that survive to spawn for each F_0 generation spawner) is the key monitoring index; thus, adult spawners in nature is the key metric. Other metrics that affect this index, such as numbers of salmon harvested, strays, natural smolts produced, and salmon spawned in nature, are also important. These data allow us to calculate rates and proportions, such as harvest rates and pHOS, which determine hatchery program levels and management actions (see Chapter 9 for more details).

For natural production of Upper Cowlitz Subbasin Coho Salmon, the data indicate that natural-origin spawner abundance has not consistently reached the recovery goal of 4,000 and exceeds the maximum pHOS threshold of 0.3 for a Primary population. This population is still in the Recolonization phase of recovery, and natural-origin spawner numbers must continue to increase in order to meet pHOS targets.

We track population metrics annually and compare annual and 5-year means with program recovery goals and targets. Recovery goals are goals that a population must meet to achieve recovery. Targets are short-term goals (annual or a few years) and may be revised each year. Trends over time track progress toward goals for conservation, harvest, and recovery. At this time, however, the inconsistent availability of data in ISIT makes it difficult to examine trends for any metrics.

Annual estimates of natural-origin returns to the Upper Cowlitz Subbasin and spawning grounds (spawner abundance) and of hatchery-origin spawners in nature (for pHOS) are the most important metrics to track over time. Harvest of natural-origin salmon is the primary source of mortality over which we have some control, so harvest rates, overall and for individual fisheries, are also important metrics. Five-year running means of these variables are reported every year.

We evaluate our effectiveness in applying the Decision Rules by comparing our goals with the actual results for each year. We examine metrics such as harvest rates and escapement to the spawning grounds/hatchery to evaluate how well we are managing the fisheries. Comparing return abundances allows us to evaluate our ability to predict run size and to improve our ability to do so. Additional metrics are monitored, allowing us to develop an even deeper understanding of this population (see Chapter 9 or 11).

For the Upper Cowlitz Subbasin Coho Salmon population, spawning in nature by hatchery- and natural-origin salmon is reported in ISIT for 2007-2015. However, the reported numbers are often identical to the reported numbers of salmon transported upstream of Cowlitz Falls Dam. Assuming some losses would occur from natural mortality or exploitation, this suggests that one of these metrics is inaccurate. Clarity is needed regarding the methods by which these metrics are calculated to more accurately identify trends.

No estimates of smolt abundance or the quantity or quality of their habitat is included in the current monitoring effort. Numbers of natural-origin smolts collected at the Cowlitz Falls Fish Facility are reported in ISIT. However, because collection efficiency is low, these data are not an accurate estimate of natural smolt production. Additionally, the data currently available in ISIT are only apportioned by age class in the form of jacks and adults only for returns to Cowlitz Salmon Hatchery, not for other recovery locations (e.g., harvest or spawning in nature), and numbers transported upstream were only reported for adults. Apportioning returns by age and sex, as well as recovery location, is necessary for accurately estimating brood year abundance, survival, and productivity, stray rate, and total run year abundance in order to better understand natural and hatchery production.

<u>Directed Studies</u>

Directed studies are designed to diagnose and solve problems associated with achieving FHMP goals. These studies inform future designs, operations, and fish management strategies that will improve the existing FHMP program so that Settlement Agreement goals can be achieved. Metrics that are most likely to provide the greatest added benefit for the FHMP are those for which we do not currently have good information and, as such, are left out of population assessment methodologies. Without that information, data from another population or conglomerate, which may or may not accurately reflect the current population, must be substituted for a parameter value in a life cycle model. Most of the metrics in the Upper Cowlitz Subbasin Coho Salmon "Big Table" (Appendix A) currently lack information. Conducting directed studies to address metrics that lack data and have a high potential to affect life cycle model sensitivity would be beneficial. Important areas of study include:

- Spawning ground surveys: Scales, pHOS, pre-spawn, genetics, spatial distribution (upper extent), and reach specific adult densities (sub-sample).
- Juvenile rearing capacity studies: Available habitat and habitat specific (run/riffle/pool) densities.
- Early life stage survival studies: Egg to fry, fry to parr, and parr to smolt survival rates.
- In-river migratory survival and behavior: Survival of migrating juveniles and movement rates.
- Reservoir survival: Predation rate and parasite loadings.

5.2.7. Summary

- Although functionally extirpated from upstream habitats following completion of Cowlitz Falls Dam, Upper Cowlitz Subbasin Coho Salmon population genes were incorporated into the Lower Cowlitz Subbasin population, providing the founding stock for recovery.
- Although the ESA framework identifies distinct Coho Salmon populations in the Cispus and Upper Cowlitz rivers, returning adults cannot be differentiated. Therefore, these populations are managed as a combined "Upper Cowlitz Subbasin" population.
- Coho Salmon recovery efforts have focused transporting natural-origin Coho Salmon returning to Cowlitz Salmon Hatchery to the Upper Cowlitz Subbasin. Additionally, hatchery-origin adults from the Integrated Hatchery Program have been transported to

the Upper Cowlitz Subbasin to supplement natural spawning and harvest opportunity.

- Recent abundance of natural-origin adults transported to the Upper Cowlitz Subbasin has approached abundance targets. However, ongoing releases of hatchery-origin adults from the Integrated Hatchery Program contribute to hatchery influence on the natural-origin population.
- The Upper Cowlitz Subbasin Coho Salmon population is currently in the Recolonization phase of recovery, and over the period covered by this FHMP (beginning in February 2020), the focus will be on rebuilding abundance of the natural-origin population by maximizing the numbers of salmon spawning in nature.
- During the period covered by this FHMP, we will produce 2.2 million smolts from the Upper Cowlitz Subbasin Integrated Hatchery Program and continue to release mature hatchery-origin salmon from this program upstream of Cowlitz Falls Dam. As downstream fish passage survival is improved and increasing numbers of natural-origin adults return, we will reduce the number of hatchery-origin salmon released upstream of Cowlitz Falls Dam to reduce hatchery influence on the natural-origin population.
- In the near-term (i.e., the period covered by this FHMP), we will:
  - Develop a plan and transition strategy to move to a single Integrated Hatchery Program derived from the Upper Cowlitz Subbasin that meets all program supplementation and harvest needs. This single, Upper Cowlitz Subbasin program will encompass all hatchery production from the current Lower Cowlitz Subbasin (Segregated) and Upper Cowlitz Subbasin (Integrated) hatchery programs.
  - Maintain flexibility to increase production within FERC licensing and ESA constraints; additional returning hatchery adults will require increased harvest management in order to manage for high return years.
  - Develop goals that take into account integrated vs. segregated SARs.
  - Develop a transition plan and begin marking natural-origin smolts at Mayfield Dam (instead of Cowlitz Falls Dam) in the next 2 years.
  - Define the disposition of surplus salmon and management strategies for high and low return years.
  - Develop a strategy for Upper Cowlitz Subbasin planting for successful natural-origin spawning and hatchery-origin harvest opportunity.
- In the long-term, we have goals of:
  - Adult abundance of >4,000 natural-origin salmon spawning in nature.
  - pHOS <0.3 (HSRG 2009).
  - pNOB more than two times pHOS, such that PNI ≥0.67
  - Harvestable population of Coho Salmon.

Population: Tilton Subbasin Coho Salmon
Oncorhynchus kisutch

ESA Listing

Status:	Threatened Listed in 2005, reaffirmed in 2011 and 2016
Evolutionarily Significant Unit:	Columbia River Coho Salmon
Major Population Group:	Cascade Coho Salmon
Recovery Region:	Lower Columbia River Salmon
Population Recovery Designation:	Stabilizing
Population Viability Rating:	
Baseline	Very Low
Objective	Very Low
Recovery Target:	2,000 natural-origin adults spawning in nature in the Tilton Subbasin
Current Recovery Phase:	Recolonization
Current Hatchery Program(s):	None
Proposed Hatchery Program(s):	None

5.3. Coho Salmon: Tilton Subbasin Population

5.3.1. Purpose

This section describes the current status of the Tilton Subbasin Coho Salmon population, based on recent and available data. VSP metrics are also identified that are needed to evaluate the status of this population with regard to recovery under ESA guidelines. Where appropriate, we propose changes to both the hatchery and monitoring programs to facilitate progress toward population recovery and our evaluation of that progress. During the period covered by this FHMP, we will shift hatchery production from the Lower Cowlitz Subbasin Segregated Hatchery Program to a single Upper Cowlitz Subbasin Integrated Hatchery Program that will produce 2.2 million smolts. While this new hatchery program is not specifically intended to supplement the Tilton Subbasin natural-origin Coho Salmon population, some of the mature salmon that return from this program may be released into the Tilton Subbasin to provide harvest opportunities and to supplement natural spawning. Adults from this program will be used to supplement natural spawning in the Tilton Subbasin and provide fisheries both below Mayfield Dam and in the Tilton Subbasin. This will benefit the Tilton Subbasin population because the hatchery-origin salmon released into the Tilton Subbasin will have a high pNOB and they will include both the early and late run individuals, which better resembles the historical population and will be a step toward local adaptation. We will continue to evaluate the hatchery program and fisheries management and make refinements or adjustments, as described in this FHMP, to effectively supplement and manage the Tilton Subbasin population.

5.3.2. Population Description

The Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan (Recovery Plan; LCFRB 2010) identifies Mayfield Dam as the delineation between the Lower and Upper Cowlitz subbasins, with the Tilton Subbasin falling within the Upper Cowlitz Subbasin (Figure 5.3-1). However, because the Recovery Plan identifies Tilton Subbasin Coho Salmon as a distinct population, they are not considered part of the Upper Cowlitz Subbasin Coho Salmon population. Unless otherwise noted hereafter, references to the Upper Cowlitz Subbasin do not include the Tilton Subbasin.

The completion of Mayfield Dam in 1963 and the subsequent termination of upstream transport in 1968 resulted in the extirpation of Coho Salmon populations in the Tilton, Cispus, and Upper Cowlitz subbasins. The Lower Cowlitz Subbasin Coho Salmon population has persisted as an aggregated population of Coho Salmon from the Lower Cowlitz, Cispus, Upper Cowlitz, and Tilton subbasins and been used as the genetic source for reintroductions of Coho Salmon to the Tilton Subbasin since at least 1996 (WDFW 2014). The Tilton Subbasin Coho Salmon population was found to be “Depressed” (LCFRB 2010) and, as part of the lower Columbia River ESU, was listed as threatened under the ESA in 2005, and reaffirmed in 2011 and 2016. With a current baseline viability rating of Very Low, and its classification as a Stabilizing population for recovery of the lower Columbia River ESU, recovery goals for this population have not been set (WDFW and LCFRB 2016) but herein we propose a level of 2,000 natural-origin adults spawning in nature as a target recovery goal for the Tilton Subbasin. Reintroduction efforts and improved monitoring since 2011 have resulted in increased abundance of Coho Salmon throughout the subbasin. In turn, greater abundance has led to an improvement in the status of the overall Cowlitz Basin Coho Salmon population, including populations above Mayfield Dam, from High to Moderate risk of extinction (NMFS 2016). Currently, spawning by Coho Salmon in the Tilton Subbasin occurs in the mainstem, and likely all accessible tributaries (LCFRB 2010; WDFW 2014).

5.3.3. Natural Production

Two critical monitoring metrics for salmon management are the numbers that return at maturation and their disposition (Figures 5.3-2 and 5.3-3; Table 5.3-1). Tilton Subbasin Coho Salmon that survive to begin their spawning migration may be harvested in commercial, sport, or tribal fisheries in the ocean, Columbia River, or Cowlitz Basin. Those escaping harvest may return to Cowlitz Salmon Hatchery and be used as broodstock, transported to the Tilton Subbasin, where they may also be recovered and counted, or surplused. They may also die prior to spawning from predation or disease and may or may not be recovered, or they may survive and attempt to spawn in the Lower Cowlitz Subbasin. Monitoring these dispositions allows us to evaluate population abundance, productivity, and progress toward recovery.

5.3.3.1. Abundance

Harvest, spawning success, and recruitment from natural- and hatchery-origin spawners all directly influence the size of this population. Critical data for monitoring the Tilton Subbasin Coho Salmon population have been only sporadically collected and are incomplete. Although the total number of adult salmon transported and released into the Tilton Subbasin is accurately and precisely known, estimates of total natural-origin salmon for the population are subject to error associated with Tilton Subbasin Coho Salmon spawning in the Lower Cowlitz Subbasin as well as the collection, transport, and release into the Tilton Subbasin of unmarked Coho Salmon that originated from the Lower Cowlitz Subbasin or from outside the Cowlitz Basin.

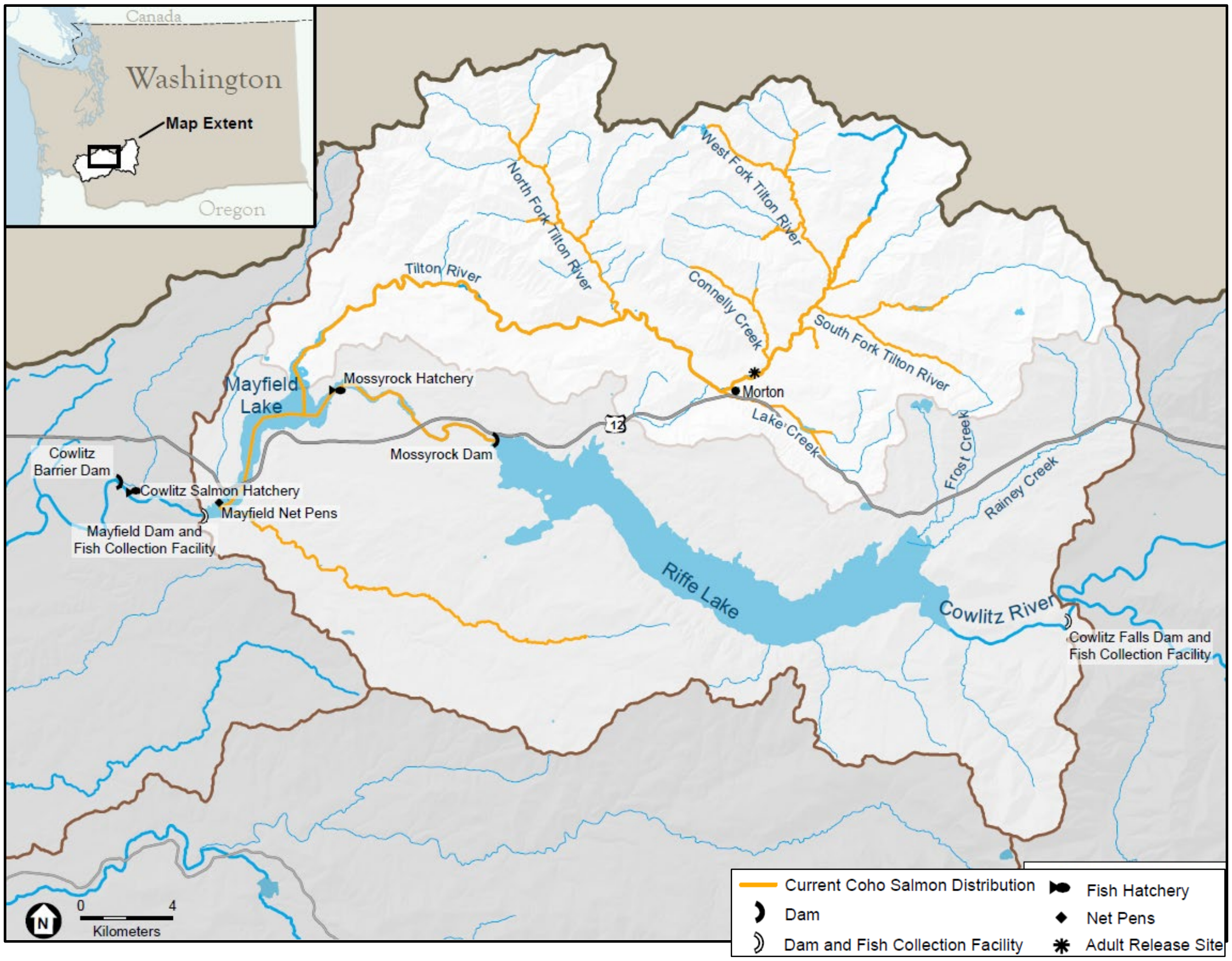


Figure 5.3-1. Distribution of Coho Salmon in the Tilton Subbasin.

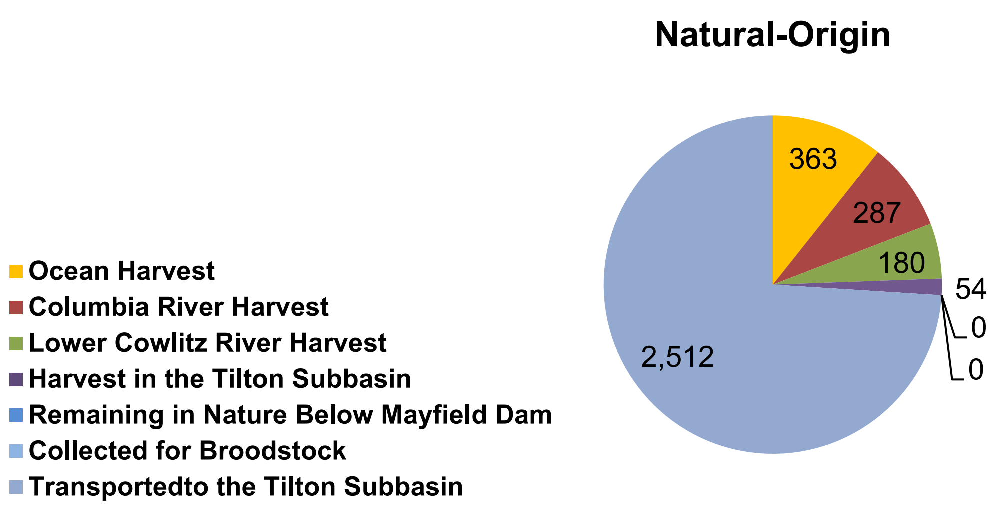


Figure 5.3-2. Mean proportions of natural-origin Tilton Subbasin Coho Salmon caught in ocean, Columbia River, or lower Cowlitz River fisheries, or that were transported to the Tilton Subbasin (and were harvested or remained in the Tilton Subbasin) from 2007-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Table 5.3-1. Mean, minimum, and maximum numbers of all hatchery- and natural-origin Coho Salmon from the Tilton Subbasin population that could be accounted for at recovery locations, and percentage of total at that recovery location, 2007-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Origin,	Numbers		
Recovery Location	Mean	Minimum	Maximum
Hatchery-origin			
Total Run[1]			
Harvest[2]	162	590	863
Ocean harvest			
Columbia River harvest			
Lower Cowlitz Subbasin harvest			
Harvest in Tilton Subbasin	162	590	863
Total Return to Cowlitz River[3]			
Return to Cowlitz Salmon Hatchery			
Collected for Broodstock			
Transported to Tilton Subbasin[4]			
Natural-origin	4,163	1,512	6,206
Total Run[1]	2,348	823	4,223
Harvest[2]			
Ocean harvest	3,341	962	13,062
Columbia River harvest	883	278	4,288
Lower Cowlitz Subbasin harvest	363	57	1,583
Harvest in Tilton Subbasin	287	51	1,776
Total Return to Cowlitz River[3]	180	49	798
Return to Cowlitz Salmon Hatchery	54	7	130
Collected for Broodstock	2,692	780	9,703
Transported to Tilton Subbasin[4]	0	0	0
Combined Hatchery- and Natural-origin	2,512	691	8,905
Total Run[1]	0	0	0
Harvest[2]	2,512	691	8,905
Ocean harvest	1,941	541	6,936
Columbia River harvest			
Lower Cowlitz Subbasin harvest	3,341	962	13,062
Harvest in Tilton Subbasin	1,937	440	5,161
Total Return to Cowlitz River [3]	363	57	1,583
Return to Cowlitz Salmon Hatchery	287	51	1,776
Collected for Broodstock	180	49	798
Transported to Tilton Subbasin[4]	1,108	169	2,011

[1] Sum of all harvest below Mayfield Dam, remaining in the Lower Cowlitz Subbasin, and returns to Cowlitz Salmon Hatchery.
[2] Total of harvest in ocean, Columbia River, lower Cowlitz River, and Tilton Subbasin fisheries.
[3] Sum of lower Cowlitz River harvest, remaining in the Lower Cowlitz Subbasin, and returns to Cowlitz Salmon Hatchery.
[4] Estimated by subtracting estimated harvest loss and multiplying by standard fallback (12%) and pre-spawn mortality (10%) rates from the numbers transported.

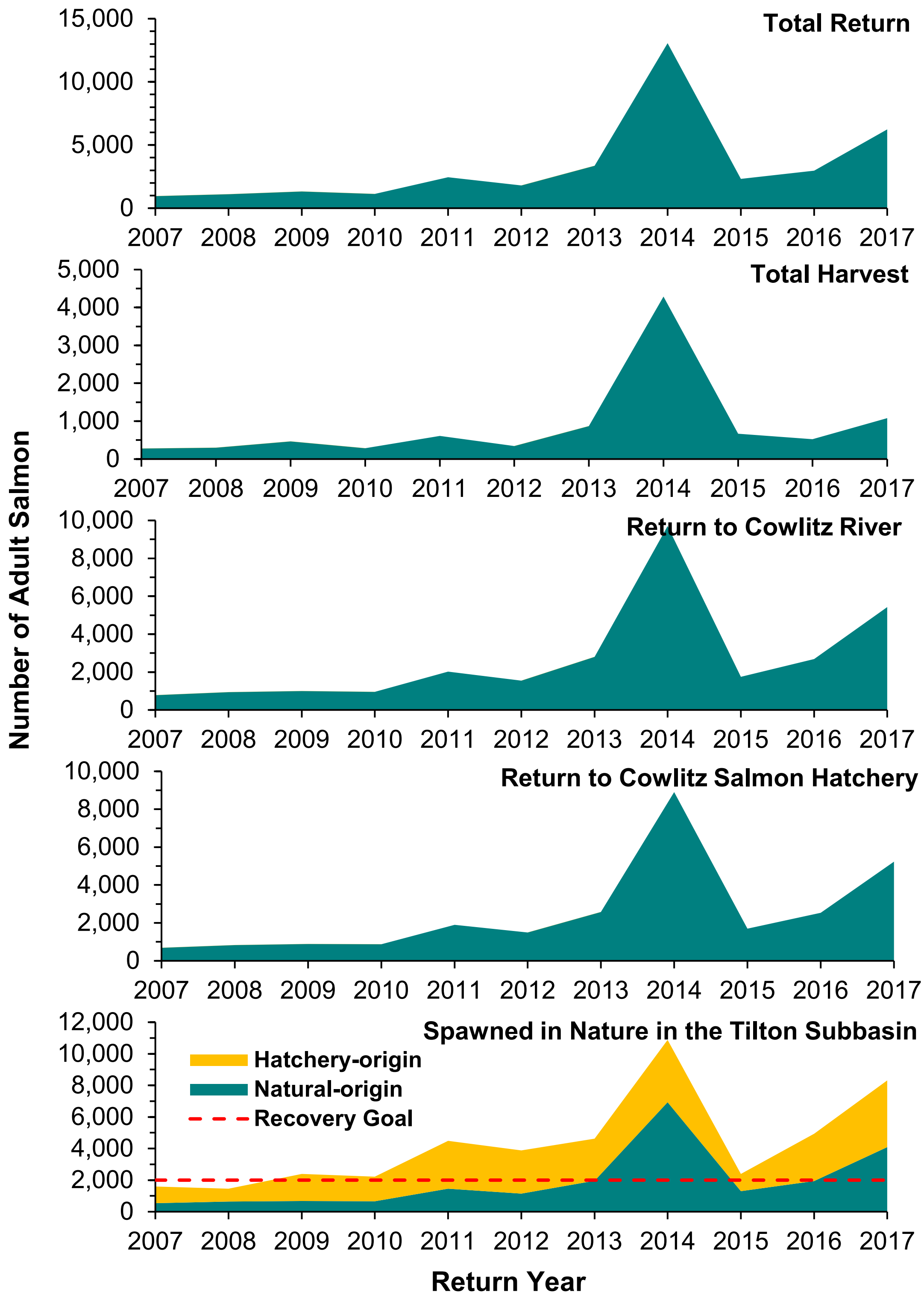


Figure 5.3-3. Estimated total run size for adult natural-origin Tilton Subbasin Coho Salmon and the numbers that returned to the Cowlitz River, were harvested, returned to Cowlitz Salmon Hatchery, or were transported to the Tilton Subbasin, 2007-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

From 2007-2017, a mean of 3,341 natural-origin Coho Salmon from the Tilton Subbasin population returned to the Cowlitz River or were harvested (Figures 5.3-2 and 5.3-3; Table 5.3-1). A mean of 2,692 natural-origin Tilton Subbasin Coho Salmon escaped the ocean and Columbia River fisheries and entered the Cowlitz River.

5.3.3.2. Harvest

Tilton Subbasin Coho Salmon contribute to important commercial, sport, and tribal fisheries in the Pacific Ocean, lower Columbia River, and within the Cowlitz Basin. From 2007-2017, a mean of 26% (883) of the total natural-origin Tilton Subbasin Coho Salmon run was harvested (Figure 5.3-2; Table 5.3-1). Of the total harvest, 41% were in the ocean, while 32% were harvested in the Columbia River, 20% in the lower Cowlitz River, and 6% in the Tilton Subbasin. Although a large percentage of the natural-origin Tilton Subbasin Coho Salmon were caught in ocean and Columbia River fisheries, 93% of those that returned to the Cowlitz River escaped harvest and arrived at the hatchery to be transported to the Tilton Subbasin. Of those transported upstream, a mean of 2% were harvested in the Tilton Subbasin fishery.

5.3.3.3. Disposition

No effort is currently conducted to identify the true origin of natural-origin salmon returning to Cowlitz Salmon Hatchery, so all unmarked natural-origin returns to the hatchery are assumed to have originated from the Tilton Subbasin and are transported there. For the 2007-2017 run years, a mean of 2,512 natural-origin Tilton Subbasin Coho Salmon were transported and released into the Tilton Subbasin, representing 75% of the total natural-origin run and 93% of those returning to the Cowlitz River (Figures 5.3-2 and 5.3-3; Table 5.3-1).

5.3.3.4. Spawning in Nature

Spawner abundance in the Tilton Subbasin is determined by the number of adults (both hatchery- and natural-origin) that are transported to the subbasin and survive to spawn. Progeny that are captured at Mayfield Dam are transported to the lower Cowlitz River and may subsequently return as natural-origin adults. From 2007-2017, a mean of 2,512 natural-origin adults were released into the Tilton Subbasin (Table 5.3-1). Because no spawning ground surveys have been conducted, we do not have actual spawning data. However, we can get a rough estimate of the number of spawners, based on the numbers transported to the Tilton Subbasin minus the number harvested and a constant rate of fallback over Mayfield Dam (12%) and pre-spawn mortality rate (10%). Using this method, we estimate that a mean of 1,941 natural-origin salmon spawned in the Tilton Subbasin from 2007-2017, which is approaching our proposed recovery target of 2,000 natural-origin adults spawning in nature. However, Coho Salmon populations are notorious for following “boom and bust” cycles, and the Tilton Subbasin population does not appear to be an exception, as the estimated number of adult spawners ranged from 541-6,936 from 2007-2017.

5.3.3.5. Natural-origin Survival and Productivity

Survival and productivity are the key metrics for monitoring populations, but neither SAR nor spawner-to-spawner productivity can be calculated for the Tilton Subbasin Coho Salmon population. First, returns are not documented by age, so a full run reconstruction of each brood year is not possible. Additionally, smolt abundance estimates are impractical/imprecise because we do not know the efficiency of the Mayfield Dam Juvenile Collection Facility. Further, we know that some of the smolts that are not captured and pass through the dam survive but do not know their survival rate. However, we can use the numbers of Coho Salmon caught at the Juvenile Collection Facility and a constant 67% collection efficiency rate to roughly estimate total smolt production.

From 2009-2017 (brood years 2007-2015), we estimate that a mean of 56,712 age-2 (yearling) smolts were produced in the Tilton Subbasin. A mean of 37,997 juvenile Coho Salmon were captured at the Mayfield Dam Juvenile Collection Facility, which captures juveniles emigrating from the Tilton Subbasin. Of those, a mean of 18% were age-1 (sub-yearlings) and 82% were age-2 (yearlings) or older. Accounting for survival of the smolts passing through Mayfield Dam, we estimate that a mean of 43,756 natural-origin smolts passed Cowlitz Salmon Hatchery each year.

5.3.3.6. Age and Composition

Only returns of those salmon that were released into the Tilton Subbasin offer an indication of age composition of this population; they are characterized as being “jacks” or “adults.” For natural-origin Tilton Subbasin Coho Salmon, jacks comprised a mean of 43% of the mature salmon released into the Tilton Subbasin from 2007-2017, and adults comprised the remaining 57%.

5.3.4. Hatchery Production

The Tilton Subbasin population currently is not supported by hatchery production that is dedicated to supplementing the population. Thus, hatchery production metrics are only relevant to the population inasmuch as they influence the number of surplus Lower Cowlitz Subbasin hatchery-origin adults available for transport to the Tilton Subbasin. From 2007-2017, a mean of 4,163 hatchery-origin Coho Salmon from the Segregated Hatchery Program were transported and released into the Tilton Subbasin. A mean of 162 of those were harvested, and we estimate (based on constant 12% fallback and 10% pre-spawn mortality rates) that a mean of 2,348 survived to spawn.

Hatchery production metrics must be monitored to ensure that production goals are met, evaluate the effectiveness of the program, and to understand the magnitude of hatchery influence on the natural population. Key monitoring metrics are the numbers of salmon harvested, collected for broodstock, and spawned (by origin, age, and sex); smolts released; and salmon returning to the Cowlitz River, Cowlitz Salmon Hatchery, and remaining in nature in the Cowlitz Basin and elsewhere (strays). Using these data, we can calculate and monitor smolt-to-adult survival and return rates.

5.3.5. Proportionate Natural Influence

PNI is a useful metric for monitoring both hatchery and natural populations. Changes in PNI can indicate a change in the effect of hatchery-origin salmon on the natural population.

Developing a population that is sustained by natural production will require reducing pHOS over time. From 2007-2017, a combined mean of 6,675 Coho Salmon were transported to the Tilton Subbasin (Table 5.3-1). Of those, a mean of 4,163 were hatchery-origin and 2,512 were natural-origin, resulting in a mean pHOS of 0.594 (with a range from 0.363-0.716).

The Tilton Subbasin population is not currently supported by a dedicated hatchery program, and hatchery influences are limited to the transport and release of hatchery-origin adults to spawn naturally. Because the hatchery-origin adults that are released into the Tilton

Subbasin are from the Lower Cowlitz Subbasin Segregated Hatchery Program, which has pHOS = 0, PNI is also zero.

5.3.6. Future Management

Because the Tilton Subbasin Coho Salmon population is designated as only a Stabilizing population for achieving MPG and ESU recovery goals, specific recovery targets have not been quantified. We propose a recovery target of 2,000 natural-origin adults spawning in nature in the Tilton Subbasin (Table 5.3-2). Population viability has been rated as Very Low (LCFRB 2010). However, since 2007, the total number of Coho Salmon transported to the Tilton Subbasin has ranged from 2,203-14,877 (mean = 6,675), with means of 4,163 hatchery-origin and 2,512 natural-origin Coho Salmon, resulting in a mean pHOS of 0.594. As a Stabilizing population, HSRG standards for hatchery influence require that pHOS not exceed "current levels" (HSRG 2009). We propose a pHOS <0.4 during the Recolonization phase and, subsequently, <0.3 during the Local Adaptation and Fully Recovered phases.

5.3.6.1. Goals for Conservation and Recovery

Progress toward achieving conservation and recovery goals is evaluated through monitoring of standard fisheries management metrics (Table 5.3-3; Appendix A, Full Big Table). The Tilton Subbasin Coho Salmon population had an historical abundance of about 5,600 salmon (LCFRB 2010). In 2010, the abundance and productivity of this population were rated as Very Low, and natural-origin abundance was estimated to be <50 (LCFRB 2010). Due to improved management and monitoring, natural-origin spawner abundance has increased dramatically compared to when the Recovery Plan was drafted. However, assuming that all adults transported above Mayfield Dam successfully spawn, hatchery-origin salmon comprise a large proportion of those spawning naturally in the Tilton Subbasin (Table 5.3-1), elevating pHOS. Moreover, adults access the Tilton Subbasin through transport and release, rather than volitionally, and do not possess unique marks/tags identifying their origin. This increases the potential for overestimating the abundance of Tilton Subbasin Coho Salmon returns.

- **Long-term Goals:** The goal for this Stabilizing Coho Salmon population is full recovery in the Tilton Subbasin, which would include, but not be limited to:
  - Adult abundance of >2,000 natural-origin adults spawning in nature.
  - pHOS <0.3.
  - pNOB of the hatchery program supplementing the Tilton Subbasin will be more than twice pHOS, such that PNI ≥0.67
  - Establishing a harvestable population of natural-origin Coho Salmon.
- **FHMP Goals:** The goals for the Upper Cowlitz Subbasin Coho Salmon population for the duration of this FHMP are to achieve attainable steps toward population recovery by focusing on increasing abundance of, and reducing hatchery influence on, the natural-origin Tilton Subbasin Coho Salmon population based on the following:
  - No dedicated hatchery program but we may supplement with salmon from the Upper Cowlitz Subbasin Integrated Hatchery Program to increase natural production and support harvest and local adaptation objectives.
  - Maintain flexibility to increase production within FERC licensing and ESA constraints. Additional returning hatchery-origin adults will require increased harvest management in order to manage for high return years.

Table 5.3-2. Recovery phase targets for Tilton Subbasin Coho Salmon. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Recovery Designation:	Stabilizing				
Current Recovery Phase:	Recolonization				
	RECOVERY PHASE				
Target Metric	Preser-vation	Recolon-ization	Local Adaptation	Fully Recovered	Last 5 Years
Natural Production					
Natural-origin Spawners in Nature	250	500	1,000	2,000	3,244[1]
Smolt Abundance (below hatchery)	25,000[2]	50,000[2]	100,000[2]	200,000[2]	43,756
Smolt Passage Survival	40%	60%	70%	75%	~77%
Productivity (5-year mean)	>1	>1	>1	>1	?
Hatchery Production					
Type of Hatchery Program	Seg	Int	Int	Int	NA
Broodstock to be Collected	940	940	940	940	NA
Integrated Hatchery Program	0	940	940	940	NA
Hatchery-Origin	0	470	235	0	NA
Natural-Origin	0	470	705	940	NA
Segregated Hatchery Program	940	0	0	0	NA
Smolts to be Produced	1,200,000	1,200,000	1,200,000	1,200,000	NA
Integrated Hatchery Program	0	1,200,000	1,200,000	1,200,000	NA
Segregated Hatchery Program	1,200,000	0	0	0	NA
Total Smolt-to-Adult Survival	>1%	>1%	>1%	>1%	NA
Proportionate Natural Influence					
pHOS (<)					
Total	0.5	0.4	0.3	0.3	0.502
Integrated Hatchery Program	0.5	0.4	0.3	0.3	N/A
Segregated Hatchery Program	0.1	N/A	N/A	N/A	0.502
pNOB (>)	0.2	0.5	0.75	1	NA
PNI (>)	0.3	0.55	0.7	0.8	0
Max % of Natural-Origin Return to Cowlitz Salmon Hatchery Collected for Broodstock	50%	40%	30%	30%	NA

[1] Estimated by subtracting estimated harvest loss and multiplying by standard fallback (12%) and pre-spawn mortality (10%) rates from the numbers transported to the Tilton Subbasin.

[2] Based on 1% SAR.

Table 5.3-3. Current values (5-year mean) and FHMP and long-term (recovery) goals of key monitoring metrics for Tilton Subbasin Coho Salmon. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Metric	Current	FHMP Goal	Long-term Goal
Total Adult Abundance	5,593	4,011	4,011
Hatchery-origin	NA	NA	NA
Natural-origin	5,593	4,011	4,011
Total Adults to Mouth of Cowlitz River	4,474	2,892	2,892
Hatchery-origin	NA	NA	NA
Natural-origin	4,474	2,892	2,892
Hatchery Broodstock (spawned; adults)	NA	NA	NA
Hatchery-origin	NA	NA	NA
Natural-origin	NA	NA	NA
pNOB (Effective = spawned; adults)	NA	NA	NA
Adult Spawners in Nature*	6,230	2,857	2,857
Hatchery-origin	2,986	857	857
Natural-origin	3,244	2,000	2,000
pHOS (Effective = spawners in nature; adults)	0.502	<0.3	<0.3
PNI (Effective)	NA	NA	NA
Smolt Abundance	31,902	80,226	80,226
Hatchery-origin (Smolts Released)	NA	NA	NA
Natural-origin	31,902	80,226	80,226
Smolt Collection Efficiency / Passage Survival	~67%	75%	75%
Smolt-to-Adult Survival (to hatchery / spawning grounds; adults)			
Hatchery-origin	NA	NA	NA
Natural-origin	?	>5%	>5%
Mean Age			
Hatchery-origin	NA	NA	NA
Natural-origin	?	?	?
Precocious Maturation Rate			
Hatchery-origin	NA	NA	NA
Natural-origin	43%	<5%	<5%
Natural-origin Productivity			
Smolts / spawner	13	>48	>48
Adults + Jacks / spawner	?	>1	>1
Total Harvest (from all fisheries)	1,486	?	?
Hatchery-origin	NA	NA	NA
Natural-origin	1,486	?	?
Harvest (% of total adult return)	27%	?	?
Hatchery-origin	NA	NA	NA
Natural-origin	27%	?	?

* Estimated by subtracting estimated harvest loss and multiplying by standard fallback (12%) and pre-spawn mortality (10%) rates from the numbers transported.

- Develop goals that take into account SARs from the Integrated vs. Segregated Hatchery Programs.
- Develop a transition plan and begin marking at Mayfield Dam (instead of Cowlitz Falls Dam) in the next 2 years.
- Define the disposition/best use of surplus salmon.
- Emphasize as key population monitoring metrics:
  - Numbers of natural-origin salmon returning to the hatchery trap.
  - Numbers of Coho Salmon transported and released in the Tilton Subbasin.
  - Harvest and pre-spawn mortality rates in the Tilton Subbasin.
  - Numbers of Coho Salmon spawning in nature in the Tilton Subbasin.
- Increase and improve monitoring, evaluation, and data collection, including numbers by origin, age, and sex of all recoveries and for all metrics:
  - Total run size and numbers returning to the Cowlitz River and Cowlitz Salmon Hatchery.
  - Harvested in fisheries in the ocean, Columbia River, and Cowlitz River.
  - Retained as broodstock and spawned.
  - Transported and released into the Tilton Subbasin and that survived to spawn.
  - Hatchery surplus.
  - Hatchery strays to/from outside of the Cowlitz Basin.
  - Hatchery rearing, growth, and survival and numbers released.
  - Natural-origin smolt production from the Tilton Subbasin.
- Eliminate Remote Site Incubation programs or ensure that those salmon are visually identifiable.

5.3.6.2. Management Targets

The Tilton Subbasin Coho Salmon population is designated as a Stabilizing population, population viability is rated as Very Low, and recent releases of hatchery-origin adults from the Lower Cowlitz Subbasin Segregated Program have increased hatchery influence on the population (LCFRB 2010). However, the abundance of natural-origin adults in the subbasin is approaching our proposed recovery goal.

- **Natural Production:** The goal of population recovery is to develop self-sustaining, naturally reproducing populations. Efforts to improve downstream smolt passage survival continue and recruitment from natural production will increase with the success of these efforts. Likewise, the ability to accurately estimate natural production will improve as collection efficiency improves at the Mayfield Dam Juvenile Bypass Facility. Counts of salmon transported to the Tilton Subbasin are reliable numbers, but we are not certain that all natural-origin salmon transported to the Tilton Subbasin originated there. In addition, pre-spawn mortality (a critical measure for estimating natural production) has not been estimated for salmon (both hatchery- and natural-origin) spawning in nature, so actual pHOS is unknown. As part of this FHMP, Tacoma Power will develop and begin to implement a rigorous monitoring program focused on evaluating program effectiveness based on regionally accepted VSP parameters.

- **Abundance – Transport and Natural Spawning:** Recolonization efforts since 1996 have increased the natural-origin total run size to a mean of 3,341 (2007-2017). We will focus our monitoring of abundance on the numbers of hatchery- and natural-origin Coho Salmon that return to the Cowlitz River, are released into the Tilton Subbasin and of actual spawners in nature each year, and the numbers of smolts and mature salmon that they produce. These metrics are critical for achieving recovery and the number of spawners is used to calculate recruits/spawner.

  Many natural-origin Coho Salmon are captured at the hatchery; however, we cannot determine the origin of those that are unmarked. In particular, we cannot distinguish between those from the Lower Cowlitz Subbasin versus those from the Tilton Subbasin or any other source of unmarked Coho Salmon. For management purposes, all unmarked/untagged (assumed to be natural-origin) Coho Salmon that are captured at Cowlitz Salmon Hatchery are considered to be from the Tilton Subbasin because they have swum past the spawning tributaries in the Lower Cowlitz Subbasin and were not marked as having come from the Upper Cowlitz Subbasin (natural-origin Coho Salmon smolts captured at Cowlitz Falls Fish Facility are wire-tagged, while those captured at the Mayfield Fish Collection Facility are unmarked). While it is likely that most of them did come from the Tilton Subbasin, we cannot know for certain and it is very likely that some originated in the Lower Cowlitz Subbasin (and simply wandered too far upstream while exploring suitable spawning areas), the Upper Cowlitz Subbasin (and escaped capture at the Cowlitz Falls Fish Facility), the Remote Site Incubation program (unmarked hatchery-origin salmon), or strayed from some other location. It is also likely that some Tilton Subbasin salmon remain below Cowlitz Salmon Hatchery. This may continue to be an issue (and a source of genetic diversity for upstream populations) unless we can find a way to quickly identify these salmon.

- **Smolts Produced in Nature:** Natural-origin smolt production from the Tilton Subbasin is not well known. Smolts are trapped at the Mayfield Dam Juvenile Bypass Facility but trapping efficiency is variable and has room for improvement. We will need to increase collection efficiency at the Mayfield Collection Facility to improve our estimate of natural-origin smolt production.

- **Smolt-to-Adult Survival:** Because smolt abundance is not estimated and returns are not documented by age, SAR cannot be estimated. This metric is important and we will monitor it as the means to do so become available through our M&E Program.

- **Productivity (Recruits/Spawner):** Because returns are not documented by age, productivity also cannot be estimated. Productivity (mature natural-origin F_1 recruits / F_0 spawner) is the primary metric for monitoring natural populations, so collection of the necessary data is critical. We will monitor this index as the data become available through our M&E Program.

- **Hatchery Production:** No hatchery production is dedicated to supplementing the Tilton Subbasin Coho Salmon population. Hatchery influence is currently limited to the transport and release of hatchery-origin adults to provide harvest opportunity and spawn naturally in the subbasin. Because the hatchery-origin salmon that are released into the subbasin are from the Lower Cowlitz Subbasin Segregated Hatchery Program, pNOB and the resulting PNI are equal to zero. Moving to a single Upper Cowlitz Subbasin

Integrated Hatchery Program that will have high pNOB will greatly benefit the Tilton Subbasin population. pHOS is also an important metric for this population and, while the HSRG recommendation for Stabilizing populations stipulate simply maintaining pHOS at "current levels," developing a population self-sustained by natural production will require low pHOS.

- **Harvest:** A mean of 26% of the natural-origin Tilton Subbasin Coho Salmon run is harvested each year. Although this level of exploitation may not prevent meeting hatchery broodstock and smolt production goals, harvest of natural-origin salmon does constrain the ability of managers to minimize pHOS, while maximizing the number of total spawners in nature. While the abundance of hatchery-origin spawners in nature can be effectively regulated by controlling the numbers transported upstream, the continued production from hatchery-origin spawners can provide benefits until returns of natural-origin spawners is sufficient to maintain a self-sustaining population. Given the ability to control numbers of hatchery-origin salmon transported upstream, harvest management of the Tilton Subbasin Coho Salmon population should focus on minimizing the harvest of natural-origin salmon rather than increasing harvest on hatchery-origin salmon.

- **Proportionate Natural Influence:** Because the hatchery-origin Coho Salmon that are released into the Tilton Subbasin are from a segregated hatchery program (Lower Cowlitz Subbasin), pNOB (and thus PNI) are zero. Recent pHOS has been as high as 0.716 (2009) and has exceeded 0.5 for all years, except 2014 and 2015. We plan to increase the influence of the natural environment on the Tilton Subbasin Coho Salmon population by replacing the Lower Cowlitz Subbasin Segregated Hatchery Program with a single Upper Cowlitz Subbasin Integrated Hatchery Program. At that time, the hatchery-origin salmon released into the Tilton Subbasin will have some natural influence. Until then, salmon from the Segregated Hatchery Program will continue to be released to supplement natural spawning and support fisheries.

5.3.6.3. Monitoring and Evaluation (M&E) and Research

<u>Baseline Studies</u>

Monitoring and evaluation needs of the Tilton Subbasin Coho Salmon population are similar to other populations in the basin and include spawning ground surveys, accurate counts of hatchery releases, harvest and returns of both hatchery- and natural-origin salmon, adequate marking, and development and evaluation of alternative management and hatchery rearing strategies. To support recovery, we need monitoring programs that are rigorous and that allow for estimation, with greater confidence, of population abundance, as well as to identify ways to improve survival. Areas of improvement that are specific to this population include:

- Estimating harvest rates in all fisheries, by origin and age.
- Estimating pre-spawn mortality, spawning areas, and natural spawning in the Tilton Subbasin, by origin and age.
- Identifying the source of natural-origin returns to Cowlitz Salmon Hatchery.
- Estimating actual pHOS (spawners).
- Estimating natural population productivity (spawner-to-spawner).
- Quantifying the number of smolts produced in the Tilton Subbasin.

Directed Studies

Directed studies are to diagnose and solve problems associated with achieving FHMP goals and to fill information gaps in the Big Table for management needs (Table 5.3-4; Appendix A). Important areas of study for the Tilton Subbasin Coho Salmon population include:

- **Spawning ground surveys:** Scales, pre-spawn mortality, genetics, spatial distribution, and reach-specific adult densities, by origin, age, and sex.
- **Juvenile rearing capacity studies:** Available habitat and habitat-specific (run/riffle/pool) densities.
- **Early life stage survival studies:** Egg to fry, fry to parr, and parr to smolt survivals.
- In-river migratory survival and behavior: Survival of migrating juveniles and movement rates.
- **Reservoir survival:** Predation rate and parasite loadings.

5.3.7. Summary

- Although functionally extirpated from upstream habitats following completion of Mayfield Dam, genes of Tilton Subbasin Coho Salmon were incorporated into the Lower Cowlitz Subbasin population, providing the founding stock for recovery.
- Coho Salmon recovery efforts have focused on transporting natural-origin Coho Salmon returning to Cowlitz Salmon Hatchery to the Tilton Subbasin.
- Additionally, surplus hatchery-origin Coho Salmon from the Lower Cowlitz Subbasin Segregated Hatchery Program have been consistently transported to the Tilton Subbasin for harvest opportunity and to supplement natural spawning.
- Recent abundances of natural-origin adults transported to the Tilton Subbasin have approached or exceeded the proposed recovery abundance target. However, ongoing releases of hatchery-origin adults from the Segregated Hatchery Program contribute to hatchery influence on the natural-origin population.
- Goals for the period covered by this FHMP:
    - Begin supplementing the Tilton Subbasin with salmon from the Upper Cowlitz Subbasin Integrated Hatchery Program.
    - Maintain flexibility to increase production within FERC licensing and ESA constraints. Additional returning hatchery-origin adults will require increased harvest management in order to manage for high return years.
    - Develop goals that take into account SARs from the Integrated vs. Segregated Hatchery Programs.
    - Develop a transition plan and begin marking natural-origin smolts at Mayfield Dam (instead of Cowlitz Falls Dam) in the next 2 years.
    - Define the disposition/best use of surplus salmon.
    - Emphasize key population monitoring metrics.
    - Increase and improve monitoring, evaluation, and data collection, including numbers by origin, age, and sex of all recoveries and for all metrics.

  - Eliminate RSI programs or ensure that those salmon are visually identifiable.
- Long-term goal:
  - Adult abundance of >2,000 natural-origin salmon spawning in nature.
  - pHOS <0.3.
  - pNOB of the hatchery program supplementing the Tilton Subbasin will be more than twice pHOS, such that PNI ≥0.67.
  - Establish a harvestable population of natural-origin Coho Salmon.
- Increased monitoring rigor for VSP metrics is needed to evaluate recovery status and trends. Data should be collected by origin, age, and sex and include, but are not limited to:
  - Hatchery- and natural-origin smolt numbers.
  - Estimates of total mature salmon numbers by origin, age, and sex.
  - Estimates of numbers of spawners in nature, strays, and pre-spawn mortalities, by origin, sex, and age.
  - Returns to Cowlitz Salmon Hatchery by origin, age, and sex.
  - Improved harvest estimates of both hatchery- and natural-origin salmon, by age.

CHAPTER 6:
WINTER STEELHEAD

Steelhead *Oncorhynchus mykiss*

ESA Listing

Status:	Threatened Listed in 1998, revised 2006, reaffirmed in 2011 and 2016
Distinct Population Segment[1]:	Lower Columbia River Steelhead
Major Population Group:	Cascade Winter Steelhead
Recovery Region:	Lower Columbia River Salmon
Populations and Recovery Designations:	Lower Cowlitz Subbasin – Contributing Upper Cowlitz Subbasin – Primary Tilton Subbasin – Contributing
Current Hatchery Program(s):	• Lower Cowlitz Subbasin Late-Winter Steelhead Integrated Hatchery Program • Upper Cowlitz Subbasin Late-Winter Steelhead Integrated Hatchery Program • Tilton Subbasin Late-Winter Steelhead Integrated Hatchery Program • Lower Cowlitz Subbasin Summer Steelhead Segregated Hatchery Program
Proposed Hatchery Program(s):	• Lower Cowlitz Subbasin Winter Steelhead Integrated or Segregated Hatchery Program • Upper Cowlitz Subbasin Winter Steelhead Integrated Hatchery Program • Tilton Subbasin Winter Steelhead Integrated Hatchery Program • Lower Cowlitz Subbasin Summer Steelhead Segregated Hatchery Program – Adjusted

[1] Lower Columbia River Steelhead were initially listed as threatened by NMFS under the Evolutionarily Significant Unit (ESU) policy (71 Federal Register 8844). However, NMFS revised the listing in 2006, applying the Distinct Population Segment (DPS) policy (61 Federal Register 4722).

6.0. Winter Steelhead: Overview

6.0.1. Program Focus for Winter Steelhead

The focus for winter steelhead will be population recovery and harvest opportunity. The Recovery Plan (LCFRB 2010) identifies four winter steelhead populations, excluding the Toutle and Coweeman rivers, in the Cowlitz Basin (Figure 6.0-1):

- Lower Cowlitz Subbasin – Contributing population
- Cispus River - Primary population
- Upper Cowlitz River - Primary population
- Tilton Subbasin - Contributing population

Following the construction of Mayfield Dam, the Cispus, Upper Cowlitz, and Tilton populations were extirpated, and the Lower Cowlitz Subbasin winter steelhead population became an aggregation of all four populations, representing the only extant population remaining in the Cowlitz Basin upstream of the Toutle River. As such, the Lower Cowlitz Subbasin population has served as the founding stock for reintroductions upstream of Mayfield Dam.

Although the ESA framework identifies distinct populations in the Cispus and Upper Cowlitz rivers, returning adults cannot be differentiated. These populations are therefore managed as a combined "Upper Cowlitz Subbasin" population. Recovery efforts for winter steelhead continue to focus on Recolonization in the Upper Cowlitz and Tilton subbasins and on Local Adaptation in the Lower Cowlitz Subbasin. The main purpose of the Recolonization phase of recovery has been to increase the abundance of natural-origin winter steelhead spawning in nature. In the Upper Cowlitz and Tilton subbasins, this has involved the transport and release of hatchery-origin winter steelhead adults from the Integrated Hatchery Programs to supplement spawning by natural-origin adults. In the Tilton Subbasin, the number of natural-origin adults transported and released into the subbasin has been approaching the recovery target for natural spawning. In contrast, numbers of natural-origin adults transported and released in the Upper Cowlitz Subbasin is well below the target for that population. The Local Adaptation phase in the Lower Cowlitz Subbasin has focused on minimizing hatchery influence, relying on the Integrated Hatchery Program that has required the collection of natural-origin broodstock from Lower Cowlitz Subbasin tributaries.

In the near-term, during the period covered by this FHMP, we will:

- Prioritize population recovery while still providing harvest opportunity, as feasible within FERC license, ESA, and basin constraints.
- Identify and monitor pHOS in each subbasin to assess hatchery influence.
- Increase total abundance (natural- and hatchery-origin) of adults in the Upper Cowlitz Subbasin to increase natural production and advance recovery.
- Improve recreational/harvest opportunity by increasing the summer-run Segregated Hatchery Program.
- Explore the possibility of developing an early-winter run steelhead program to more closely emulate historic run-timing of winter steelhead in the basin, and to provide additional recreational/harvest opportunity.
- Define the triggers or thresholds for moving from one stage of recovery to another (e.g., abundance, spatial distribution) while considering various recovery strategies.
- Reduce the abundance of hatchery-origin late-winter steelhead spawners in the Lower Cowlitz Subbasin.

The long-term goal for winter steelhead in the Cowlitz Basin will be to prioritize recovery of the Upper Cowlitz Subbasin population, while promoting Local Adaptation in the Lower Cowlitz and Tilton subbasins. In addition, long-term goals would involve the implementation of any summer-run hatchery program adjustments or an early-winter run hatchery program that are identified in the near-term, as consistent with recovery goals.

6.0.2. Population Structure

As noted above, four historical populations of winter steelhead have been recognized in the Cowlitz Basin, excluding the Toutle and Coweeman rivers: Lower Cowlitz Subbasin, Upper Cowlitz/Cispus Subbasin, and Tilton Subbasin populations (Myers et al. 2006; Figure 6.0-1; Table 6.0-1). These endemic populations spawned and reared in the tributaries and mainstem of the larger rivers in each basin. Historically, the Lower Cowlitz Subbasin population alone may have represented one of the largest winter steelhead runs in the Lower Columbia Basin (LCFRB 2010). Closure of Mayfield Dam in 1963 and the subsequent termination of transport of mature steelhead above the dams in 1968 resulted in the extirpation of the steelhead populations in the Upper Cowlitz and Tilton subbasins. Although the Lower Cowlitz Subbasin winter steelhead population persists, by the early 1990s it was recognized to be at Moderate risk of extinction due to hydroelectric development in the 1960s and ongoing habitat degradation and hatchery influences (Nehlsen et al. 1991; Busby et al. 1996; LCFRB 2010; Ford et al. 2011). While the Lower Cowlitz Subbasin population has been the genetic source for reintroductions of winter steelhead to the Upper Cowlitz and Tilton subbasins since 1995, by 2013, the Lower Cowlitz Subbasin population was not considered to be viable (NMFS 2013). The most recent 5-year status review (NMFS 2016) concluded that the lower Columbia River winter steelhead DPS, of which the Cowlitz Basin populations are a component, continues to be at Moderate risk of extinction. The Lower Columbia Conservation and Sustainable Fisheries Plan (WDFW and LCFRB 2016) classifies the current status of these populations as at “high risk” of extinction (Lower Cowlitz Subbasin) or “extinct or at very high risk” of extinction (Tilton, Upper Cowlitz, and Cispus subbasins). However, ongoing reintroduction efforts and improved monitoring since 2011 have enhanced our understanding of the Cowlitz Basin steelhead population and returning natural adults, and recent the abundance of natural-origin adults has shown increasing trends that have approached recovery targets for some populations. Recent efforts have focused on improving downstream dam passage survival and our understanding of natural productivity.

With the listing of these populations under the ESA in 1998, the focus was on recovery of the original four populations, and conservation was elevated to a higher management priority, resulting in changes in hatchery, harvest, and habitat actions. The Upper Cowlitz and Cispus rivers populations are designated as Primary populations in relation to their contribution to recovery of the lower Columbia River ESU, while the Lower Cowlitz and Tilton subbasin populations are designated as Contributing populations (LCFRB 2010). Recovery relies on the extant Lower Cowlitz Subbasin winter steelhead population as the founding population for re-establishing the populations above Mayfield Dam. Recovery actions have been undertaken over the past three decades, but delisting of the DPS cannot occur until all four historical populations have been restored with a probability of persistence that is high or, at a minimum, is consistent with their historical condition. Reintroductions of the populations above Mayfield Dam have provided opportunities for the continued growth and genetic diversification of the entire Cowlitz Basin population.

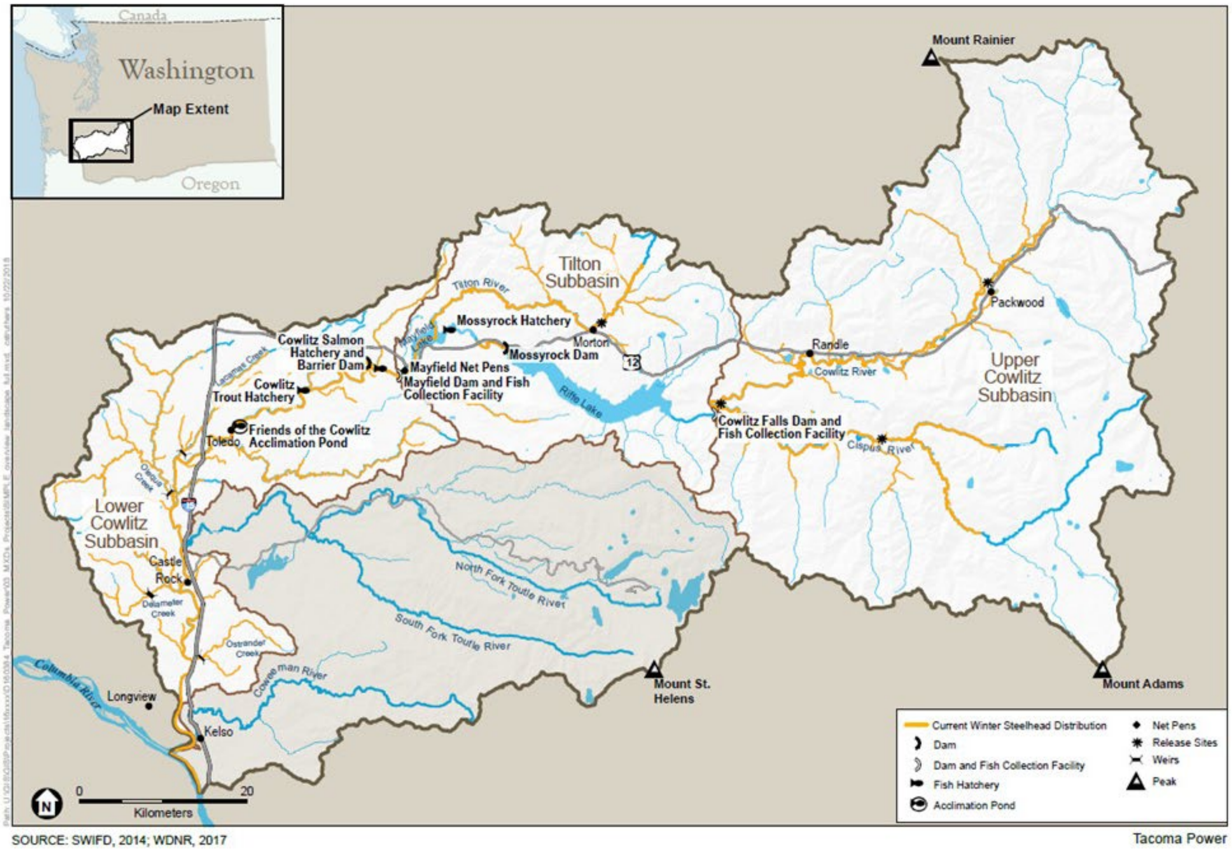


Figure 6.0-1. Distribution of Winter Steelhead in the Cowlitz Basin, Washington.

6.0.3. Life History Diversity

Winter steelhead adults from the indigenous Lower Cowlitz, Upper Cowlitz, and Tilton subbasin populations are currently classified as a late-winter run, based on the timing of their return to the Cowlitz River from March to as late as early June (Tacoma Power 2011). Until recently, the Segregated Hatchery Program also supported a non-native (Chambers Creek of Puget Sound origin) early-winter steelhead run distinguished by their return to the Cowlitz River from November through February. The early-winter run program was terminated following the 2011 FHMP to reduce the risk of hatchery introgression. However, the indigenous population was thought to have historically included a larger early-winter run component, which still exists but at a lower prevalence. A non-native (Skamania origin) Segregated Summer Steelhead Hatchery Program continues today but is thought to pose a lesser risk of introgression because its spawning is temporally isolated.

Winter steelhead spawning in the Cowlitz Basin generally occurs from early March through early June, and fry emerge from June through August (LCFRB 2010). Although information on smolt age is limited, most juveniles are thought to rear for 2 years in the Cowlitz Basin before outmigrating, with the remainder rearing for 1 or 3 years (LCFRB 2010). Outmigration typically occurs in April and May, with a peak in early May. Limited age composition data indicate that most natural-origin Cowlitz Basin winter steelhead spend 2 (54.2%) or 4 (32.2%) years in the ocean before returning to spawn (LCFRB 2010). Hatchery-origin winter steelhead demonstrate a more uniform age-structure, primarily returning after 2 years in the ocean.

Table 6.0-1. Recovery priority, baseline viability status, viability and abundance objectives, and productivity improvement targets for Cowlitz Basin winter steelhead populations (from LCFRB 2010).

	Demographically Independent Population			
	Lower Cowlitz Subbasin	Cispus Subbasin[1]	Upper Cowlitz Subbasin[1]	Tilton Subbasin
Run	Late	Late	Late	Late
Recovery Priority Designation[2]	Contributing	Primary	Primary	Contributing
Abundance				
Historic[3]	1,400	1,500	1,400	1,700
Current (last 5 years)[4]	350	<50	<50	<50
Target[5]	400	500	500	200
Baseline Viability[6]				
Abundance & Productivity	Low	Very Low	Very Low	Very Low
Spatial Structure	Medium	Medium	Medium	Medium
Diversity	Medium	Medium	Medium	Medium
Net Viability Status	Low	Very Low	Very Low	Very Low
Viability Improvement[7]	+5%	>500%	>500%	>500
Recovery Viability Objective[6]	Medium	High	High	Low
Proportionate Natural Influence				
pHOS	<0.3	<0.3	<0.3	<0.3
pNOB	>0.3	>0.6	>0.6	1
PNI	>0.5	>0.67	>0.67	>0.5

1 For current management purposes, the Cispus Subbasin and Upper Cowlitz Subbasin populations are combined into an Upper Cowlitz Subbasin population with abundances equal to the sum of the two separate populations.

2 Primary, Contributing, and Stabilizing designations reflect the relative contribution of the population to Major Population Group recovery goals.

3 Historic population size was mean number, inferred from presumed habitat conditions using EDT Model and NMFS back-of-envelope calculations.

4 Approximate current mean annual number of naturally produced fish returning to the watershed. Note that these values are 5-year means and are not necessarily consistent with mean values over various intervals that are presented elsewhere.

5 Abundance targets were estimated by population viability simulations based on viability goals.

6 Viability status is based on Technical Recovery Team viability rating approach. Viability objective is based on the scenario contribution. Very Low (>60% chance of extinction); Low (26-60% chance of extinction); Medium (6-25% chance of extinction); High (1-5% chance of extinction); Very High (<1% chance of extinction).

7 Improvement is the relative increase in population abundance and productivity required to reach the prescribed viability goal.

6.0.4. History

The Cowlitz Basin winter steelhead population is thought to have been one of the largest in the Lower Columbia Basin, including an estimated historical escapement of 6,000 spawners upstream of the Toutle River, but current baseline escapement (<500 natural-origin spawners) represents <9% of the original size (Table 6.0-1; WDFW and LCFRB 2016). Other estimates of historical abundance suggest an annual run size of 22,000 winter steelhead in the Cowlitz Basin, with a spawning escapement of 11,000 above Mayfield Dam (WDF and WDG 1946, as cited in Myers et al. 2006). By the early 1960s, a mean of 11,081 adult steelhead were collected annually at the Mayfield Dam Fish Passage Facility. However, the combination of harvest, hydropower development, and the effects of habitat loss and hatchery supplementation took their toll on these populations and resulted in their subsequent listing under the ESA (WDF et al. 1993; Myers et al. 2006; LCFRB 2010).

Hatcheries have been operated on the Cowlitz River for over 100 years and, since 1957, have included releases of hatchery winter steelhead (LCFRB 2010; Myers et al. 2006). A mean of roughly 180,000 hatchery winter steelhead smolts were released annually in the Cowlitz Basin from 1967-1994 (LCFRB 2010). However, by this period (late 1970s and 1980s), the mean run size of natural-origin winter steelhead in the Cowlitz Basin fell dramatically to only 309 steelhead, representing just 1.7% of the combined (hatchery- and natural-origin) run (LCFRB 2010). To limit the harvest of natural-origin steelhead, mark-selective regulations have been in place for most lower Columbia River tributaries, including the Cowlitz Basin, since the late 1980s (WDFW and LCFRB 2016).

Cowlitz Falls Dam was completed in 1994. At the same time, excess hatchery-origin winter steelhead from the Lower Cowlitz Subbasin population began to be transported above Mayfield and Cowlitz Falls dams in an effort to reintroduce the historical populations in the Cispus, Upper Cowlitz, and Tilton subbasins (Myers et al. 2006). As soon as the natural-origin offspring of these salmonids began returning, a combination of hatchery- and natural-origin winter steelhead were transported, with the desire to produce as many natural smolts as possible and, ultimately, to produce a self-sustaining natural population in each of the three basins above the hydroelectric complex. The transplanted steelhead likely have genes from the original populations above Mayfield Dam, and with their return to those areas, it is expected that these genes will be of great benefit to the restoration effort.

Segregated hatchery programs using out-of-basin broodstock were also operated in the Cowlitz Basin for summer steelhead (Skamania stock) since at least 1971 (Meyers et al. 2006) and early-winter steelhead (Puget Sound stock) since 1957 (LCFRB 2010). From 1995-2014, roughly 200,000-700,000 summer steelhead and 150,000-700,000 early-winter steelhead hatchery smolts were released annually (WDFW and LCFRB 2016). Releases of late-winter steelhead hatchery smolts during this period ranged from 100,000 to over 700,000 (WDFW and LCFRB 2016). To minimize hatchery influence on the endemic winter steelhead population, the late-winter steelhead hatchery programs were converted to Integrated Hatchery Programs in 2012.

The process of building self-sustaining natural populations that meet abundance targets has been slow. Historically, smolt survival associated with dam and reservoir passage has not been sufficient to support a self-sustaining population. However, both upstream and downstream fish passage programs now allow for the return of increasing numbers of naturally produced steelhead to populations that had been extirpated. Improvements made at the downstream juvenile facilities at Mayfield and Cowlitz Falls dams are expected to increase the abundance of outmigrants and should help to improve the status of the Tilton Subbasin and Upper Cowlitz Subbasin winter steelhead populations, respectively. Natural-origin abundance varies widely and has generally been below the combined recovery target of 1,600 spawners; from 2013-2017, the estimated number returning to spawning grounds or transported above the dams has ranged from 656 to 1,628 (Figure 6.0-2). For the entire Cowlitz Basin, land development and increasing human population pressures will likely continue to degrade habitat, especially in lowland areas. In addition, poor ocean conditions can increase the risk of extinction. As such, this DPS is still considered to be at Moderate risk of extinction (NWFSC 2015).

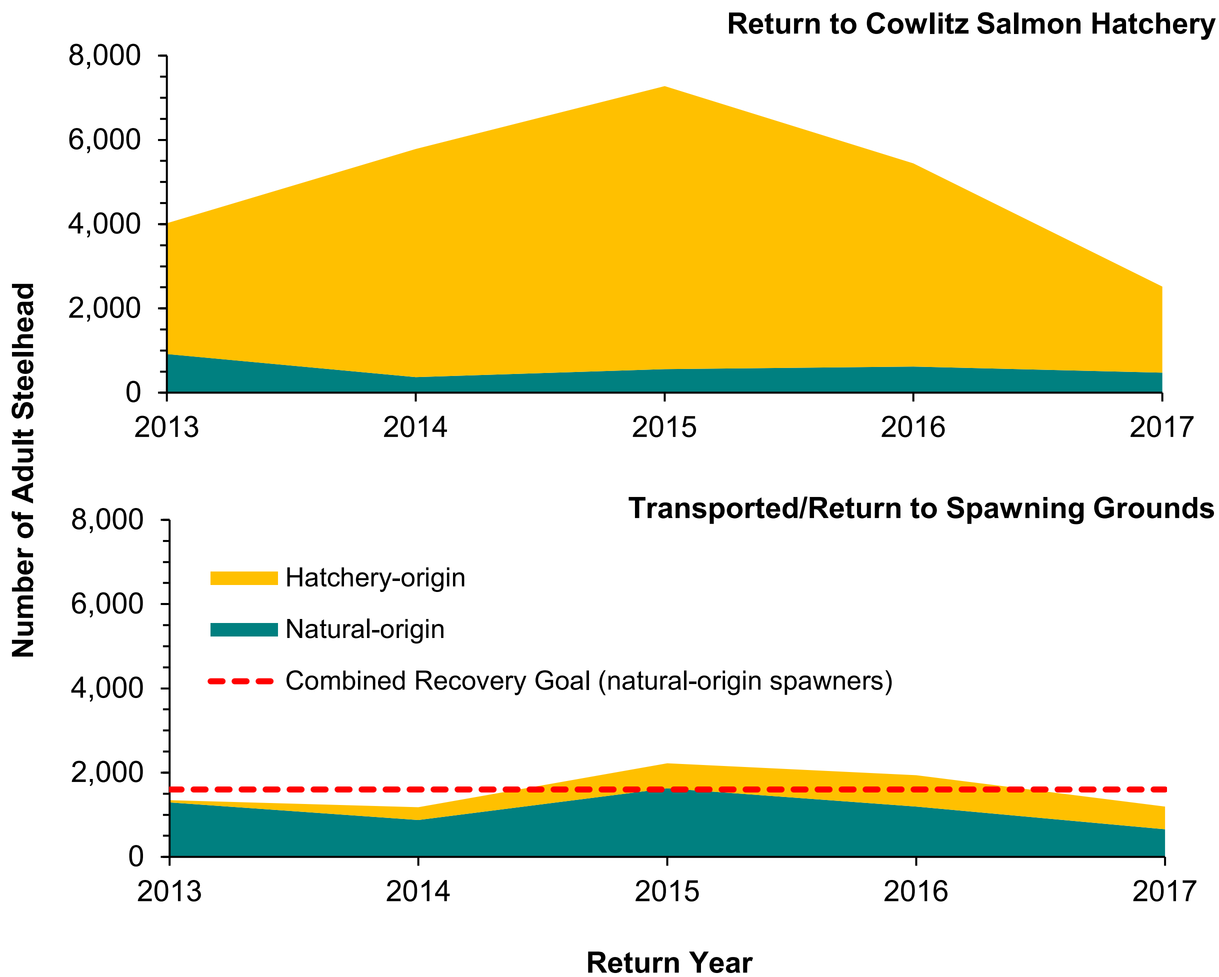


Figure 6.0-2. Numbers of hatchery- and natural-origin winter steelhead from the Cowlitz Basin above the Toutle River returning to Cowlitz Salmon Hatchery, and/or transported or returning to spawning grounds, 2013-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

6.0.5. Distribution

Historically, winter steelhead were distributed throughout the Cowlitz Basin in the mainstem and accessible tributaries, including in the Upper Cowlitz, Cispus, and Tilton subbasins. Below Mayfield Dam, winter steelhead are currently distributed throughout the mainstem Cowlitz River, with spawning documented in Olequa, Ostrander, Salmon, Arkansas, Delameter, Stillwater, and Whittle creeks (LCFRB 2010; Figure 6.0-1). The upstream transport program provides access to the Tilton, upper Cowlitz, and Cispus rivers and their accessible tributaries. In the Upper Cowlitz Subbasin, known spawning areas are in the mainstem Cowlitz River near the town of Packwood in the mainstem reach between its confluences with the Muddy and Clear forks, and in the lower Ohanapecosh River (LCFRB 2010).

Habitat above Mayfield and Cowlitz Falls dams appears to be productive, but this reintroduction effort has been hindered by the poor survival of smolts through the dams and associated reservoirs as well as poor capture efficiency of out-migrating smolts for transport around the dams. Although winter steelhead also inhabit the Toutle and Coweeman rivers, both tributaries to the lower Cowlitz River, these are considered separate populations for recovery purposes and outside the scope of this FHMP.

Historically, natural spawning by winter steelhead (both hatchery- and natural-origin) has not been extensively monitored or managed but, in recent years, there have been improvements in both monitoring and management. To reduce the abundance of hatchery-origin strays spawning in tributaries, weirs have been installed on Delameter, Lacamas, Olequa, and Ostrander creeks in the Lower Cowlitz Subbasin; only natural-origin late-winter steelhead are released above the weirs. Any hatchery-origin fish above weirs are individuals that successfully passed when the weirs were blown-out. The weirs provide locations to monitor distribution and abundance. Spawning ground surveys are also conducted on the streams with weirs and a subsample of other lower Cowlitz River tributaries, but not in the mainstem lower Cowlitz River. In the Tilton and Upper Cowlitz subbasins, known numbers of both hatchery- and natural-origin steelhead are transported and released, but neither their survival to, nor location of, spawning is monitored.

6.0.6. Abundance

The total run size of winter steelhead in the Cowlitz Basin includes the number of hatchery- and natural-origin steelhead that can be accounted for from ocean, Columbia River, and lower Cowlitz River fisheries, plus those spawning in the Lower Cowlitz Subbasin or captured at Cowlitz Salmon Hatchery. Harvest data provided in ISIT are incomplete, so total run size cannot be estimated for any of the winter steelhead populations based on available information. Returns to Cowlitz Salmon Hatchery offer a relative indication of total abundance; from 2013-2017, a mean of 4,420 hatchery-origin and 588 natural-origin late-winter steelhead returned to Cowlitz Salmon Hatchery (Figure 6.0-2; Table 6.0-2).

Productive spawning and rearing habitats still exist above the Cowlitz River Hydroelectric Complex, and recent improvements in steelhead smolt survival have helped reintroduction efforts. Although downstream migrant traps are operated for juvenile steelhead at Cowlitz Falls and Mayfield dams and help to assess the success of the adult releases, collection efficiency at Mayfield Dam is not yet high enough to provide precise estimates of smolt abundance from the Tilton Subbasin population. Additionally, smolt traps operated in the lower Cowlitz River are not able to capture an adequate proportion of outmigrants, so the abundance of natural-origin juveniles is not rigorously monitored. Likewise, limited effort is expended to examine annual abundance of natural-origin juveniles prior to smoltification. As a result, there is much uncertainty about the abundance of natural-origin steelhead smolts in the Cowlitz Basin.

6.0.7. Harvest

Although no commercial or tribal fisheries target Cowlitz Basin winter steelhead (LCFRB 2010), recreational harvest is an important component of Cowlitz Basin winter steelhead management and has the potential to affect population recovery. The Cowlitz Basin is one of the most intensively fished basins in Washington and is considered the top winter steelhead river in the state for recreational fishing (LCFRB 2010). The mark-selective regulations in place since the 1980s, as well as ESA restrictions on recreational fisheries, help to limit harvest impacts on natural-origin winter steelhead. LCFRB (2010) reports that <2% of natural-origin Cowlitz Basin steelhead are lost in recreational fisheries. ISIT assumes a 2% harvest based on the threshold for ESA impacts across all years, but no annual estimates of natural-origin harvest are available. Any information on the topic is based on natural-origin encounter rate from the lower Cowlitz River creel survey.

ISIT provides hatchery-origin harvest data for terminal fisheries in the respective subbasins for each population (i.e., harvest of Lower Cowlitz Subbasin steelhead in the Lower Cowlitz Subbasin and Upper Cowlitz Subbasin steelhead in the Upper Cowlitz Subbasin), but neither hatchery- nor natural-origin harvest data are available for the Tilton Subbasin terminal fishery. However, no estimates of ocean or Columbia River harvest are provided. Moreover, harvest rates for the lower Cowlitz River fishery are not population-specific (the Tilton and Upper Cowlitz subbasin populations are assumed to experience the same harvest rates in the lower Cowlitz River terminal fishery as the Lower Cowlitz Subbasin population).

Managing for population recovery would support high harvest rates for hatchery-origin steelhead while keeping harvest of the natural-origin salmonids as low as possible until the population can support harvest (Paquet et al. 2011). WDFW established long-term goals for harvest of Cowlitz Basin steelhead in terms of catch numbers, harvest rates, and seasons by fishery (Tacoma Power 2011). These are not necessarily the goals associated with the Settlement Agreement, but rather long-term goals that may require implementation of measures beyond the scope of the Settlement Agreement. Goals for individual fisheries are as follows:

- **Preterminal fishery:** ≤1% exploitation rate.
- **Lower Cowlitz Subbasin winter steelhead fishery (November-April):** In-river catch of 10,000-20,000 adults.
- **Lower Cowlitz Subbasin summer steelhead fishery (May-August):** In-river catch of 10,000-20,000 adults.
- **Upper Cowlitz Subbasin fishery (November-May)**: In-river catch consistent with return of 12,000 adults.
- **Tilton Subbasin fishery (November-May):** In-river catch consistent with return of 4,000-6,000 adults.

6.0.8. Natural Production

To recover a steelhead population, we must develop a self-sustaining natural population. To successfully manage toward population recovery, it is also important to know the abundance of the population at important points in their life cycle. Overall, we need to know (by origin, sex, and age) how many steelhead are spawning in nature (F_0 generation) and how many of their offspring (F_1 generation) smolt and leave the Cowlitz River and subsequently survive to produce the next (F_2) generation. Because spawning ground surveys are not conducted in the Upper Cowlitz or Tilton subbasins, any estimates to date of steelhead successfully reproducing on the spawning grounds are based simply on the number transported above the dams; we do not know how many survive to spawn. Collections of steelhead smolts at Cowlitz Falls and Mayfield dams offer an important monitoring point and provide a reliable number of smolts transported and released downstream, but the accuracy of the actual smolt production estimates has been constrained by poor collection efficiency.

The combined recovery abundance target for winter steelhead populations in the Cowlitz Basin is 1,600 natural-origin adults spawning in nature (Table 6.0-1); this target consists of the Primary population in the Upper Cowlitz Subbasin (1,000 spawners, including the Cispus River drainage) and Contributing populations in the Lower Cowlitz (400 spawners) and Tilton (200 spawners) subbasins (LCFRB 2010).

Although natural spawning of hatchery-origin salmonids is not directly credited toward meeting natural production targets, hatchery-origin adults are currently transported above Mayfield and Cowlitz Falls dams to spawn naturally as part of the recovery program. While these hatchery-origin steelhead are F_1 progeny of at least one natural-origin parent, the goal is to ultimately eliminate natural spawning of hatchery-origin salmonids once natural-origin abundance targets are met.

6.0.8.1. Natural Origin Adult Transport and Natural Spawning

Naturally produced smolts from the Upper Cowlitz Subbasin are implanted with CWTs when collected at Cowlitz Falls Dam so that they can be identified as belonging to the Upper Cowlitz Subbasin population. Upon returning to the hatchery as adults, these steelhead are either transported back to the Upper Cowlitz Subbasin to spawn naturally or retained as broodstock. All untagged natural-origin returns to the hatchery are assumed to have originated from the Tilton Subbasin and are either transported back to that subbasin to spawn naturally or retained as broodstock. Some of these returns may also include strays from the Lower Cowlitz Subbasin or other rivers below Mayfield Dam. While some uncollected smolts from the Upper Cowlitz Subbasin may pass Cowlitz Falls Dam without receiving a CWT, they are not thought to successfully pass below Mossyrock Dam and so are an unlikely component of the untagged adults returning to the Cowlitz Salmon Hatchery.

ISIT provides estimates of natural spawning abundance in the Lower Cowlitz Subbasin, but for the Tilton and Upper Cowlitz subbasins, the number of natural-origin adults transported and released represents the best approximation of natural spawner abundance. For the 2013-2017 run years, a mean of 644 natural-origin adults spawned naturally in the Lower Cowlitz Subbasin, 319 were transported to the Tilton Subbasin, and 166 were transported to the Upper Cowlitz Subbasin. These estimates suggest that abundance is approaching the recovery target of 400 natural-origin spawners in the Lower Cowlitz Subbasin and 200 natural-origin spawners in the Tilton Subbasin, although the number transported to the Tilton Subbasin does not account for losses from harvest, pre-spawn mortality, or fallback. In contrast, the number transported to the Upper Cowlitz Subbasin is still well below the combined recovery target of 1,000 natural-origin spawners in the Upper Cowlitz and Cispus rivers.

6.0.8.2. Natural Origin Smolt Production and Transport

Natural-origin smolt production from the Lower Cowlitz Subbasin is unknown and cannot be estimated at present. Smolt monitoring in the Lower Cowlitz Subbasin is conducted using a screw trap in the mainstem Cowlitz River and is difficult due to the large size of the river. Further confounding these estimates is the presence of unmarked steelhead smolts from the Tilton and Upper Cowlitz subbasins, which cannot be discerned from those from the Lower Cowlitz Subbasin. Natural-origin steelhead smolt production from the Tilton and Upper Cowlitz subbasins is not well known because of poor collection efficiency at Mayfield and Cowlitz Falls dams. We will increase collection efficiency to improve our estimate of natural-origin smolt production from above Mayfield Dam.

6.0.9. Artificial Production

Hatchery winter steelhead have been released in the Cowlitz Basin since 1957, and production currently occurs exclusively at Cowlitz Trout Hatchery (LCFRB 2010). Until 2012, Segregated Hatchery Programs supported production of the non-native early-winter (Puget Sound stock) and summer (Skamania stock) steelhead stocks, as well as the indigenous late-winter stock. Genetic analyses, described in the 2011 FHMP (Tacoma Power 2011), compared the level of introgression into the natural Cowlitz Basin populations among the three Segregated Hatchery Programs. Results indicated that the early-winter steelhead stock had the highest level of introgression, so this program was terminated in 2012. While the summer steelhead Segregated Hatchery Program persists today, the late-winter steelhead program began transitioning from a Segregated to an Integrated Hatchery Program, also in 2012.

For the Lower Cowlitz Subbasin population, this transition began with the collection of natural-origin adults from tributary weirs in the Lower Cowlitz Subbasin for use as broodstock through crosses with hatchery-origin returns to Cowlitz Salmon Hatchery. The Integrated Hatchery Programs for the Upper Cowlitz and Tilton subbasins were developed using natural-origin returns to Cowlitz Salmon Hatchery as broodstock and supplemented with hatchery-origin returns as needed. Beginning in 2015, as the first adults from the new Integrated Hatchery Program started to return, both natural- and hatchery-origin adults from the Integrated Hatchery Program have been transported and released in the Upper Cowlitz and Tilton subbasins. The purpose of these releases during the Recolonization phase of recovery is to increase spawning in nature and the subsequent number of natural-origin returns becoming available to use as broodstock and in spawn in nature.

Moving forward, we will continue this approach for the Upper Cowlitz and Tilton subbasin populations until the targets of the Recolonization phase of recovery are met and the Local Adaptation phase begins. In addition, we will explore options for providing increased opportunity for recreation and harvest while ensuring that achieving population recovery goals is prioritized. Hatchery best management practices will be used, and hatchery production metrics must be monitored to ensure that production goals are met, and also to understand the magnitude of hatchery influence on the natural population that it is supplementing. Key monitoring metrics are the numbers of steelhead collected and spawned (by origin, age, and sex), green eggs, eyed eggs, fry, parr, smolts released, and of mature hatchery-origin steelhead returning to the Cowlitz River and Cowlitz Salmon Hatchery (by age and sex). Using these data, we also calculate and monitor hatchery effectiveness metrics and smolt-to-adult survival and return rates.

6.0.9.1. Overall Hatchery Program Goals

The overall goals of hatchery programs for steelhead within the Cowlitz Basin are to:

1) Promote recovery of populations inhabiting the Cowlitz Basin, particularly the Upper Cowlitz Subbasin population.
2) Provide fisheries for recreational and harvest opportunities while prioritizing population recovery.
3) Support educational and research opportunities.

Specific and quantifiable objectives of the hatchery programs to achieve these goals are described in detail within the respective sections for each of the Cowlitz Basin winter steelhead populations (Sections 6.1, 6.2, and 6.3).

6.0.9.2. Existing Hatchery Program

Winter steelhead that are captured at Cowlitz Salmon Hatchery may be hatchery-origin steelhead, natural-origin steelhead that are attempting to migrate above the hydroelectric dams, or natural-origin steelhead from the Lower Cowlitz Subbasin that strayed upstream and entered the hatchery trap. From 2013-2017, a mean of 5,008 adult winter steelhead returned to Cowlitz

Salmon Hatchery, of which 4,420 (88%) were hatchery-origin while 588 (12%) were natural-origin (Table 6.0-2). During this period, a mean total of 413 winter steelhead were collected as broodstock at Cowlitz Salmon Hatchery, of which 295 (71%) were hatchery-origin and 118 (29%) were natural-origin. Those salmonids produced a mean of 648,881 smolts from the Integrated Hatchery Program.

Table 6.0-2. Mean, minimum, and maximum numbers of all hatchery- and natural-origin winter steelhead from the Cowlitz Basin above the Toutle River that could be accounted for at recovery locations and percentage of total at that recovery location, 2013-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Origin and Recovery Location	Mean	Minimum	Maximum
Hatchery-origin			
Total Run[1]	Not All Data Are Available		
Harvest[2]	Not All Data Are Available		
Total Return to Cowlitz River[3]	Not All Data Are Available		
Return to Cowlitz Salmon Hatchery	4,420	2,046	6,716
Collected for Broodstock	295	244	385
Transported/Return to Spawning Grounds	445	51	740
Natural-origin			
Total Run[1]	Not All Data Are Available		
Harvest[2]	Not All Data Are Available		
Total Return to Cowlitz River[3]	Not All Data Are Available		
Return to Cowlitz Salmon Hatchery	588	369	918
Collected for Broodstock	118	64	166
Transported/Return to Spawning Grounds	1,129	656	1,628
Combined Hatchery- and Natural-origin			
Total Run[1]	Not All Data Are Available		
Harvest[2]	Not All Data Are Available		
Total Return to Cowlitz River[3]	Not All Data Are Available		
Return to Cowlitz Salmon Hatchery	5,008	2,520	7,276
Collected for Broodstock	413	376	449
Transported/Return to Spawning Grounds	1,574	1,177	2,222

[1] Sum of all harvest in ocean, Columbia River, and Lower Cowlitz Subbasin fisheries, plus number returning to Lower Cowlitz Subbasin spawning grounds, and collected at Cowlitz Salmon Hatchery or tributary weirs in the Lower Cowlitz Subbasin.
[2] Total of harvest in ocean, Columbia River, Lower Cowlitz Subbasin, and Upper Cowlitz Subbasin fisheries.
[3] Sum of Lower Cowlitz Subbasin harvest plus number returning to Lower Cowlitz Subbasin spawning grounds and collected at Cowlitz Salmon Hatchery or tributary weirs in the Lower Cowlitz Subbasin.

6.0.9.3. Hatchery Origin Adult Transport and Natural Spawning

As part of the Integrated Hatchery Program, adult winter steelhead collected at the hatchery are transported to habitats above Mayfield Dam where they may spawn naturally. In addition, natural- and hatchery-origin steelhead from the Integrated Hatchery Program that do not return to the hatchery may remain in the Lower Cowlitz Subbasin to spawn naturally. From 2013-2017, a mean of 1,574 winter steelhead adults returned to the spawning grounds in the Lower Cowlitz Subbasin or were transported above Mayfield Dam to either the Tilton or Upper Cowlitz subbasins. Of those, means of 445 (28%) were hatchery-origin and 1,129 (72%) were natural-origin winter steelhead. This number does not account for losses from harvest, pre-spawn mortality, or fallback for upriver populations, so the actual number of hatchery-origin steelhead spawning in nature is unknown, and pHOS is not characterized as accurately as the available data represent.

6.0.10. Survival and Productivity

SAR of hatchery-origin winter steelhead is unknown because the age of returning adults (i.e., brood year) is not provided in ISIT. SAR of natural-origin winter steelhead is also unknown because necessary data are unavailable but is expected to be greater than that of the hatchery-origin steelhead. Because the numbers of spawners and the numbers of returns by brood year are unavailable, productivity (spawner-to-spawner) cannot be calculated.

6.0.11. Proportionate Natural Influence and Age Composition

PNI is an index of the influence that hatcheries have on salmonid populations, as a whole. PNI is calculated using two proportions: the proportion of spawners in nature that are hatchery-origin (pHOS) and the proportion of the hatchery broodstock that is comprised of natural-origin salmonids (pNOB). HSRG (2009) recommendations for Primary populations with integrated hatchery programs are that pHOS <0.3 and that pNOB should be greater than twice pHOS so that PNI >0.67. For Primary populations with a segregated hatchery program, the HSRG (2009) recommends pHOS <0.05.

Age composition cannot be completely calculated from the data in ISIT because they are not compiled by age or brood year. Age classes are only characterized as “jacks” or “adults,” and these data are only available for returns to Cowlitz Salmon Hatchery, not for any other recovery locations. Jacks comprise a small percentage of mature returns to Cowlitz Salmon Hatchery. From 2012-2017, <1% of mature steelhead returning to the hatchery were jacks.

6.0.12. Marking and Tagging

Identifying the origin and/or release group to which a steelhead belongs is crucial to effective monitoring and evaluation. All hatchery-origin steelhead are marked with an adipose fin clip. In addition, hatchery-origin steelhead from the Tilton Subbasin and Upper Cowlitz Subbasin Integrated Hatchery Programs are marked with a left- or right-ventral clip. Natural-origin smolts from the Upper Cowlitz Subbasin are implanted with a CWT in the snout upon collection at Cowlitz Falls Fish Facility[1], while natural-origin smolts from the Tilton Subbasin are either untagged (i.e., if uncollected) or are implanted with a CWT in the dorsal sinus. Marking and tagging schemes may differ from year to year, especially for hatchery-origin releases, which may also include experimental groups. Recent marking strategies have relied on CWTs implanted in steelhead smolts from the Upper Cowlitz Subbasin. Marking and tagging schemes for each group, within each brood year, will be set by the Monitoring and Evaluation subgroup, approved by the FTC, and documented in each year’s Annual Operating Plan.

[1] It is assumed that any natural-origin steelhead smolts from the Upper Cowlitz Subbasin that pass Cowlitz Falls Dam without being collected are unable to reach the ocean; thus, all returning adults from the Upper Cowlitz Subbasin population are assumed to have a CWT in their snout.

6.0.13. Summary

- The continued genetic exchange among winter steelhead in the hatchery and those spawning naturally in the Lower Cowlitz Subbasin since 1963 has caused Cowlitz Basin winter steelhead to functionally become a single population.
- Although the ESA framework identifies distinct winter steelhead populations in the Cispus and Upper Cowlitz rivers, returning adults cannot be differentiated. These populations are therefore managed as a combined "Upper Cowlitz Subbasin" population.
- Activities covered by this FHMP will prioritize the recovery of the indigenous winter steelhead populations, while still promoting harvest opportunity. Implementation will be guided by ESA, the FERC license, and basin-specific constraints.
- The Upper Cowlitz Subbasin population is currently in the Recolonization phase of recovery. This FHMP period will prioritize increasing the abundance of winter steelhead (both hatchery- and natural-origin) spawning in the Upper Cowlitz Subbasin to increase the subsequent number of natural-origin F1 returns. This will be accomplished through increasing the size of the Integrated Hatchery Programs above Mayfield Dam.
- While the Tilton Subbasin population is still in the Recolonization phase, the abundance of natural-origin adults transported and released in the subbasin is approaching the recovery goal for natural-origin spawners. However, actual spawner abundance is unknown and must be estimated before this population can transition to the Local Adaptation phase of recovery.
- To maximize natural spawners above the weirs for the lower Cowlitz Subbasin population, we will stop collecting natural-origin broodstock from tributary weirs, allowing these steelhead to spawn in nature. In addition, we will shift hatchery production to the Upper Cowlitz Subbasin and evaluate whether the Integrated Hatchery Program for the Lower Cowlitz Subbasin should be continued or transitioned to a Segregated Hatchery Program.
- We will explore opportunities to increase recreational/harvest opportunity in the Lower Cowlitz Subbasin by adjusting the Segregated Summer Steelhead Segregated Hatchery Program and developing an Early-winter Hatchery Program that is consistent with recovery goals.

The following sections present information on the three managed winter steelhead populations in the Cowlitz Basin: Lower Cowlitz Subbasin population (Section 6.1), Upper Cowlitz Subbasin population (Section 6.2), and Tilton Subbasin population (Section 6.3).

Population: Lower Cowlitz Subbasin Winter Steelhead
Oncorhynchus mykiss

Distinct Population Segment:	Cascade Winter Steelhead Lower Columbia River Steelhead DPS Lower Columbia River Salmon Recovery Region
ESA Listing Status:	Threatened Listed in 1998, revised 2006, reaffirmed in 2011 and 2016
Population Recovery Designation:	Contributing
Population Viability Rating:	
Baseline	Low
Objective	Medium
Recovery Goal:	400 natural-origin winter steelhead spawning in the Lower Cowlitz Subbasin
Current Recovery Phase:	Local Adaptation
Current Hatchery Program(s):	• Cowlitz Trout Hatchery Integrated Late Winter (Cowlitz-origin) Steelhead Hatchery Program; • Cowlitz Trout Hatchery Segregated Summer (Skamania-origin) Steelhead Hatchery Program
Proposed Hatchery Program(s):	• Adjusted Cowlitz Trout Hatchery Integrated Winter (Cowlitz-origin) Steelhead Hatchery Program to include earlier run-timing, reduced natural-origin broodstock collection from Lower Cowlitz Subbasin, and reduced production of hatchery-origin late-winter steelhead in Lower Cowlitz Subbasin • Cowlitz Trout Hatchery Segregated Summer (Skamania-origin) Steelhead Hatchery Program

6.1. Winter Steelhead: Lower Cowlitz Subbasin Population

6.1.1. Purpose

This section describes the current status of the Lower Cowlitz Subbasin winter steelhead population based on recent and available data. In addition, we identify the VSP metrics needed to evaluate this population's status with regard to reaching recovery under ESA guidelines. Where appropriate, we propose changes to both hatchery and monitoring programs to facilitate the evaluation of progress toward population recovery. Although the Lower Cowlitz Subbasin winter steelhead population has exceeded the recovery abundance target in four of the last 5 years, the PNI remains below the target threshold. During the period covered by this FHMP, we begin working toward increasing natural influence on the population. Although the transition from a Segregated Hatchery Program to an Integrated Hatchery Program began in 2013, the number of natural-origin broodstock collected from tributaries in the Lower Cowlitz Subbasin has been insufficient to meet desired integration rates. Moreover, those natural-origin steelhead taken as broodstock are effectively removed from spawning naturally in the Lower Cowlitz Subbasin. One means of reducing the influence of hatchery-origin spawners is to increase the number of natural-origin spawners allowed to spawn naturally. Moving forward, we will reduce the number of natural-origin returns collected from the Lower Cowlitz Subbasin, leaving these winter steelhead to spawn naturally in the subbasin. Simultaneously, we will reduce the number of Lower Cowlitz Subbasin hatchery-origin winter steelhead produced each year in favor of production for programs originating from the Tilton River and Upper Cowlitz Subbasin.

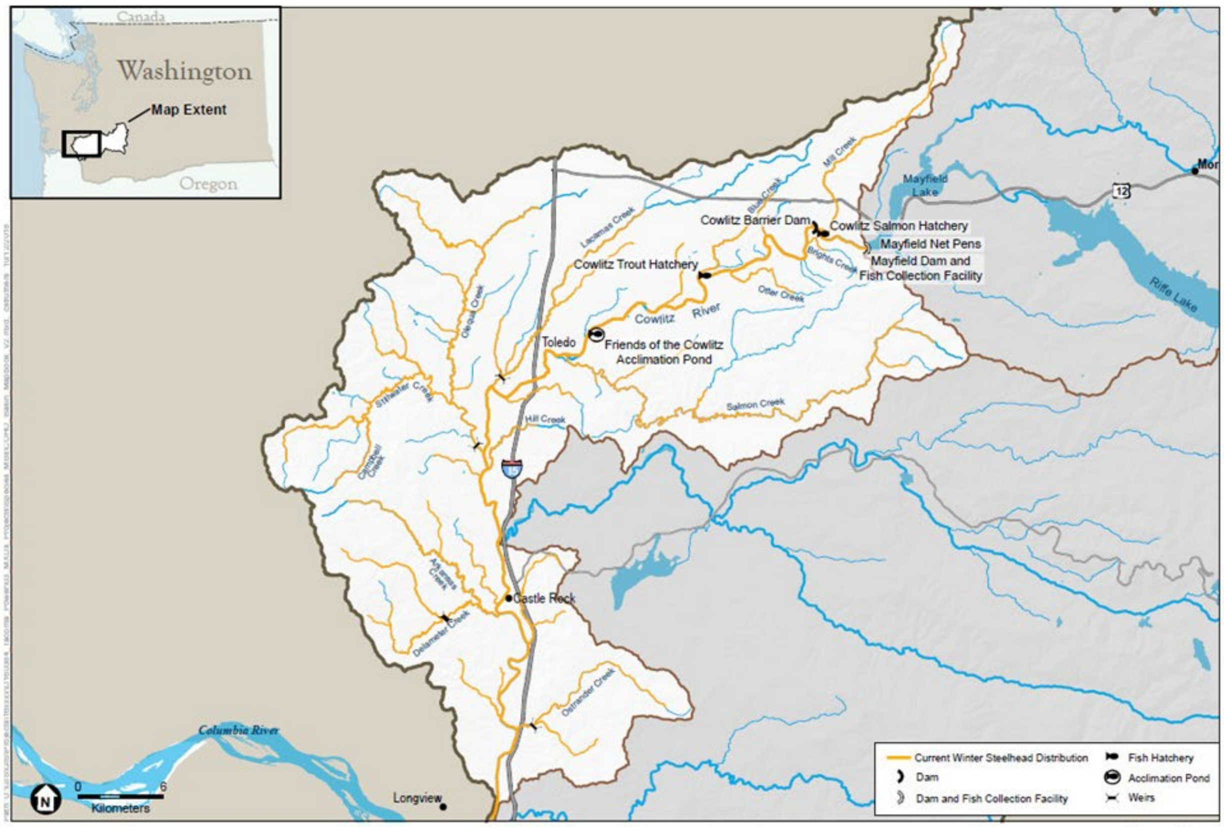
The indigenous Lower Cowlitz Subbasin winter steelhead population is currently considered a late-winter run, returning to the Cowlitz River from March to as late as early June (Tacoma Power 2011). The short-term goal for steelhead in the Lower Cowlitz Subbasin is to prioritize recovery of the Upper Cowlitz Subbasin winter steelhead population while still providing harvest opportunity. To achieve that goal, we will attempt to extend the run timing of winter steelhead so that the overall run timing more closely emulates what was historically exhibited in the Cowlitz Basin, promoting Local Adaptation of the population while extending harvest opportunity. In addition, we will continue to evaluate the hatchery program and fisheries management and will make refinements or adjustments, as described in this FHMP, to effectively manage the Lower Cowlitz Subbasin winter steelhead population.

6.1.2. Population Description

The Lower Cowlitz Subbasin winter steelhead population includes all natural-origin winter steelhead that occupy the Cowlitz River and all tributaries downstream of the Barrier Dam (rkm 81), excluding the Toutle and Coweeman rivers, as well as those from the current Integrated Hatchery Program at Cowlitz Trout Hatchery (Figure 6.1-1). Following the extirpation of winter steelhead populations upstream of Mayfield Dam, the Lower Cowlitz Subbasin winter steelhead population became an aggregation of all three populations[1], representing the only extant population remaining in the Cowlitz Basin upstream of the Toutle River. The Lower Cowlitz Subbasin population has served as the founding stock for reintroductions upstream of Mayfield Dam. Although no run size information was available, this population was found to be “Depressed” (WDFW 1993) and, as part of the lower Columbia River DPS, was listed as threatened under the ESA in 1998, and reaffirmed in 2011 and 2016. This population is classified as a Contributing population for recovery of the lower Columbia River DPS and must attain its recovery and viability goals for the DPS to be considered recovered (WDFW and LCFRB 2016).

The Lower Cowlitz Subbasin winter steelhead population is currently supplemented by hatchery production. The most recent 5-year means for natural-origin spawners has exceeded the recovery goal for the population.

[1] The Lower Cowlitz Subbasin population may have also been similarly influenced by the Toutle River population following the eruption of Mount St. Helens.



SOURCE: SWIFD, 2014; WDNR, 2017 Tacoma Power

Figure 6.1-1. Distribution of winter steelhead in the Lower Cowlitz Subbasin.

6.1.3. Natural Production

6.1.3.1. Abundance

Two critical monitoring metrics for salmonid management are the numbers that return at maturation and their disposition (Table 6.1-1; Figures 6.1-2 and 6.1-3). Lower Cowlitz Subbasin winter steelhead that survive to begin their spawning migration may be harvested in commercial, sport, or tribal fisheries in the ocean, Columbia River, or Cowlitz River. Those escaping harvest may return to Cowlitz Salmon Hatchery or natural spawning grounds, where they are recovered and counted (Table 6.1-1). They may also die from predation or disease at any time and not be recovered. Monitoring the frequency of these fates allows us to evaluate population health, productivity, and progress toward recovery. However, these data, which are critical to monitoring the Lower Cowlitz Subbasin winter steelhead population, have been only sporadically collected and are incomplete, making population trends difficult to discern at this time.

Juvenile production of winter steelhead in the Lower Cowlitz Subbasin includes the natural production of smolts as well as fish released from Cowlitz Trout Hatchery. Estimates of natural production for juvenile winter steelhead are not available.

The recovery goal for the Lower Cowlitz Subbasin winter steelhead population is an annual abundance of 400 natural-origin salmonids spawning in nature (LCFRB 2010).

Table 6.1-1. Mean, minimum, and maximum numbers of all hatchery- and natural-origin adult winter steelhead from the Lower Cowlitz Subbasin population accounted for at recovery locations, and percentage of total at each recovery location, 2007, 2008, and 2013-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Origin and Recovery Location	Mean	Minimum	Maximum
Hatchery-origin			
Total Run[1]		Not All Data Are Available	
Harvest[2]		Not All Data Are Available	
Ocean harvest		Data Not Available	
Columbia River harvest		Data Not Available	
Lower Cowlitz Subbasin harvest	8,891	5,011	14,512
Total Return to Cowlitz River[3]	12,964	7,829	20,811
Return to spawning grounds	219	51	535
Return to Cowlitz Salmon Hatchery	3,854	1,725	6,189
Collected for Broodstock	280	243	338
Natural-origin			
Total Run[1]		Not All Data Are Available	
Harvest[2]		Not All Data Are Available	
Ocean harvest		Data Not Available	
Columbia River harvest		Data Not Available	
Lower Cowlitz Subbasin harvest[4]	11	4	24
Total Return to Cowlitz River[3]	555	202	1,200
Return to spawning grounds	533	198	1,156
Return to Cowlitz Salmon Hatchery	0	0	0
Collected for Broodstock[5]	11	0	30
Combined Hatchery- and Natural-origin			
Total Run[1]		Not All Data Are Available	
Harvest[2]		Not All Data Are Available	
Ocean harvest		Data Not Available	
Columbia River harvest		Data Not Available	
Lower Cowlitz Subbasin harvest	8,902	5,015	14,536
Total Return to Cowlitz River[3]	13,519	8,135	22,011
Return to spawning grounds	753	337	1,266
Return to Cowlitz Salmon Hatchery	3,854	1,725	6,189
Collected for Broodstock[5]	291	246	338

1 Sum of all harvest plus number returning to Lower Cowlitz Subbasin spawning grounds, and Cowlitz Salmon Hatchery (hatchery-origin) or collected at weirs for broodstock (natural-origin).
2 Total of harvest in ocean, Columbia River, and Lower Cowlitz Subbasin fisheries from ISIT harvest.
3 Sum of Lower Cowlitz Subbasin harvest plus number returning to Lower Cowlitz Subbasin spawning grounds, and Cowlitz Salmon Hatchery (hatchery-origin) or collected at weirs for broodstock (natural-origin).
4 Based on ISIT assumption of a 2% harvest rate on natural-origin winter steelhead in the Lower Cowlitz Subbasin.
5 Natural-origin winter steelhead were not collected for broodstock prior to 2013, although values reflect the 2007-2008 and 2013-2017 period.

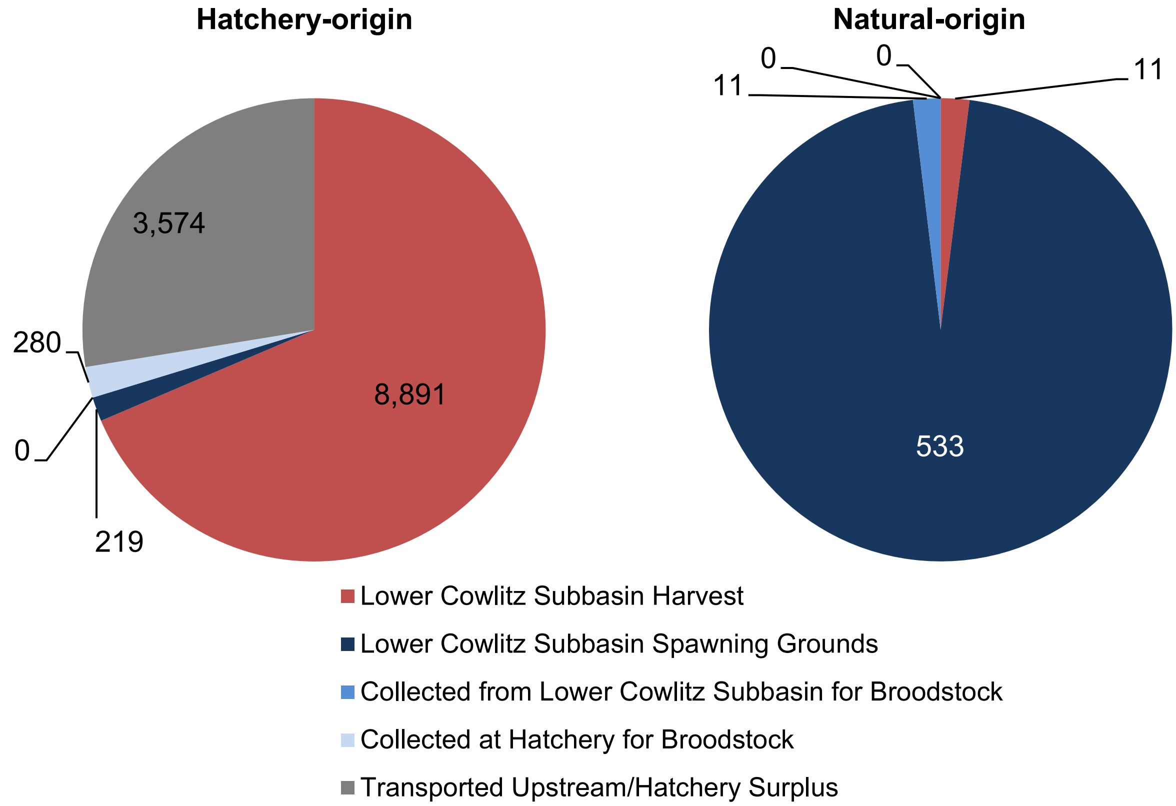


Figure 6.1-2. Mean numbers and proportions of hatchery- and natural-origin Lower Cowlitz Subbasin winter steelhead caught in non-ocean fisheries, collected from the Lower Cowlitz Subbasin for use as broodstock (natural-origin only), returned to Lower Cowlitz Subbasin spawning grounds, or returned to Cowlitz Salmon Hatchery (comprised of hatchery broodstock and hatchery surplus), 2013-2017. Note: No natural-origin Lower Cowlitz Subbasin winter steelhead were recorded as having returned to Cowlitz Salmon Hatchery because those caught at the hatchery are assumed to have come from populations upstream of Mayfield Dam. Data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

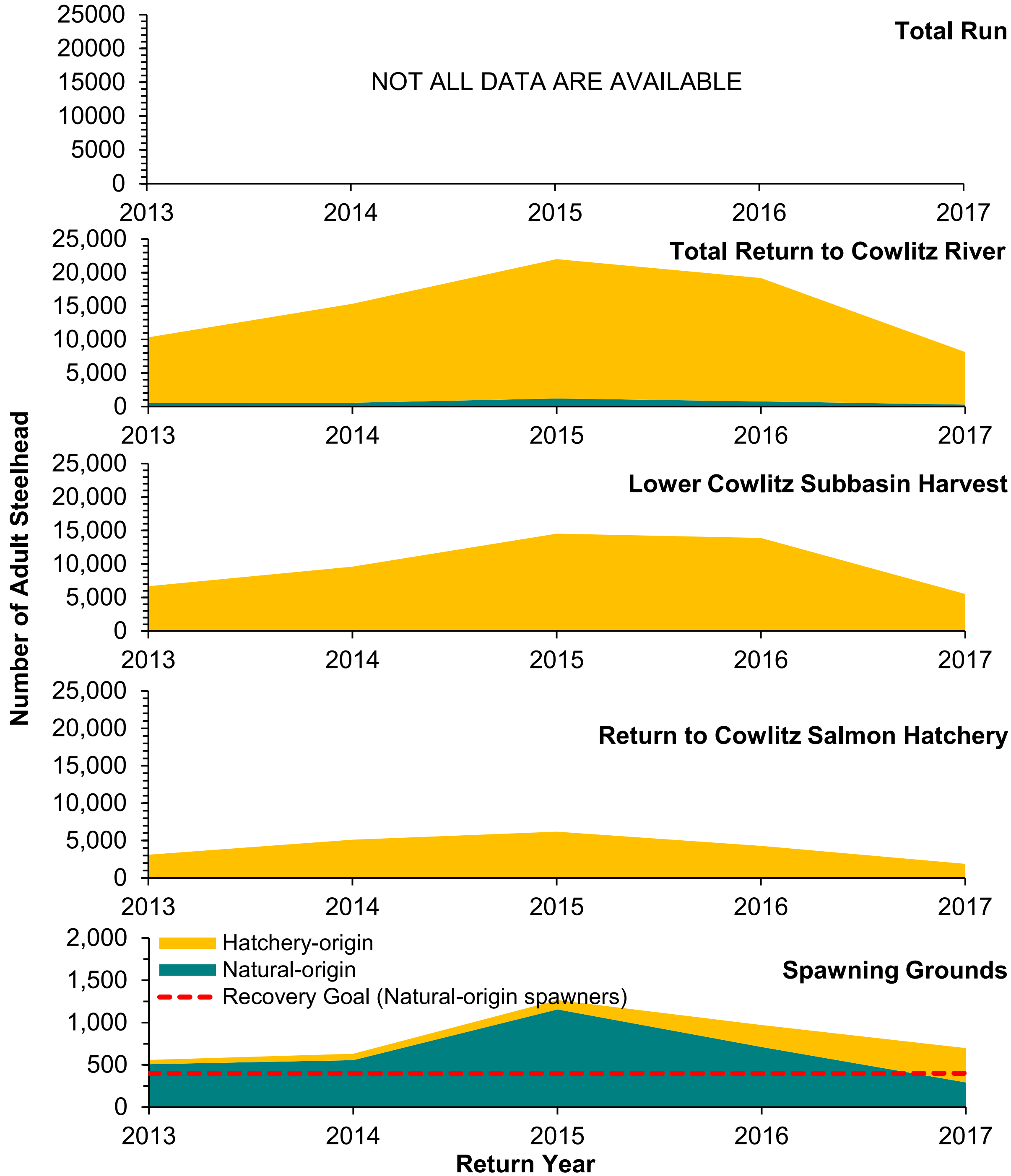


Figure 6.1-3. Estimated total run size for natural- and hatchery-origin adult Lower Cowlitz Subbasin winter steelhead and the numbers that returned to the Cowlitz River, were harvested, returned to Cowlitz Salmon Hatchery, or returned to Lower Cowlitz Subbasin spawning grounds, 2013-2017. Notes: Distinct scale is used for spawning ground returns. Data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Total run size could not be estimated for either hatchery- nor natural-origin winter steelhead because numbers harvested from the ocean and Columbia River fisheries are not included in ISIT. From 2007-2008, and 2013-2017 (the years for which data for natural-origin winter steelhead were consistently available in ISIT), means of total returns to the Cowlitz River were 555 natural-origin winter steelhead (Figures 6.1-2 and 6.1-3; Table 6.1-1). A mean of 533 natural-origin winter steelhead remained on the spawning grounds in the Lower Cowlitz Subbasin. Beginning with the initiation of the Integrated Hatchery Program in 2013 and continuing through 2017, a mean of 14 natural-origin winter steelhead were collected at Lower Cowlitz Subbasin weirs and were used as broodstock. Natural-origin winter steelhead returning to Cowlitz Salmon Hatchery are assumed to have originated from populations upstream of Mayfield Dam.

6.1.3.2. Harvest

Harvest is an important component of the management of Lower Cowlitz Subbasin winter steelhead and has the potential to affect population recovery. Few winter steelhead are harvested in ocean and Columbia River fisheries, so harvest rates are not provided in ISIT and total exploitation cannot be estimated comprehensively. Retention of natural-origin winter steelhead is not permitted in Cowlitz Basin fisheries, so natural-origin exploitation rates reflect incidental mortality; because this rate is unknown, ISIT assumes a 2% harvest rate on natural-origin winter steelhead in the Lower Cowlitz Subbasin.

6.1.3.3. Spawning in Nature

The Lower Cowlitz Subbasin winter steelhead population recovery goal of 400 natural-origin steelhead spawning in nature was exceeded during 4 (2013-2017) of the 7 (2007-2008 and 2013-2017) years for which data are available (mean = 533; Figure 6.1-3; Table 6.1-1). From 2007-2008 and 2013-2017, a mean of 555 natural-origin winter steelhead from the Lower Cowlitz Subbasin population returned to the Cowlitz River (Figure 6.1-2 and 6.1-3; Table 6.1-1). Of those, 2% were harvested, 96% returned to Lower Cowlitz Subbasin spawning grounds, and 2% were collected at Lower Cowlitz Subbasin weirs for use as hatchery broodstock. No Lower Cowlitz Subbasin winter steelhead were recorded as having returned to Cowlitz Salmon Hatchery because all unmarked natural-origin steelhead captured there are assumed to have come from populations upstream of Mayfield Dam. From 2007-2008 and 2013-2017, a mean of 753 total winter steelhead spawned in the Lower Cowlitz Subbasin, of which 533 (71%) were natural-origin (Figures 6.1-2 and 6.1-3; Table 6.1-1).

Collecting and transporting natural-origin winter steelhead from the Cowlitz Salmon Hatchery trap to the Tilton Subbasin likely reduces the abundance of natural-origin Lower Cowlitz Subbasin winter steelhead in the Lower Cowlitz Subbasin, as well as their spawning and subsequent juvenile production. On the other hand, it is also likely that some Tilton Subbasin natural-origin winter steelhead remain in the Lower Cowlitz Subbasin to spawn and offset any numeric reduction to the Lower Cowlitz Subbasin population. All Upper Cowlitz Subbasin winter steelhead returning to the hatchery after 2020 will have a CWT. These fish will be readily distinguishable from untagged natural-origin returns. Currently, all juvenile natural-origin steelhead handled at the Cowlitz Falls Fish Facility (snout) and the Mayfield Counting House (dorsal-sinus) are implanted with CWT. This strategy was implemented in 2018/19, so it will be possible to positively identify disposition at the separator starting in 2021. Taken in total, the effects associated with adult returns spawning out of location on actual adult natural-origin abundance are uncertain, but should be considered in the future to facilitate effective management of populations in both the Lower Cowlitz and Tilton subbasins.

6.1.3.4. Smolt Production

No estimate of winter steelhead smolt abundance is available for the Lower Cowlitz Subbasin winter steelhead population. A smolt trap is operated on the lower Cowlitz River, but any juveniles captured may be from the Lower Cowlitz, Upper Cowlitz, or Tilton subbasins, so the data are confounded. Additionally, production from tributaries downstream from the smolt trap is unsampled.

6.1.3.5. Natural-origin Survival and Productivity

Survival and productivity are key metrics for monitoring populations. However, neither SAR, TSAR, nor smolts/spawner can be calculated for the Lower Cowlitz Subbasin winter steelhead population because smolt abundance in the Lower Cowlitz Subbasin is not monitored. Recent harvest rates in the ocean and Columbia River are also unavailable, which precludes estimating total run size and, consequently, estimates of survival and productivity. A rough estimate of recruits/spawner can be calculated, but it is an underestimate because a substantial number of natural-origin spawners and/or recruits are likely not being accounted for, including those in an unmonitored tributary, the mainstem Cowlitz River, or natural-origin recruits trapped at Cowlitz Salmon Hatchery. Additionally, age composition data for natural-origin returns that do not return to Cowlitz Salmon Hatchery are unavailable, so a full run reconstruction for each brood year is not possible.

Without the information necessary for full run reconstruction, such as recruits per spawner and spawner-to-spawner R/S, estimates of productivity cannot be developed. Likewise, smolt abundance is difficult to ascertain because of poor smolt trap collection efficiency in the lower Cowlitz River and because smolts produced naturally in the Lower Cowlitz Subbasin cannot be effectively distinguished from those produced upstream of Mayfield Dam. However, if we can develop a good estimate of smolt numbers, we will also monitor smolt productivity. Smolts produced/spawner provides a view of the productivity of the freshwater rearing habitat, but this metric is less valuable for overall population monitoring, as it is affected by freshwater rearing density, and survival from smolt to maturation can be widely variable.

6.1.3.6. Age Composition

Age composition cannot be completely calculated from the data in ISIT because they are not compiled by age or brood year. Age classes are only characterized as jacks or adults, and these data are only available for returns to Cowlitz Salmon Hatchery, not for any other recovery locations. Moreover, ISIT does not define the length criteria by which jacks and adults are discriminated. Because natural-origin returns to the hatchery are assumed to originate from populations above Mayfield Dam, no natural-origin Lower Cowlitz Subbasin winter steelhead are handled at the hatchery.

6.1.4. Hatchery Production

Hatchery production metrics must be monitored to ensure that production goals are met, to evaluate the effectiveness of the program, and to understand the magnitude of hatchery influence on the natural population that it is supplementing. Key monitoring metrics are the numbers of steelhead harvested, collected, and spawned (by origin, age, and sex), smolts released, and steelhead returning to the Cowlitz River and Cowlitz Salmon Hatchery, as well as remaining in nature. Collection of these data allows us to calculate and monitor smolt-to-adult survival and return rates.

Hatchery winter steelhead have been planted in the Cowlitz Basin since 1957 (LCFRB 2010). The recent termination of the Segregated Early-Winter Steelhead Hatchery Program (non-native Puget Sound stock) reduced introgression risks for the late-winter steelhead stock indigenous to the Cowlitz Basin. Continuation of the non-native (Skamania origin) Segregated Summer Steelhead Hatchery Program poses lesser risks of introgression because their spawning is temporally and spatially isolated. As of the 2011 FHMP (Tacoma Power 2011), the Lower Cowlitz Subbasin Late-Winter Steelhead Hatchery Program had a production target of releasing 362,855 smolts in 2012 (brood year 2011) and 478,122 smolts in 2013 (brood year 2012). Since 2013, the program goal has been 478,000 smolts.

6.1.4.1. Abundance

As noted above for natural-origin steelhead, data that are critical to monitoring the Lower Cowlitz Subbasin winter steelhead population have been only sporadically collected and are incomplete, making population trends difficult to discern at this time.

Juvenile production of winter steelhead in the Lower Cowlitz Subbasin includes natural production of smolts as well as fish released from Cowlitz Trout Hatchery. From 2007-2008 and 2013-2017[2], a mean of 441,837 Lower Cowlitz Subbasin smolts were released annually from Cowlitz Trout Hatchery (Table 6.1-2).

The recovery goal for the Lower Cowlitz Subbasin winter steelhead population is an annual abundance of 400 natural-origin salmonids spawning in nature (LCFRB 2010). The total run size could not be estimated for hatchery- nor natural-origin winter steelhead because numbers harvested from the ocean and Columbia River fisheries are not included in ISIT. From 2007-2008, and 2013-2017 (the years for which data for natural-origin winter steelhead were consistently available in ISIT), means of total returns to the Cowlitz River were 12,964 hatchery-origin winter steelhead (Figures 6.1-2 and 6.1-3; Table 6.1-1). A mean of 219 hatchery-origin winter steelhead remained on the spawning grounds in the Lower Cowlitz Subbasin, while a mean of 3,854 hatchery-origin winter steelhead returned to Cowlitz Salmon Hatchery.

6.1.4.2. Harvest

Harvest is an important component of the management of Lower Cowlitz Subbasin winter steelhead and has the potential to impact population recovery. Hatchery-origin winter steelhead are the foundation of an important recreational fishery in the Lower Cowlitz Subbasin. They are also captured in Columbia River recreational fishery and can be caught incidentally in ocean fisheries targeting other species. Few winter steelhead are harvested in ocean and Columbia River fisheries, so harvest rates are not provided in ISIT and total exploitation cannot be estimated comprehensively. However, the vast majority of harvest occurs in the Lower Cowlitz Subbasin. Of the population returning to the Cowlitz River from 2007-2008 and 2013-2017, a mean of 8,891 was harvested (Figure 6.1-1). Of that, >99% were hatchery-origin winter steelhead.

[2] While not defined in ISIT, smolt releases are assumed to reflect a given brood year.

Table 6.1-2. Mean, minimum, and maximum hatchery and natural spawning metrics for Lower Cowlitz Subbasin winter steelhead, 2007-2008 and 2013-2017 spawn years. Note: Data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

	2007-2008, 2013-2017 Spawn Years		
Spawning Location, Metric	Mean	Minimum	Maximum
Hatchery			
Adults and Jacks Collected	291	246	338
Hatchery-origin	280	243	338
Natural-origin	11	0	30
Pre-spawn Survival Rate	88%	81%	93%
Adults and Jacks Spawned	255	225	301
Hatchery-origin	246	208	301
Natural-origin	9	0	27
Total Green Eggs	653,756	521,656	725,328
Mean Fecundity	5,493	4,501	6,116
Mean Fertility	Data Not Available		
Total Eyed Eggs	Data Not Available		
Smolts Released*	441,837	304,581	588,893
Green Egg-to-Smolt Survival	69%	43%	87%
Smolt Productivity (smolts/spawner)	1,757	1,012	2,187
Nature			
Spawners	753	337	1,266
Hatchery-origin	219	51	535
Natural-origin	533	198	1,156
Smolts Produced	Data Not Available		
Smolt Productivity (smolts/spawner)	Data Not Available		

6.1.4.3. Hatchery Spawning

Total returns to the Cowlitz River offer a relative metric of performance; from 2007-2008 and 2013-2017, a mean of 12,964 hatchery-origin adults from the Lower Cowlitz Subbasin Hatchery Program returned to the Cowlitz River (Figures 6.1-2 and 6.1-3; Table 6.1-1). Of those, 69% were harvested, 30% returned to Cowlitz Salmon Hatchery, and less than 2% returned to the Lower Cowlitz Subbasin spawning grounds (Figures 6.1-2 and 6.1-3; Table 6.1-1).

6.1.4.4. Hatchery Rearing

From 2007-2008 and 2013-2017, a mean of 280 hatchery-origin winter steelhead were collected for broodstock (Table 6.1-2). Mean pre-spawn survival was 88% and a mean of 246 of those collected were spawned, of which a mean of 47% were females. A mean of 11 natural-origin broodstock were collected annually from 2007-2008 and 2013-2017 at tributary weirs in the Lower Cowlitz Subbasin for use as broodstock. However, none were collected until 2013, when the Integrated Hatchery Program was initiated.

From 2007-2008 and 2013-2017, an estimated mean of 653,756 green eggs were collected at Cowlitz Salmon Hatchery from a mean of 119 females (Table 6.1-2). Mean fecundity was 5,493 green eggs; however, neither the annual fertility rate nor the number of eyed eggs are provided in ISIT. From brood years 2007-2008 and 2013-2017, a mean of 441,837 smolts were released. Mean green egg-to-smolt survival for these brood years was 69%.

6.1.4.5. Age Composition

As noted above for natural-origin steelhead, age composition cannot be completely calculated from the data in ISIT because they are not compiled by age or brood year. Age classes are only characterized as jacks or adults and these data are only available for returns to Cowlitz Salmon Hatchery, not for any other recovery locations. Moreover, ISIT does not define the length criteria by which jacks and adults are discriminated. Nonetheless, from 2007-2008 and 2013-2017, less than 1% of the hatchery-origin winter steelhead that returned to Cowlitz Salmon Hatchery were identified as jacks. Fish used for broodstock are sampled for scales so age can be estimated.

6.1.5. Proportionate Natural Influence

PNI is a useful metric for monitoring both hatchery and natural populations. Changes in PNI can indicate an increase or decrease in the effect of hatchery-origin steelhead on the natural population.

From 2007-2008 and 2013-2017, a mean of 753 winter steelhead spawned in the Lower Cowlitz Subbasin, excluding than the Toutle and Coweeman rivers (Figures 6.1-2 and 6.1-3; Table 6.1-1). Of those, a mean of 219 were hatchery-origin and 533 were natural-origin. Mean spawner pHOS was 0.31, ranging from 0.09-0.73. Prior to 2013, no natural-origin winter steelhead were used as broodstock, so both pNOB and PNI during that period were equal to 0. The Integrated Hatchery Program began in 2013, and pNOB has ranged from 0.01-0.11 (mean = 0.05) over the most-recent 5-year period (2013-2017), while PNI has ranged from 0.05-0.47 (mean = 0.22). Over the same 2012-2017 period, pHOS has declined to a mean of 0.23.

6.1.6. Future Management

The Lower Cowlitz Subbasin winter steelhead population is designated as a Contributing population for meeting MPG and DPS recovery goals, with a minimum abundance target of 400 natural-origin spawners in nature. Population viability was rated as Low (LCFRB 2010, WDFW and LCFRB 2016), but natural-origin abundance has improved and the minimum abundance target was exceeded annually from 2013-2016. Although the target was not met in 2007, 2008, or 2017 and natural-origin abundance data are unavailable for 2009-2012, the most-recent (2013-2017) 5-year mean was 645, so this population may be meeting its recovery goal for abundance. Likewise, the most-recent 5-year (2013-2017) mean pHOS was 0.23, suggesting that this population is meeting the HSRG standard of pHOS <0.3 for hatchery influence in a Contributing population with an integrated hatchery program. However, natural influence on the hatchery program remains low; mean pNOB from 2013-2017 was only 0.05, well below the HSRG standard of >0.3, and the resulting mean PNI was only 0.22, well below the HSRG standard of >0.5.

Going forward, the goals and plans for this program are responsive to the current status of the population and are described in the following sections. The program will focus on exceeding the recovery target for abundance, with a high PNI (>0.5) and low pHOS (<0.3). In addition, we will maintain a fishery for hatchery-origin winter steelhead while minimizing the impacts on natural-origin winter steelhead in subbasin tributaries. The plan to accomplish these goals is to shift some Integrated Hatchery Program production from the Lower Cowlitz Subbasin to the Upper Cowlitz Subbasin, and potentially to a Segregated Hatchery Program for the Lower Cowlitz Subbasin.

6.1.6.1. Goals for Conservation and Recovery

Progress toward achieving conservation and recovery goals is evaluated through monitoring of standard fisheries management metrics (Table 6.1-4; Appendix A, Full Big Table). The Lower Cowlitz Subbasin winter steelhead population had an historical escapement of about 1,400 natural-origin winter steelhead and has a recovery goal of 400 natural-origin spawners in nature (LCFRB and WDFW 2016). In 2010, abundance and productivity of this population were rated as Low (LCFRB 2010). While on the verge of meeting the abundance recovery goal for natural-origin spawners (Figure 6.1-3; Table 6.1-1), hatchery influence on the population remains high. Hatchery reform and optimization form the basis of making progress toward conservation and recovery goals.

- **Long-term Goals:** The goal for this Contributing winter steelhead population is full recovery and continued support of recreational/harvest opportunity, which would include, but not be limited to, the following actions.
    - Prioritizing ESA recovery over harvest, while still promoting harvest opportunity.
    - Reducing or eliminating late-run hatchery-origin Lower Cowlitz Subbasin winter steelhead.
        - This will support minimizing or eliminating the removal of natural-origin winter steelhead from Lower Cowlitz Subbasin tributaries for use as broodstock.
        - Shifting production to Upper Cowlitz Subbasin winter steelhead would prioritize recovery of that population.
    - Increasing recreational/harvest opportunity in the Lower Cowlitz Subbasin by adjusting the Segregated Summer Steelhead Hatchery Program and exploring the possibility of developing an Early-winter Hatchery Program that is consistent with recovery goals.
    - Exploring termination of the Lower Cowlitz Subbasin Late-winter Steelhead Hatchery Program relative to meeting recovery goals. HSRG standards for a Contributing population with an integrated hatchery program are pHOS <0.3 and PNI >0.5, requiring pNOB >0.3. However, increasing pNOB would likely require increased mining of natural-origin

broodstock from tributaries, a measure that is inconsistent with the goal of increasing the abundance of natural-origin spawners in the Lower Cowlitz Subbasin.

  - Developing an early-winter steelhead program to more closely emulate historic run timing of winter steelhead. This action advances Local Adaptation of populations and increases duration of harvest opportunity.

- **FHMP Goals:** Program goals for the period covered by this FHMP are attainable steps toward population recovery. The goals for the Lower Cowlitz Subbasin winter steelhead population are to:
  - Maintain natural-origin spawner abundance >400 in the Lower Cowlitz Subbasin (Table 6.1-3).
  - Define the triggers or thresholds for moving from one stage of recovery to another (e.g., abundance, spatial distribution) while considering various recovery strategies.
  - Define the disposition of surplus winter steelhead and management strategies for high and low return years.
  - Identify a strategy to assess pHOS in the mainstem lower Cowlitz River.
  - Assess the current strategy for monitoring of natural spawning steelhead in the Lower Cowlitz Subbasin.
  - Increase and improve monitoring, evaluation, and data collection, including numbers and age, sex, and origin of all recoveries:
    - Returning to Cowlitz Salmon Hatchery.
    - Retained as broodstock.
    - Transported and released upstream of Mayfield Dam.
    - Hatchery surplus.
    - Hatchery strays to/from outside of the Cowlitz Basin.
    - Actual spawners in nature.
    - Natural smolts produced.
  - Emphasize natural-origin spawners in nature and hatchery-origin return to Cowlitz Salmon Hatchery as key population metrics for winter steelhead.
  - Reduce the abundance of hatchery surplus by increasing hatchery-origin harvest without increasing natural-origin exploitation rate.

Table 6.1-3. Recovery phase targets for Lower Cowlitz Subbasin winter steelhead.

Species:	Winter Steelhead
Population Name:	Lower Cowlitz Subbasin
Recovery Designation:	Contributing
Current Recovery Phase:	Local Adaptation

	RECOVERY PHASE				
Target Metric	Preser-vation	Recolon-ization	Local Adaptation	Fully Recovered	Last 5 Years
Natural Production					
Natural-origin Spawners in Nature	?	?	?	400	645
Smolt Abundance (below hatchery)	?	?	?	?	?
Smolt Passage Survival	N/A	N/A	N/A	N/A	N/A
Productivity (5-year mean)	>1	>1	>1	>1	?
Hatchery Production					
Type of Hatchery Program	Int/Seg	Int/Seg	Int	Int	Int
Broodstock to be Collected	?	?	?	?	?
Integrated Hatchery Program	?	?	?	?	?
Hatchery-Origin	?	?	?	?	?
Natural-Origin	?	?	?	?	?
Segregated Hatchery Program	?	?	?	?	?
Smolts to be Produced	?	?	?	?	?
Integrated Hatchery Program	?	?	?	?	?
Segregated Hatchery Program	?	?	?	?	?
Total Smolt-to-Adult Survival	?	?	?	?	?
Proportionate Natural Influence					
pHOS (<)					
Total	0.3	0.3	0.3	0.3	0.23
Integrated Hatchery Program	0.3	0.3	0.3	0.3	0.23
Segregated Hatchery Program	0.1	0.1	0.1	0.1	NA
pNOB (>)	0.3	0.3	0.3	0.3	0.05
PNI (>)	0.5	0.5	0.5	0.5	0.22
Max % of Natural-Origin Return to Cowlitz Salmon Hatchery Collected for Broodstock	%	%	%	%	NA

Table 6.1-4. Current values (5-year mean) and FHMP and long-term (recovery) goals for key monitoring metrics for Lower Cowlitz Subbasin winter steelhead.

Metric		Current (5-Year Mean)	FHMP Goal	Long-Term (Recovery Plan)
Total Adult Abundance		#	#	#
	Hatchery-origin	#	#	#
	Natural-origin	#	#	#
Total Adult Abundance to Mouth of Cowlitz River		#	#	#
	Hatchery-origin	#	#	#
	Natural-origin	#	#	#
Hatchery Broodstock (spawned; all ages)		#	#	#
	Hatchery-origin	# (not %)	# (not %)	# (not %)
	Natural-origin	# (not %)	# (not %)	# (not %)
	pNOB (Effective = spawned)	proportion	>0.3	1
Adult Spawners in Nature		# (not %)	# (not %)	# (not %)
	Hatchery-origin	# (not %)	# (not %)	# (not %)
	Natural-origin	# (not %)	# (not %)	# (not %)
	pHOS (Effective = spawners in nature; all ages)	proportion	<0.3	<0.1
PNI (Effective)		proportion	>0.5	>0.9
Smolt Abundance		#	#	#
	Hatchery-origin (smolts released)	#	#	#
	Natural-origin	#	#	#
Smolt Collection Efficiency/Passage Survival		N/A (%)	N/A (%)	N/A (%)
Smolt-to-Adult Survival (to hatchery/ spawning grounds; excluding Jacks)		%	%	%
	Hatchery-origin	%	%	%
	Natural-origin	%	%	%
		if not available, presumed to be higher than hatchery-origin		
Mean Age		#	#	#
	Hatchery-origin	#	#	#
	Natural-origin	#	#	#
Jacking rate		%	%	%
	Hatchery-origin	%	%	%
	Natural-origin	%	%	%
Natural-origin Productivity				
	Smolts/spawner	ratio	>1 No decrease? Density dependence?	
	Adults + Jacks/spawner	ratio	>1 No decrease? Density dependence?	
Total Harvest (from all fisheries)		#	#	#
	Hatchery-origin	#	#	#
	Natural-origin	#	#	#
Harvest (% of total adult + jack return)		%	%	%
	Hatchery-origin	%	%	%
	Natural-origin	%	%	%

6.1.6.2. Management Targets

The primary factor inhibiting progress toward conservation goals for this population is hatchery influence on the natural-origin segment of the population. An excess of hatchery-origin winter steelhead spawn naturally in the Lower Cowlitz Subbasin, despite the presence of weirs in several tributaries. In addition, while natural-origin steelhead may not be retained in the ocean, Columbia River, or Lower Cowlitz Subbasin fisheries, incidental catch and associated mortality reduce the number available to spawn. Information regarding losses of natural-origin steelhead is limited to an assumed rate of 2% provided in ISIT.

- **Natural Production:** The goal of population restoration is to develop self-sustaining, naturally reproducing population. Activities by Tacoma Power to protect and enhance habitat in the Lower Cowlitz Subbasin are expected to benefit smolt production and the subsequent return of natural-origin winter steelhead, but the current monitoring program is insufficient to evaluate the effectiveness of those efforts. Counts of winter steelhead returning to the hatchery are reliable, while estimates of harvest, returns to spawning grounds, and spawners in nature have wide variances because of low sampling rates. As part of this FHMP, Tacoma Power will develop and begin to implement a rigorous monitoring program that is focused on evaluating program effectiveness based on regionally accepted VSP parameters.
- **Abundance – Natural Spawning:** Recent data indicate that the Lower Cowlitz Subbasin winter steelhead population is approaching its recovery goal of 400 natural-origin spawners in nature. However, two issues confound accurately estimating the abundance of the population. First, some steelhead spawning in nature are missed because not all tributaries are surveyed, and no surveys are conducted in the mainstem Cowlitz River, where some steelhead spawning likely occurs. Secondly, we cannot determine the origin of some unmarked winter steelhead returning to the Cowlitz River; specifically, we cannot distinguish between those from the Lower Cowlitz and Tilton subbasins or any other source of unmarked winter steelhead. For management purposes, all unmarked/untagged (assumed to be natural-origin) steelhead that are captured at Cowlitz Salmon Hatchery are considered to be from the Tilton Subbasin because they have migrated past the spawning reaches in the Lower Cowlitz Subbasin and lack the CWT identifying them as originating from the Upper Cowlitz Subbasin. While it is possible that some did come from the Tilton Subbasin, we cannot know for certain, and some likely originated from the Lower Cowlitz Subbasin (and simply wandered too far upstream while exploring suitable spawning areas) or strayed from some other location. It is also likely that some Upper Cowlitz or Tilton Subbasin winter steelhead remain below Cowlitz Salmon Hatchery.

  Going forward, we will focus our monitoring of abundance on documenting the total number of hatchery- and natural-origin spawners, their respective pre-spawn mortality rates, and pHOS. These metrics are critical for achieving recovery, and the number of spawners is used to calculate recruits/spawner.
- **Smolts Produced in Nature:** Natural-origin smolt production from the Lower Cowlitz Subbasin is unknown and cannot be estimated at present. Smolt monitoring in the Lower Cowlitz Subbasin is conducted using a screw trap in the mainstem Cowlitz River and is difficult because of the large size of the river. Additionally, the presence of unmarked winter steelhead smolts from the Tilton Subbasin, which cannot be discerned from those from the Lower Cowlitz Subbasin, further confounds these estimates. Increasing collection efficiency at Mayfield Dam will help to distinguish production from the Lower Cowlitz Subbasin. Given the challenges of monitoring the mainstem Cowlitz

River, estimating smolt production from the Lower Cowlitz Subbasin would require capturing smolts as they leave the tributaries, but monitoring individual tributaries is logistically daunting because of the number that must be monitored.

- **Smolt-to-Adult Survival:** Because smolt abundance is not estimated and returns are not documented by age, SAR cannot be estimated. This metric is important but less critical for monitoring natural populations than for hatchery populations. We will monitor this index as the data become available, through our M&E Program.
- **Productivity (Recruits/Spawner):** Because returns are not documented by age, productivity also cannot be estimated. Productivity (mature natural-origin F_1 recruits/F_0 spawner) is the primary metric for monitoring natural populations, so collection of the necessary data is critical. We will monitor this index as data become available through our M&E Program.
- **Hatchery Production:** Despite the use of natural-origin broodstock since 2013, pNOB and PNI do not meet HSRG standards for minimizing hatchery influence on natural populations. Therefore, we will shift the focus in integrated hatchery production of winter steelhead from the Lower Cowlitz Subbasin to other populations. Natural-origin winter steelhead returning to Cowlitz Salmon Hatchery will be transported upstream to the Upper Cowlitz Subbasin (if coded-wire-tagged) or the Tilton Subbasin (if untagged/dorsal-sinus coded-wire-tagged). A portion of these tagged and untagged natural-origin winter steelhead will be retained as broodstock to support recovery of their respective populations upstream of Mayfield Dam. Natural-origin winter steelhead will no longer be collected from Lower Cowlitz Subbasin tributaries to support the Integrated Lower Cowlitz Subbasin Hatchery Program. Rather, these steelhead will be allowed to spawn naturally with the anticipated, albeit indirect, effect of reducing pHOS in the Lower Cowlitz Subbasin.
- **Abundance:** The Cowlitz Trout Hatchery Winter Steelhead Program produced a mean annual return to the Cowlitz River of 12,964 adult hatchery-origin steelhead from 2007-2008 and 2013-2017. Based on our anticipated modifications to the Integrated Hatchery Program, we will develop production goals going forward to meet the recovery targets for abundance of natural-origin adults spawning in the Lower Cowlitz Subbasin, recovery targets for hatchery influence, as well as harvest targets. Because information on harvest outside of the Lower Cowlitz Subbasin is lacking, estimates of total run size cannot be developed for recent years. Going forward, we will focus our monitoring of abundance on the numbers that are harvested and that return to the Cowlitz River and to Cowlitz Salmon Hatchery, which are critical for calculating SAR and TSAR, as well as the number that remain to spawn in nature, used for pHOS and PNI calculations.
- **Broodstock Collection and Spawning:** Mining of natural-origin broodstock from tributaries in the Lower Cowlitz Subbasin reduces the number of natural-origin spawners in nature which, indirectly, increases pHOS. We will no longer collect broodstock in this manner, rather shifting implementation of the Winter Steelhead Integrated Hatchery Program to collection of natural-origin broodstock from returns to Cowlitz Salmon Hatchery. This will effectively terminate the Integrated Hatchery Program for Lower Cowlitz Subbasin winter steelhead. Thus, the Integrated Hatchery Program will shift to focus on supplementing recovery of the Upper Cowlitz and Tilton Subbasin winter steelhead populations, while also providing harvest opportunity in the Cowlitz Basin, including in the Lower Cowlitz Subbasin.

  We will collect all broodstock from salmonids that return to Cowlitz Salmon Hatchery and ensure that both male and female natural-origin genotypes are incorporated into the broodstock for the Integrated Hatchery Program. Initially, when low abundance of natural-origin returns constrains natural-origin broodstock collection and spawning decisions, the percentage of natural-origin returns to Cowlitz Salmon Hatchery collected for broodstock may not exceed 30%.

We will employ hatchery best management practices for broodstock collection and spawning to ensure that the broodstock represents the entire population in age and run timing and to maximize genetic diversity of the F_1 generation. We will use spawning matrices for all hatchery spawning. Hatcheries, especially those with a conservation mandate, should use spawning matrices in which the gametes from every individual are mixed (approximately evenly) with those of at least two individuals of the opposite sex (Campton 2004).

- **Smolt Production:** Winter steelhead hatchery-origin smolts will be reared at Cowlitz Trout Hatchery. The production goals for the Integrated Winter Steelhead Hatchery Program will be determined during the first year of the FHMP, but ultimately all winter steelhead smolt production will come from the Integrated Hatchery Program. We will develop, test, and evaluate different rearing and release strategies to develop an optimum strategy for this population.
- **Smolt-to-Adult Survival:** SAR is the primary metric for monitoring hatchery populations, especially those for which return abundance is lower than expected. However, because returns are not documented by age, SAR cannot currently be estimated. To support calculations of SAR, rigorous estimates of the returns of hatchery-origin steelhead by age class are needed. To do so, we will collect scales and/or CWTs from at least a sample of recoveries at all collection sites. Additional data need to include the rate of precocious maturation and the sex ratio of hatchery-origin steelhead by age. We will monitor this index as the data become available, through our M&E Program.
- **Productivity:** Population productivity (number of F_1 generation recruits that survive to spawn for each F_0 generation spawner) is of less importance, but is still useful, for monitoring hatchery populations, where survival to the smolt stage is unnaturally high. Once production goals for the Integrated Hatchery Program are established, we will estimate the number of winter steelhead recruited to the maturing/mature population per F_0 spawner to evaluate whether production goals are being met. Because ISIT does not provide age composition of returns, productivity estimates are currently unavailable. Expanded data collection to include age at all collection sites will support calculations of productivity and monitoring of this metric over time through our M&E Program.
- **Strays and Spawning in Nature:** Only about 2% of hatchery-origin winter steelhead entering the Cowlitz River are recovered on the natural spawning grounds in the Lower Cowlitz Subbasin. However, this estimate is based only on hatchery-origin steelhead identified as having spawned in monitored streams in the Lower Cowlitz Subbasin, so it is likely a low estimate for three reasons. First, hatchery-origin winter steelhead are captured at weirs on Delameter, Lacamas, Olequa, and Ostrander creeks and removed. The ultimate destination of these salmonids, had they not been captured, is unknowable, but some of them likely would have remained to spawn in nature and should be considered strays. Second, other tributaries to the Lower Cowlitz Subbasin are not monitored, where hatchery-origin strays have likely spawned. The number of natural-origin and hatchery-origin winter steelhead spawning in these streams is also unknown, but the proportion may be similar to that of those captured and removed from the weirs. Lastly, there has been no accounting for hatchery-origin winter steelhead that stray to

other spawning locations, outside of the Cowlitz Basin. To get an accurate estimate of the true stray rate, these winter steelhead (probably a small number, but we do not know) must also be accounted for. Conversely, hatchery-origin steelhead that spawn in Blue Creek (which passes through the grounds of Cowlitz Trout Hatchery) or immediately below the hatchery ladder are also considered strays. Implementation of expanded spawning surveys, as well as examining CWT data for strays outside of the Cowlitz Basin from the Upper Cowlitz Subbasin Hatchery Program (started 2018), will improve data collection and rigor for estimating stray rates and our understanding of the biology and management of these steelhead.

- **Surplus:** A surplus of hatchery-origin winter steelhead returning to the Cowlitz River can affect the viability of the natural-origin population if a sufficient number of them remain to spawn in nature and increase pHOS. Our goal is to maximize the harvest of hatchery-origin winter steelhead, but if hatchery-origin winter steelhead are going to spawn in nature, we would prefer that they came from an integrated program, hence the priority to advance that program.
- **Harvest:** A mean of 52% of the combined Lower Cowlitz Subbasin winter steelhead returning to the Cowlitz River are harvested each year in the Lower Cowlitz Subbasin. The majority (53%) of hatchery-origin returns are harvested compared to only 2% of natural-origin returns. Harvest of hatchery-origin steelhead would ideally be as high as possible to reduce pHOS, while still allowing sufficient broodstock. While a 2% natural-origin harvest is low, this value is only based on an assumed rate used in ISIT that reflects the limit of ESA impacts. Empirical harvest rates on natural-origin steelhead (whether greater or smaller) would provide clearer guidance for management decisions. Of the remaining hatchery-origin steelhead entering the Cowlitz River, 46% return to Cowlitz Salmon Hatchery; the remaining 1% return to spawning grounds in the Lower Cowlitz Subbasin. While this is a small percentage, the number of hatchery-origin returns to the spawning grounds from 2007-2008 and 2013-2017 (mean = 219) is on the same order of magnitude as the number of natural-origin spawning ground returns (mean = 533). The vast majority of hatchery fish encountered have been in Blue Creek (the tributary leading to the Cowlitz Trout Hatchery).

  To clearly understand harvest rates on Lower Cowlitz Subbasin winter steelhead, hatchery-origin harvest outside of the Cowlitz Basin will be monitored using the CWT recovery and sampling rate data in the RMIS and robust creel surveys. Harvest in the Cowlitz Basin will be monitored with rigorous creel surveys.
- **Proportionate Natural Influence:** We propose to increase the influence of the natural environment on the Lower Cowlitz Subbasin winter steelhead population by no longer mining natural-origin broodstock from Lower Cowlitz Subbasin tributaries, allowing these steelhead to spawn naturally in the subbasin, which will decrease pHOS and increase PNI.
- **Age Composition:** From 2007-2008 and 2013-2017, less than 1% of the hatchery-origin winter steelhead that returned to Cowlitz Salmon Hatchery were identified as jacks. As long as we can keep pHOS low, the natural-origin population will likely also produce a low percentage of jacks.

6.1.6.3. Monitoring and Evaluation (M&E) and Research

Baseline Monitoring

Monitoring and evaluation needs for the Lower Cowlitz Subbasin winter steelhead population are similar to other populations in the basin and include spawning ground surveys, accurate counts of hatchery releases and returns of both hatchery- and natural-origin steelhead, adequate marking, and evaluation of alternative management and hatchery rearing strategies. To support recovery, our monitoring programs need to be rigorous and to allow for estimation, with greater confidence, of population abundance, as well as to identify ways to improve survival. The following are areas of improvement that are specific to this population:

- Estimating harvest rates of hatchery- and natural-origin salmonids in all fisheries.
- Estimating hatchery- and natural-origin escapement to the Lower Cowlitz Subbasin.
- Estimating hatchery- and natural-origin escapement to Lower Cowlitz Subbasin spawning areas, spawners in nature, and pre-spawning mortality.
- Documenting hatchery- and natural-origin returns to Cowlitz Salmon Hatchery;
- Documenting numbers of winter steelhead collected for hatchery broodstock and spawned.
- Estimating pHOS, pNOB, and PNI.
- Estimating natural-origin population productivity (spawner-to-spawner).
- Estimating hatchery-origin smolt production and SAR.

Directed Studies

Directed studies are designed to diagnose and solve problems associated with achieving FHMP goals and to fill management needs and information gaps in the Big Table (Table 6.1-4; Appendix A). Important areas of study for the Lower Cowlitz Subbasin winter steelhead population include:

- **Juvenile rearing capacity studies:** Available habitat and habitat-specific (run/riffle/pool) densities.
- **Hatchery program studies:** Size at release, time of release, growth rates, broodstock collection, and spawning protocols.
- **Early life stage survival studies:** Egg to fry, fry to parr, and parr-to-smolt survival rates.
- **In-river migratory survival and behavior:** Survival of migrating juveniles and movement rates.
- **Hatchery supplementation experiments:** Assessing the impact of returning hatchery-origin adults.
- **Hatchery practices:** Examining the size and timing of release, growth rate in hatchery, broodstock collection techniques, and spawning protocols.
- **Hatchery fish performance:** Identify the source and potential solutions to solving prevalent and persistent diseases within hatchery steelhead programs.

6.1.7. Summary

- Rather than removing natural-origin spawners from the Lower Cowlitz Subbasin to use as broodstock in supporting the Integrated Hatchery Program, those steelhead will be left to spawn naturally. Instead, the Integrated Hatchery Program will rely on natural-origin steelhead returning to Cowlitz Salmon Hatchery, and the focus will be on recovery of the Upper Cowlitz and Tilton Subbasin winter steelhead populations through supplementation from the Integrated Hatchery Program.
- Hatchery-origin steelhead have been planted in the Cowlitz Basin since 1957. This has included planting of stocks of both in-basin and out-of-basin origin with considerably different run-timing (summer and early-winter run) that is dramatically different from the indigenous late-winter run stock.
- Natural-origin spawner abundance in the Lower Cowlitz Subbasin is approaching the recovery/management goal of 400. However, the Integrated Hatchery Program is not meeting all HSRG standards for hatchery influence (pNOB is <0.3 and PNI is <0.5).
- Eliminating the collection of natural-origin broodstock from the Lower Cowlitz Subbasin will effectively terminate the hatchery program for the Lower Cowlitz Subbasin winter steelhead population. To provide additional harvest opportunity and promote Local Adaptation of the other two populations, we will explore options for establishing an early-winter run of steelhead. In addition, we will adjust the summer run steelhead program to further increase recreational/harvest opportunity.
- Goals for the period covered by this FHMP are to:
    - Maintain natural-origin spawner abundance >400 in the Lower Cowlitz Subbasin (Table 6.1-3).
    - Define the triggers or thresholds for moving from one stage of recovery to another (e.g., abundance, spatial distribution) while considering various recovery strategies.
    - Define the disposition of surplus winter steelhead and management strategies for high and low return years.
    - Increase and improve monitoring, evaluation, and data collection, including numbers and age, sex, and origin of all recoveries.

Intentionally blank page

Population: Upper Cowlitz Subbasin Winter Steelhead *Oncorhynchus mykiss*

Evolutionarily Significant Unit:	Cascade Winter Steelhead Lower Columbia River Steelhead DPS Lower Columbia River Salmon Recovery Region
ESA Listing Status:	Threatened Listed in 1998, revised 2006, reaffirmed in 2011 and 2016
Population Recovery Designation:	Primary
Population Viability Rating:	
Baseline	Very Low
Objective	High
Recovery Goal:	1,000 natural-origin steelhead spawning in the Upper Cowlitz Subbasin (500 in both the Cispus and upper Cowlitz rivers)
Current Recovery Phase:	Recolonization
Current Hatchery Program(s):	Cowlitz Trout Hatchery Winter Steelhead Integrated Hatchery Program, 118,000 smolts
Proposed Hatchery Program(s)	Cowlitz Trout Hatchery Winter Steelhead Integrated Hatchery Program, 236,000

6.2. Winter Steelhead: Upper Cowlitz Subbasin Population

6.2.1. Purpose

This section describes the current status of the Upper Cowlitz Subbasin winter steelhead population, based on recent and available data. We identify VSP metrics needed to evaluate the status of this population with regard to recovery under ESA guidelines. Where appropriate, we propose changes to both hatchery and monitoring programs to facilitate progress toward population recovery and our evaluation of that progress. The Upper Cowlitz Subbasin winter steelhead population is currently in the Recolonization phase of recovery. As a Primary population for recovery of the lower Columbia River steelhead DPS, we will prioritize recovery of this population, while still allowing for recreational/harvest opportunity, by increasing the abundance of natural- and hatchery-origin winter steelhead in the Upper Cowlitz Subbasin. In addition, we will evaluate opportunities and develop a plan to increase early run timing for the population so that it more closely emulates the historic run timing of winter steelhead and increases recreation/harvest opportunity.

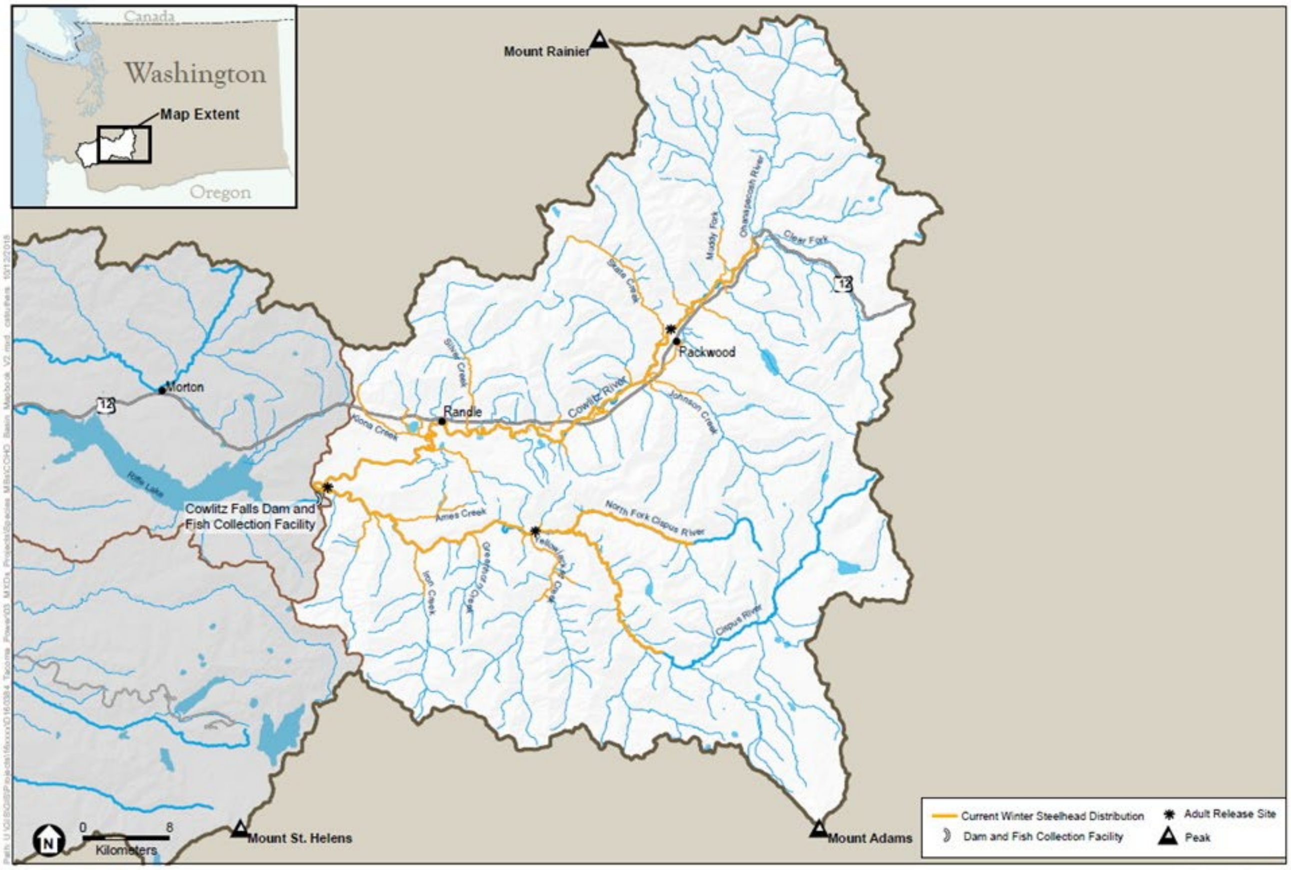
During the period covered by this FHMP, we will continue to produce at least 118,000 smolts from the Upper Cowlitz Subbasin Integrated Hatchery Program and continue to release hatchery-origin steelhead spawners from this program upstream of Cowlitz Falls Dam. As downstream fish passage survival continues to improve and increasing numbers of natural-origin adults return, we will reduce the number of hatchery-origin adults released upstream of Cowlitz Falls Dam to reduce hatchery influence on the natural-origin population. We will also continue to evaluate the hatchery program and fisheries management, and make refinements or adjustments, as described in this FHMP, to effectively supplement and manage the Upper Cowlitz Subbasin winter steelhead population.

6.2.2. Population Description

The Upper Cowlitz Subbasin winter steelhead population includes all natural-origin winter steelhead that occupy the Cowlitz River and its tributaries upstream of Cowlitz Falls Dam (Upper Cowlitz and Cispus subbasins; Figure 6.2-1). Closure of Mayfield Dam in 1963 and the subsequent termination of transport of steelhead above the dams in 1968 resulted in the extirpation of the steelhead populations in the Cispus and upper Cowlitz rivers and the aggregation of their genes into the existing Lower Cowlitz Subbasin population or into a residualized Rainbow Trout population in the Upper Cowlitz Subbasin. These upper river populations are now considered to be at Very High risk of extinction (LCFRB 2010).

The Lower Cowlitz Subbasin winter steelhead population has persisted and has been used as the genetic source for reintroductions to the Upper Cowlitz Subbasin (Cispus and upper Cowlitz rivers) since transport of mature steelhead to the Upper Cowlitz Subbasin resumed in 1994. The Upper Cowlitz Subbasin winter steelhead population, as part of the lower Columbia River DPS, was listed as threatened under the ESA in 1998. NMFS (2016) reaffirmed the threatened status of the DPS, which remains at “moderate risk” of extinction. They cite the passage program in the Cowlitz Basin as having the potential to provide considerable improvements in abundance and spatial structure. NMFS (2016) also states that, while reintroduction efforts have not yet produced a self-sustaining population, “recent low winter-run returns to the upper Cowlitz River may be anomalous, related more to the development of an integrated hatchery broodstock and temporary modifications at the Cowlitz Falls Dam to benefit Chinook salmon than to a decline in viability”. Because this population is classified as a Primary population for recovery of the lower Columbia River DPS, it must attain its recovery and viability goals for the DPS to be considered recovered (LCFRB 2010).

The Upper Cowlitz Subbasin winter steelhead population is currently supplemented by the Winter Steelhead Integrated Hatchery Program. The current goal is for the Integrated Hatchery Programs for this population and the Lower Cowlitz and Tilton subbasin populations to be managed separately. However, during years when Upper Cowlitz and/or Tilton subbasin returns are low, these programs have consistently incorporated hatchery-origin returns from the Lower Cowlitz Subbasin. In contrast, the Summer Steelhead Segregated Hatchery Program, which is confined to the Lower Cowlitz Subbasin, is consistently managed separately from all winter steelhead hatchery programs. The Upper Cowlitz Subbasin Integrated Hatchery Program releases yearling smolts directly from Cowlitz Trout Hatchery into the lower Cowlitz River each spring. In addition, mature steelhead of both hatchery- and natural-origin are transported and released upstream of Cowlitz Falls Dam to spawn naturally. Currently, steelhead spawning in the Upper Cowlitz Subbasin occurs in the mainstem and tributaries of the upper Cowlitz and Cispus rivers (LCFRB 2010).



SOURCE: SWIFD, 2014; WDNR, 2017 Tacoma Power

Figure 6.2-1. Distribution of winter steelhead in the Upper Cowlitz Subbasin.

6.2.3. Natural Production

Two critical monitoring metrics for steelhead management are the numbers that return at maturation and their disposition (Figure 6.2-2; Table 6.2-1). Upper Cowlitz Subbasin winter steelhead that survive to maturity may be harvested in commercial, sport, or tribal fisheries in the ocean, lower Columbia River, or lower Cowlitz River. Those escaping harvest may return to Cowlitz Salmon Hatchery or remain on the natural spawning grounds in the Lower Cowlitz Subbasin. Natural-origin winter steelhead from the Upper Cowlitz Subbasin that are collected at Cowlitz Salmon Hatchery may be retained for broodstock or transported above Cowlitz Falls Dam for release, along with some hatchery-origin winter steelhead, where they may be harvested, die prior to spawning from predation or disease, or survive to spawn naturally. Monitoring these dispositions allows us to evaluate population health, productivity, and progress toward recovery.

6.2.3.1. *Abundance*

The recovery goal for the Upper Cowlitz Subbasin winter steelhead population is an annual abundance of 1,000 natural-origin steelhead spawning in nature, 500 in each the Cispus and upper Cowlitz rivers (LCFRB 2010). Only natural-origin winter steelhead that were released into the Upper Cowlitz Subbasin and survive to spawn are counted toward the recovery goal.

Table 6.2-1. Mean, minimum, and maximum numbers of all hatchery- and natural-origin adult winter steelhead from the Upper Cowlitz Subbasin population that could be accounted for at recovery locations 2012-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Origin and Recovery Location	Mean	Minimum	Maximum
Hatchery-origin			
Total Run[1]	Not All Data Are Available		
Harvest[2]	Not All Data Are Available		
Ocean harvest	Data Not Available		
Columbia River harvest	Data Not Available		
Lower Cowlitz River harvest	Data Not Available		
Upper Cowlitz Subbasin harvest	56	0	149
Total Return to Cowlitz River[3]	Not All Data Are Available		
Return to Cowlitz Salmon Hatchery	187	0	369
Collected for Broodstock	27	0	61
Transported above Cowlitz Falls Dam	161	0	331
Remain in Upper Cowlitz Subbasin	105	0	256
Natural-origin			
Total Run[1]	Not All Data Are Available		
Harvest[2]	Not All Data Are Available		
Ocean harvest	Data Not Available		
Columbia River harvest	Data Not Available		
Lower Cowlitz River harvest	Data Not Available		
Upper Cowlitz Subbasin harvest	Data Not Available		
Total Return to Cowlitz River[3]	Not All Data Are Available		
Return to Cowlitz Salmon Hatchery	297	31	672
Collected for Broodstock	62	7	92
Transported above Cowlitz Falls Dam	235	24	580
Remain in Upper Cowlitz Subbasin	Data Not Available		
Combined Hatchery- and Natural-origin			
Total Run[1]	Not All Data Are Available		
Harvest[2]	Not All Data Are Available		
Ocean harvest	Data Not Available		
Columbia River harvest	Data Not Available		
Lower Cowlitz River harvest	Data Not Available		
Upper Cowlitz Subbasin harvest	Data Not Available		
Total Return to Cowlitz River[3]	Not All Data Are Available		
Return to Cowlitz Salmon Hatchery	484	321	686
Collected for Broodstock	88	68	113
Transported above Cowlitz Falls Dam	396	253	580
Remain in Upper Cowlitz Subbasin	Not All Data Are Available		

[1] Sum of all harvest below Cowlitz Salmon Hatchery plus numbers returning to Cowlitz Salmon Hatchery.
[2] Total of harvest in ocean, Columbia River, Lower Cowlitz Subbasin, and Upper Cowlitz Subbasin fisheries.
[3] Sum of Lower Cowlitz Subbasin harvest plus number returning to Lower Cowlitz Subbasin spawning grounds, and Cowlitz Salmon Hatchery (hatchery-origin) or collected at weirs for broodstock (natural-origin).

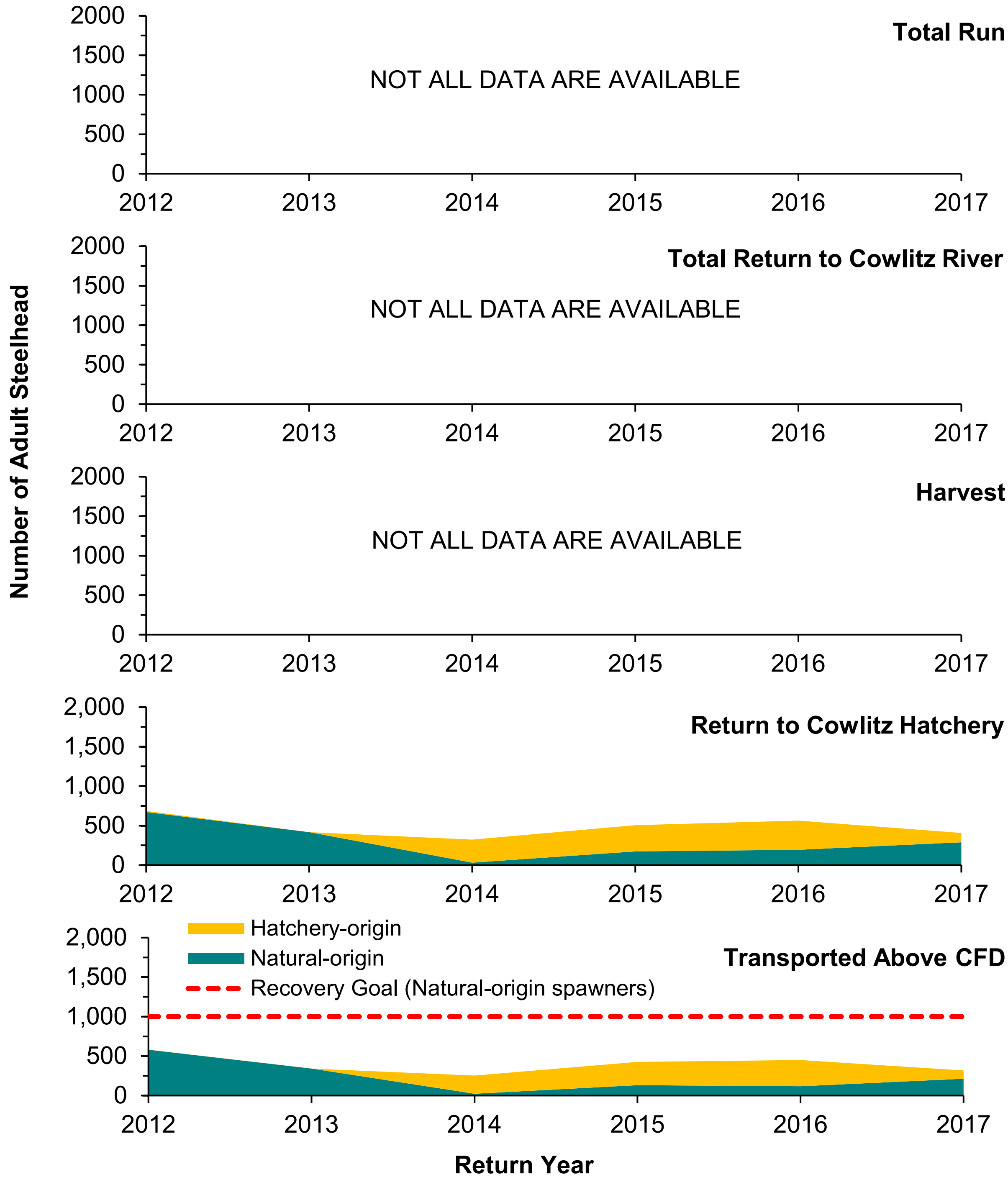


Figure 6.2-2. Total run size of hatchery- (Integrated Hatchery Program) and natural-origin Upper Cowlitz Subbasin winter steelhead and numbers that returned to the Cowlitz River, were harvested, returned to the Cowlitz Salmon Hatchery, or were transported upstream of Cowlitz Falls Dam, 2012-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Data that are critical to monitoring the Upper Cowlitz Subbasin winter steelhead population have not been consistently collected and are incomplete. Collection of outmigrants at the Cowlitz Falls Fish Facility offers some indication of smolt abundance, specifically collection efficiency and numbers collected and released downstream. Although collection efficiency has not been as high as desired and has ranged widely, which precludes accurate estimates of total natural-origin juvenile winter steelhead production, the monitoring program has improved and will continue to do so.

Data are unavailable for harvest of Upper Cowlitz Subbasin winter steelhead in the ocean, Columbia River, or lower Cowlitz River fisheries, so it is not possible to develop estimates of total run size or returns to the Cowlitz River. Returns to Cowlitz Salmon Hatchery offer a relative indication of total abundance; from 2012-2017, a mean of 297 natural-origin Upper Cowlitz Subbasin winter steelhead returned to Cowlitz Salmon Hatchery (Figure 6.2-2; Table 6.2-1).

6.2.3.2. *Harvest*

Upper Cowlitz Subbasin winter steelhead may be harvested in the commercial, sport, and tribal fisheries in the Pacific Ocean, lower Columbia River, and within the Cowlitz Basin. However, harvest data for Upper Cowlitz Subbasin winter steelhead are only available for the Upper Cowlitz Subbasin fishery, and exclusively for hatchery-origin steelhead.

6.2.3.3. *Disposition*

From 2013-2017, an annual mean of 235 natural-origin adults collected at Cowlitz Salmon Hatchery were transported and released in the Upper Cowlitz Subbasin (Figure 6.2-2). It is unknown what percentage of the total Upper Cowlitz Subbasin run size these steelhead comprise. Likewise, while spawner survey data are not available, the total number of steelhead transported annually has been well below the recovery benchmark for natural spawner abundance.

6.2.3.4. *Spawning in Nature*

Because total run size cannot currently be estimated, the number of natural-origin steelhead returning to Cowlitz Salmon Hatchery offers the best indication of total natural production. From 2012-2017, a mean of 297 natural-origin winter steelhead from the Upper Cowlitz Subbasin population returned to Cowlitz Salmon Hatchery (Table 6.2-1). While actual spawning abundance is unknown, the numbers of natural-origin adult returns indicate that the population is still well below the recovery target of 1,000 natural spawners.

6.2.3.5. *Smolt Production*

From 2014-2018, a mean of 9,439 winter steelhead juveniles were captured at the Cowlitz Falls Fish Facility, which captures juveniles emigrating from the Upper Cowlitz Subbasin. All of those captured were classified as age-2. Mean collection efficiency was estimated to be 68.9*%, so we estimated that 13,270 age-2 winter steelhead were produced from the Upper Cowlitz Subbasin.

6.2.3.6. *Natural-origin Survival and Productivity*

Survival and productivity are the key metrics for monitoring populations. However, neither SAR nor productivity can currently be calculated for the Upper Cowlitz Subbasin winter steelhead population because returns are not documented by age, so a full run reconstruction of each brood year is not possible. Although recent downstream fish passage collection efficiency and survival rates have increased, estimates of natural smolt production in the Upper Cowlitz Subbasin are not available.

6.2.3.7. *Age Composition*

For run years 2012-2017, ISIT data indicate that only adult winter steelhead (i.e., no jacks) returned to Cowlitz Salmon Hatchery or were transported upstream of Cowlitz Falls Dam.

6.2.4. Hatchery Production

Hatchery production metrics must be monitored to ensure that production goals are met, to evaluate the effectiveness of the program, and to understand the magnitude of hatchery influence on the natural population. Key monitoring metrics are the numbers of steelhead harvested, collected for broodstock, spawned (by origin, age, and sex), smolts released, and steelhead returning to the Cowlitz River, Cowlitz Salmon Hatchery, and remaining in nature in the Cowlitz Basin and elsewhere. Using these data, we can calculate and monitor smolt-to-adult survival and return rates, and evaluate the effectiveness of the hatchery program.

Winter steelhead were reintroduced to the Upper Cowlitz Subbasin before the 2011 FHMP (Tacoma Power 2011), relying on the Lower Cowlitz Subbasin Segregated Late-Winter Steelhead Hatchery Program as the brood source. As the reintroduction progressed, the Upper Cowlitz Subbasin Integrated Winter Steelhead Hatchery Program was initiated. Beginning in 2013, natural-origin winter steelhead that originated from the Upper Cowlitz Subbasin and returned to Cowlitz Salmon Hatchery were incorporated into the broodstock. Since 2013, broodstock spawned to support this program have consisted of a mean of 57 natural-origin and 25 hatchery-origin steelhead annually (Table 6.2-2). In several years, due to low returning numbers of Upper Cowlitz Subbasin natural-origin and hatchery-origin fish, hatchery-origin fish from the Lower Cowlitz integrated program were used to backfill the need to reach the egg take goal. The goal of the Integrated Hatchery Program has been to produce approximately 118,000 smolts annually that are marked (CWT and adipose clip) as the F_1 progeny of natural-origin broodstock. These fish are reared at Cowlitz Trout Hatchery and directly released into the lower Cowlitz River to avoid the loss due to low fish passage survival at Cowlitz Falls Dam.

6.2.4.1. *Abundance*

As noted above under *Natural Production*, data are unavailable for harvest of Upper Cowlitz Subbasin winter steelhead in ocean, Columbia River, or lower Cowlitz River fisheries, so it is not possible to develop estimates of total run size or returns to the Cowlitz River. Returns to Cowlitz Salmon Hatchery offer a relative indication of total abundance; from 2012-2017, a mean of 187 hatchery-origin[1] Upper Cowlitz Subbasin winter steelhead returned to Cowlitz Salmon Hatchery (Figure 6.2-2; Table 6.2-1).

1 For the purposes of this section, hatchery-origin Upper Cowlitz winter steelhead consist of those collected for broodstock at Cowlitz Salmon Hatchery or transported above Cowlitz Falls Dam; ISIT does not distinguish Upper Cowlitz Subbasin winter steelhead returns to Cowlitz Salmon Hatchery by origin.

Table 6.2-2. Mean, minimum, and maximum hatchery and natural spawning metrics for Upper Cowlitz Subbasin winter steelhead, 2012-2017 spawn/brood years. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

	2012-2017 Run Years		
Spawning Location, Metric	Mean	Minimum	Maximum
Hatchery Spawning			
Mature Steelhead Collected	88	68	113
Hatchery-origin	27	0	61
Natural-origin	62	7	92
Mature Steelhead Spawned	82	66	102
Hatchery-origin	25	0	61
Natural-origin	57	7	86
Pre-spawn Survival Rate	93%	88%	100%
Total Green Eggs	154,163	118,218	207,523
Mean Fecundity	3,740	3,040	4,816
Mean Fertility	Data Not Available		
Total Eyed Eggs	Data Not Available		
Smolts Released[1]	121,429	104,113	138,103
Green Egg-to-Smolt Survival	77%	70%	89%
Smolt Productivity (smolts / spawner)[1]	1,519	1,245	1,739
Natural Spawning			
Spawners	Data Not Available		
Hatchery-origin	Data Not Available		
Natural-origin	Data Not Available		
Smolts Produced	Data Not Available		
Smolt Productivity (smolts / spawner)	Data Not Available		

1 Brood years 2012-2016.

6.2.4.2. *Harvest*

As noted above under *Natural Production*, harvest data for Upper Cowlitz Subbasin winter steelhead are only available for the Upper Cowlitz Subbasin fishery, and exclusively for hatchery-origin steelhead. No hatchery-origin winter steelhead were transported above Cowlitz Falls Dam from 2012-2013, but from 2014-2017, mean harvest in the Upper Cowlitz Subbasin fishery was 56 steelhead (Table 6.2-1), 32% of the hatchery-origin winter steelhead transported above Cowlitz Falls Dam from 2014-2017.

6.2.4.3. *Disposition*

Upper Cowlitz Subbasin integrated hatchery-origin winter steelhead returning to Cowlitz Salmon Hatchery that are deemed in excess of broodstock requirements are transported above Cowlitz Falls Dam to supplement natural spawning and provide harvest opportunities in the Upper Cowlitz Subbasin. A mean of 161 hatchery-origin winter steelhead were transported and released above Cowlitz Falls Dam from 2012-2017, representing 86% of those returning to Cowlitz Salmon Hatchery (Figure 6.2-2; Table 6.2-1). Hatchery-origin steelhead transported to the Upper Cowlitz Subbasin are available for harvest, and those that survive may spawn naturally. No surveys are currently conducted to document survival to spawning.

6.2.4.4. *Hatchery Spawning*

As with natural-origin returns, estimates of the total run size for hatchery-origin Upper Cowlitz Subbasin winter steelhead are precluded by the lack of harvest data below Mayfield Dam. The number of hatchery-origin steelhead returning to Cowlitz Salmon Hatchery therefore offers the best indication of run size. From 2012-2017, a mean of 187 hatchery-origin winter steelhead assigned to the Upper Cowlitz Subbasin population returned to Cowlitz Salmon Hatchery (Table 6.2-1). Of those returning to Cowlitz Salmon Hatchery, a mean of 27 were collected for broodstock while the remainder were transported and released above Cowlitz Falls Dam.

6.2.4.5. *Hatchery Rearing*

From 2012-2015, an estimated mean of 154,163 green eggs were collected from a mean of 85 adults for the Integrated Hatchery Program (Table 6.2-2). Mean fecundity was 3,740 green eggs, but eyed-egg data are not available so fertility rate cannot be calculated. From brood years 2012-2016, a mean of 121,429 smolts were released in 2013-2015. Mean green egg-to-smolt survival for brood years 2012-2016 was 77%.

6.2.4.6. *Age Composition*

As noted above under Natural Production, for run years 2012-2017, ISIT data indicate that only adult winter steelhead (i.e., no jacks) returned to Cowlitz Salmon Hatchery or were transported upstream of Cowlitz Falls Dam.

6.2.5. Proportionate Natural Influence

PNI is a useful metric for monitoring both hatchery and natural populations. Changes in PNI can indicate an increase or decrease in the effect of hatchery-origin steelhead on the natural population.

To reduce the effect of hatchery supplementation on the natural population that it supplements, we try to maximize the number (and percentage) of natural-origin steelhead in the hatchery broodstock and minimize spawning by hatchery-origin steelhead in nature. Absent spawning survey data, the best approximation of pHOS we can derive is based on the number of steelhead transported above Cowlitz Falls Dam, minus the number removed through harvest. This approach fails to account for other losses, such as fallback, predation, and pre-spawn mortality and is also constrained by the lack of harvest data for natural-origin steelhead in the Upper Cowlitz Subbasin. Nonetheless, the resulting estimate of mean pHOS for 2012-2017 was 0.47, which exceeds the HSRG standard of <0.3 for a Primary population with an integrated hatchery program.

Given the known broodstock contribution for both natural- and hatchery-origin steelhead, pNOB can be more accurately quantified. Natural-origin broodstock were first used in the Integrated Winter Steelhead Hatchery Program in 2012. From 2012-2017, mean pNOB was 0.64, which exceeds the HSRG standard of >0.60 for a Primary population with an integrated hatchery program.

Estimates of PNI are subject to the same constraints as pHOS in terms of data availability (i.e., no spawning survey data). Based on this limited data, mean PNI from 2012-2017 was 0.57, which does not meet the HSRG standard of >0.67 for a Primary population with an integrated hatchery program (Table 6.2-3).

6.2.6. Future Management

The Upper Cowlitz Subbasin winter steelhead population is designated as a Primary population for achieving MPG and DPS recovery goals, with a minimum abundance target of 1,000 natural-origin spawners in nature, which is the combined abundance targets for the Upper Cowlitz (500 spawners) and Cispus (500 spawners) River populations. Population viability remains at a rating of Very Low, with natural production being supplemented by hatchery-origin adults transported to the Upper Cowlitz Subbasin (WDFW and LCFRB 2016). From 2012-2017, the total number of natural-origin winter steelhead transported to the Upper Cowlitz Subbasin has ranged from 24-580 (mean = 235). The maximum number transported during this period (n = 580) occurred prior to initiation of the Integrated Hatchery Program, so natural-origin spawner abundance is well below the minimum natural-origin spawner abundance recovery target of 1,000. However, the population is in the early stages of transitioning to an Integrated Hatchery Program, and the expectation is that as supplementation with hatchery-origin adults spawning in the subbasin continues, the number of subsequent natural-origin spawners will increase.

During the period covered by this FHMP, we will transition to a larger Integrated Hatchery Program, with a goal of producing at least 236,000 smolts propagated from a combination of natural- and hatchery-origin broodstock. The intent is to increase the transport and release of both hatchery- and natural-origin adults above Cowlitz Falls Dam so that natural production increases, while also sustaining harvest opportunities downstream of Mayfield Dam. The long-term goal will be to transition fully to an Integrated Hatchery Program that supports the recovery of the Upper Cowlitz Subbasin population, as well as harvest both downstream of Mayfield Dam and in the Upper Cowlitz Subbasin. To accomplish this, within the first year of the FHMP, we will define the triggers or thresholds for moving from one stage of recovery to another (e.g., adult abundance, spatial distribution, fish passage survival) while considering various recovery strategies. We will also develop a plan within the first year of the FHMP to develop an early-run segment of the population that more closely emulates historic winter steelhead run timing.

6.2.6.1. *Goals for Conservation and Recovery*

The Upper Cowlitz Subbasin winter steelhead population was identified as a high recovery priority (LCFRB 2010) and will play a Primary role in the recovery of the lower Columbia River steelhead DPS. Progress toward achieving conservation and recovery goals and identification of factors that limit recovery are evaluated through monitoring of standard fisheries management metrics (Table 6.2-3; Appendix A, Full Big Table). The Upper Cowlitz Subbasin winter steelhead population had an historical abundance of about 2,900 steelhead (1,400 in the upper Cowlitz River and 1,500 in the Cispus River) and has a recovery target of 1,000 natural-origin spawners in nature (LCFRB 2010). In 2010, the abundance and productivity of this population was rated as Very Low, with <50 spawners in the Upper Cowlitz and Cispus river subpopulations (LCFRB 2010). Today, natural-origin spawner abundance is >50 in most years, but still well below the recovery target.

Table 6.2-3. Recovery phase targets for Upper Cowlitz Subbasin winter steelhead.

Species:	Winter Steelhead
Population Name:	Upper Cowlitz Subbasin
Recovery Designation:	Primary
Current Recovery Phase:	Recolonization

	RECOVERY PHASE				
Target Metric	Preser-vation	Recolon-ization	Local Adaptation	Fully Recovered	Last 5 Years
Natural Production					
Natural-origin Spawners in Nature	1,000	1,000	1,000	1,000	359*
Smolt Abundance (below hatchery)	TBD	TBD	TBD	TBD	NA
Smolt Passage Survival	40%	50%	TBD	TBD	78%
Productivity (5-year mean)	>1	>1	>1	>1	?
Hatchery Production					
Type of Hatchery Program	Seg/Int	Int	Int	Int	Int
Broodstock to be Collected	TBD	TBD	TBD	TBD	85
Integrated Hatchery Program	TBD	TBD	TBD	TBD	85
Hatchery-Origin	TBD	TBD	TBD	TBD	29
Natural-Origin	TBD	TBD	TBD	TBD	56
Segregated Hatchery Program	0	0	0	0	0
Smolts to be Produced	TBD	TBD	TBD	TBD	121,429
Integrated Hatchery Program	TBD	TBD	TBD	TBD	121,429
Segregated Hatchery Program	TBD	TBD	TBD	TBD	0
Total Smolt-to-Adult Survival	TBD	TBD	TBD	TBD	NA
Proportionate Natural Influence					
pHOS (<)					
Total	TBD	TBD	TBD	TBD	0.47*
Integrated Hatchery Program	TBD	TBD	TBD	TBD	0.47*
Segregated Hatchery Program	0.1	N/A	N/A	N/A	N/A
pNOB (>)	TBD	TBD	TBD	TBD	0.64
PNI (>)	TBD	TBD	TBD	TBD	0.57*
Max % of Natural-Origin Return to Cowlitz Salmon Hatchery Collected for Broodstock	TBD	TBD	TBD	TBD	26%

* Based on numbers transported rather than spawning.

- **Long-term Goals:** The goal for this Primary winter steelhead population is full recovery, which would include, but not be limited to:
  - Prioritizing population recovery while still providing harvest opportunity.
  - Adult abundance of >1,000 natural-origin winter steelhead spawning in nature.
  - pHOS <0.3 (HSRG 2009).
  - pNOB more than two times pHOS, such that PNI ≥0.67
  - A harvestable population of winter steelhead in the Upper Cowlitz Subbasin as well as below Mayfield Dam.
  - An early-run component that more closely emulates the historic run timing of winter steelhead in the Cowlitz Basin.
- **FHMP:** The goals for this program during the period covered by this FHMP are to:
  - Increase total abundance (both natural- and hatchery-origin) in the Upper Cowlitz Subbasin to advance recovery.
  - Define triggers (i.e., Decision Rules) for moving from one stage of recovery to another (e.g., adult abundance, spatial distribution, fish passage survival) while considering various recovery strategies.
  - Emphasize as key population monitoring metrics:
    - Numbers returning to the Cowlitz River.
    - Numbers of natural-origin steelhead returning to the hatchery trap.
    - Relative numbers of mature natural- and hatchery-origin steelhead transported and released in the Upper Cowlitz Subbasin.
    - Relative numbers of natural- and hatchery-origin steelhead spawning in nature in the Upper Cowlitz Subbasin.
  - Begin monitoring natural spawning in the Upper Cowlitz Subbasin to achieve natural-origin spawner abundance >1,000.
  - Increase and improve monitoring and evaluation, including:
    - Natural smolt production.
    - Abundance of hatchery- and natural-origin spawners.
    - Age, sex, and origin of recoveries at all recovery locations.
    - Document strays from outside of the Cowlitz Basin and Cowlitz River strays at sites outside the Cowlitz Basin.
  - Develop a plan within year-one of the FHMP to establish an early-run component for winter steelhead that:
    - Considers best available science, existing data, and available literature to devise a recovery strategy that does the most good and the least harm to the population.
    - Minimizes conflict with restoration of the late winter steelhead run in the Upper Cowlitz Subbasin.

- Considers many options, including hatchery rearing strategies, broodstock collection techniques, and other hatchery management practices to modify run- and spawn-timing.
- Identifies a timeline for initiation of this program.
- Recognizes the need for some harvest opportunity.
- Fits within the recovery objectives.

6.2.6.2. *Management Targets*

In recent years, low natural-origin and hatchery origin abundances, high pHOS, poor smolt survival, and unknown levels of natural-origin harvest losses have prevented this population from meeting its recovery goals. Improved smolt passage survival will aid in creating a self-sustaining naturally spawning population in the subbasin, but will not solve all of the problems. Reestablishing a self-sustaining population will ultimately require natural spawning by a sufficient number of natural-origin steelhead and for their survival to exceed replacement (spawner-to-spawner productivity >1). To reach this outcome, we will reduce the PNI rate of the current program to 0.5 and double the size of the current hatchery production for the Upper Cowlitz Subbasin to 236,000 smolts. This approach will not change the number of natural-origin fish being taken into the hatchery and increase the number of hatchery-origin fish returning to the separator. If the Integrated Hatchery Program exhibits a smolt-to-adult survival rate of only 2%, we would expect to get 4,720 adults back to meet broodstock needs and seed the Upper Cowlitz Subbasin prior to moving onto the next phase of recovery.

- **Natural Production:** The goal of population restoration is to produce self-sustaining natural-origin populations. We will develop rigorous monitoring programs that allow us to estimate, with greater confidence, the abundance of steelhead in these populations, when populations have become self-sustaining, as well as to identify areas where we can improve survival. Efforts to improve downstream fish passage survival continue, and recruitment from natural production will increase with the success of these efforts. Likewise, the ability to accurately estimate natural production will improve as collection efficiency at downstream passage facilities improves. Counts of steelhead returning to the Upper Cowlitz Subbasin are be reliable, but estimates of harvest, returns to spawning grounds, and the number of spawners in nature have wide variances due to low sampling rates, when estimated at all, so actual pHOS is unknown. Pre-spawn mortality (largely due to senescence) does not seem to be estimated (or is inconsistently estimated) for spawners in nature. As part of this FHMP, Tacoma Power will develop and begin to implement a rigorous monitoring program that is focused on evaluating program effectiveness based on regionally accepted VSP parameters.

  During the current Recolonization phase of recovery, natural production in the Upper Cowlitz Subbasin has relied on spawning by a combination of transported hatchery- and natural-origin adults. We have accepted the resulting near-term increase in pHOS (>0.3) in order to receive the demographic boost that the population needs and, as such, will continue utilizing hatchery production during the period covered by this FHMP to supplement natural production. However, as the transition to an Integrated Hatchery Program progresses during this period, we will increase the contribution of natural-origin broodstock, as run size permits. In the long term, all hatchery production will transition to a fully Integrated Hatchery Program that relies entirely on natural-origin broodstock. However, as natural-origin productivity and abundance increase, reductions in releases of hatchery-origin steelhead into the Upper Cowlitz Subbasin, reductions in natural-origin exploitation, and/or increased hatchery-origin harvest will be needed to reduce pHOS to an acceptable level. Until smolt passage improves, greater releases of hatchery-origin adults above Cowlitz Falls Dam will be continued to increase natural smolt production, and the subsequent return of natural-origin spawners to meet recovery abundance goals.

- **Abundance – Transport and Natural Spawning:** The recovery goal for the Upper Cowlitz Subbasin winter steelhead population of 1,000 natural-origin spawners has not yet been met. While pNOB has met the HSRG standard in recent years, pHOS and PNI have not. However, this population is still in the Recolonization phase of recovery and the Integrated Hatchery Program was only recently initiated.

  To meet recovery goals, the number of returning natural-origin spawners must increase and the proportional contribution of hatchery-origin steelhead spawning in the Upper Cowlitz Subbasin must decrease. We will focus our monitoring of abundance on the numbers of hatchery- and natural-origin steelhead that return to the Cowlitz Salmon Hatchery, that are transported to the Upper Cowlitz Subbasin, and that spawn in nature each year. These metrics are critical for achieving recovery.

- **Smolts Produced in Nature:** Although natural-origin smolts are collected at the Cowlitz Falls Fish Facility, their numbers are not reported in ISIT. Natural-origin smolt production from the Upper Cowlitz Subbasin is not comprehensive and cannot be estimated with sufficient precision until collection efficiencies of downstream passage facilities improve. The smolt monitoring effort in the lower Cowlitz River is conducted in the mainstem Cowlitz River, which is difficult because of the large size of the river. Additionally, the fact that smolts from natural production in the lower Cowlitz River are also present confounds these estimates. To estimate smolt production from the Upper Cowlitz Subbasin, we need to capture representative smolts as they leave the upper river.

- **Smolt-to-Adult Survival:** Because accurate estimates of smolt abundance are not currently available, neither SAR nor TSAR can be estimated. These metrics are important but less critical for monitoring natural populations than for hatchery populations. We will monitor these indices as means to do so become available, which will require a comprehensive and robust M&E Program.

- **Productivity (Recruits/Spawner):** Population productivity (number of F_1 generation recruits that survive to spawn for each F_0 generation spawner; "spawner-to-spawner") is the primary monitoring metric for any population, especially natural populations. It provides an overall view of population performance and trajectory, where:

  - If productivity >1, the population is increasing.
  - If productivity <1, the population is declining.

  Given the current difficulty in estimating smolt abundance and origin, deriving productivity estimates remains a challenge and a significant data gap.

- **Hatchery Production:** During recovery efforts to date, hatchery influences on the Upper Cowlitz Subbasin population have consisted of the transport and release of hatchery-origin adults that spawn naturally and the use of both hatchery- and natural-origin broodstock (mean pNOB = 0.64). The number of adults successfully spawning in the Upper Cowlitz Subbasin is unknown, so our best estimates of pHOS (mean = 0.47) and PNI (mean = 0.57) can currently only be approximated based on the numbers transported and released. Given the low returns of natural-origin adults and the abundance of hatchery-origin adults released in the subbasin, these metrics of hatchery influence exceed recovery targets, and natural influence on the Upper Cowlitz Subbasin population has been limited.

We will continue transporting hatchery-origin adults to the Upper Cowlitz Subbasin over the period covered by this FHMP; however, as the number of natural-origin returns subsequently increases, the Integrated Hatchery Program will incorporate a greater proportion of natural-origin returns in the hatchery broodstock to increase the influence of the natural environment on the Upper Cowlitz Subbasin population. Decisions for implementing the Integrated Hatchery Program will be reviewed and revised, as necessary (e.g., based on the number of returning natural-origin adults).

We will continue transporting hatchery-origin adults to the Upper Cowlitz Subbasin over the period covered by this FHMP. We will develop and implement a rigorous sampling and monitoring program, along with a database for the hatchery program, to allow managers to better evaluate and manage the hatchery programs. The numbers of broodstock to be collected, by week, origin, age class, and sex, will be set at the Annual Action Plan meeting. The collection schedule will be based on the smolt production needs of each program and the most recent 5-year means of pre-spawn mortality, fecundity, fertility, hatching rates, and survival rates from hatching-to-swim-up fry, fry-to-parr (at marking), and parr-to-smolt survival rates. Improved monitoring of returns will also be needed to estimate stray and smolt-to-adult survival and return rates and evaluate the hatchery programs. These data will be used to inform decisions for implementing and revising the Integrated Hatchery Program, as necessary (e.g., based on the number of returning natural-origin adults).

- **Abundance:** We will focus our monitoring of abundance on the numbers of hatchery-origin winter steelhead that return to the Cowlitz River and to Cowlitz Salmon Hatchery, which are critical for calculating SAR and TSAR. As the Integrated Hatchery Program continues to develop, we will establish production goals that align with the prioritization of recovery, while also providing for harvest opportunity.
- **Broodstock Collection and Spawning:** We will collect all broodstock from steelhead that return to Cowlitz Salmon Hatchery and will ensure that both male and female natural-origin genotypes are incorporated into the broodstock for the Integrated Hatchery Program. The currently low abundance of natural-origin returns will initially constrain natural-origin broodstock collection and spawning decisions, as the percentage of natural-origin returns to Cowlitz Salmon Hatchery collected for broodstock will not exceed 30%.

  We will employ hatchery best management practices for broodstock collection and spawning to ensure that the broodstock represents the entire population in age and run timing in order to maximize genetic diversity of the F_1 generation. Hatcheries, especially those with a conservation mandate, should use spawning matrices in which the gametes from every individual are mixed (approximately evenly) with those of at least two individuals of the opposite sex. In integrated programs, we will strive to ensure that there are no HxH crosses in order to minimize the hatchery influence on the F_1 generation and any population that it spawns with.
- **Smolt Production:** Winter steelhead hatchery-origin smolts will be reared at Cowlitz Trout Hatchery. The Settlement Agreement (Section 6.1.5), states that, “The hatchery complex will be designed with flexibility so managers can employ innovative rearing practices, low densities, and replication of historic fish out-migration size and timing.” It is clear that the intent of the Settlement Agreement is to rear steelhead so that they are as similar, in both appearance and performance, to natural-origin steelhead as possible.

We will begin developing and evaluating novel rearing and release strategies (e.g., smaller, natural-sized steelhead smolts) to improve program performance by decreasing the rates of precocious maturation and straying, and increasing the rates of in-hatchery survival, smolt-to-adult survival, and smolt-to-adult return. This will further minimize the hatchery influence on the F_1 generation and any population that it spawns with.

- **Smolt-to-Adult Survival:** SAR and TSAR are the primary indices for monitoring a hatchery program. SAR indicates the success of the program in producing steelhead that survive in nature and return to the hatchery; a sufficient number is needed to support hatchery broodstock (for segregated or partially integrated programs) or for release into nature to support natural spawning. TSAR is indicative of the overall success of a hatchery program to support all aspects that hatchery steelhead may support—commercial, tribal, and/or recreational fisheries in the ocean, Columbia River, and the Cowlitz River and/or its tributaries, hatchery broodstock, and/or natural spawning. We will monitor these indices by all means available, and it will be necessary to estimate abundances at all locations, which will require a comprehensive and robust M&E Program.
- **Productivity:** Population productivity (number of F_1 generation recruits that survive to spawn for each F_0 generation spawner; "spawner-to-spawner") is the primary monitoring metric for any population, especially natural populations. However, this metric is of less importance to hatchery-origin populations, where survival to the smolt stage is unnaturally high. Population productivity for hatchery-origin steelhead should be well above replacement (R/S = 1) because of the huge survival advantage afforded by rearing in a hatchery. Therefore, recruits / spawner (smolt recruits or mature recruits) is less important for monitoring hatchery populations.
- **Strays and Spawning in Nature:** Because all mature steelhead reaching the Upper Cowlitz Subbasin are sorted for transport, and because only F_1 progeny hatchery-origin steelhead (i.e., marked with both ad-clip and CWT) are transported and released into the Upper Cowlitz Subbasin, the risk of hatchery-origin strays from outside the integrated program spawning naturally in the subbasin is low.

  While stray rates to out-of-basin locations are also likely low, it is reasonably certain that Cowlitz River hatchery-origin steelhead do stray into other streams such as the Toutle, Coweeman, Kalama, Lewis, or Willamette rivers, and that steelhead from other basins stray into the lower Cowlitz River. The magnitude of both forms of straying is not known, as the data are either not collected or are not reported. This will need to change to accurately evaluate the effectiveness of these hatchery programs.
- **Surplus:** The Integrated Hatchery Program allows for flexibility in dealing with hatchery returns that exceed broodstock needs because hatchery-origin steelhead can be transported upstream of Cowlitz Falls Dam to advance the restoration of steelhead to the Upper Cowlitz Subbasin, and support harvest opportunities in the subbasin. However, an excess of hatchery-origin steelhead returning to Cowlitz Salmon Hatchery can have indirect effects on the viability of the natural-origin population. While an overabundance of hatchery-origin steelhead could result in overcrowding in the Upper Cowlitz Subbasin if holding areas are limited, current abundance levels are low. In addition, the increased natural smolt production afforded by hatchery-origin adults spawning in nature will continue to be needed until the abundance of natural-origin spawners are sufficient to maintain a self-sustaining population.
- **Harvest:** Decreasing the exploitation of natural-origin steelhead would incrementally increase potential natural spawning abundance. Because retention of natural-origin is

prohibited in recreational fisheries, harvest rates are likely low. Reducing harvest rates further may be an impractical means of substantially increasing natural-origin abundance. However, an important data gap in ISIT is the harvest rates for natural-origin steelhead, particularly in terminal fisheries. Gaining a clear understanding of harvest impacts on natural-origin Upper Cowlitz Subbasin winter steelhead is critical.

- **Proportionate Natural Influence**: We will increase the influence of the natural environment on the Upper Cowlitz Subbasin winter steelhead population by increasing pNOB through the use of an increasing number and proportion of natural-origin broodstock. This will depend on an anticipated increase in the returns of natural-origin steelhead to Cowlitz Salmon Hatchery as the progeny of natural spawning by hatchery-origin adults in the Upper Cowlitz Subbasin return. We will also explore means of decreasing pHOS by increased harvest of hatchery-origin steelhead and/or decreased transports of hatchery-origin steelhead upstream of Cowlitz Falls Dam as natural production increases. We will use the HSRG guidelines for pHOS and PNI by maintaining PNI >0.67 and trying to maintain pHOS <0.3. In early years of the Integrated Hatchery Program, pHOS has exceeded 0.3, but we expect that as Fish Passage Survival increases, both natural-origin abundance and natural production will quickly increase.
- **Age Composition:** Because all steelhead returning to the Upper Cowlitz Subbasin are handled, the age composition of those transported can be controlled. ISIT reports only adult steelhead being transported upstream of Cowlitz Falls Dam. However, the age composition of those returning to the hatchery is provided. Collecting this information in the future will be important for evaluating potential effects of releasing early maturing steelhead for natural production in the Upper Cowlitz Subbasin.

6.2.6.3. *Monitoring and Evaluation (M&E) and Research*

Baseline Monitoring

Baseline studies are required to adequately monitor a population so that we can effectively manage it. Baseline monitoring is conducted annually to track the population's trajectory and variability and includes the basic data required to operate a one-stage or two-stage life cycle model. Because smolt abundance cannot be reliably monitored for the natural-origin Upper Cowlitz Subbasin winter steelhead population until the collection efficiency of the Cowlitz Falls Fish Facility improves, year-class abundance is more accurately determined based on the latter returns of mature steelhead; therefore, baseline studies for this population will focus on mature steelhead returns until collection efficiency improves.

Current M&E work for Upper Cowlitz Subbasin winter steelhead is focused on addressing monitoring needs, such as:

- Estimating harvest rates of hatchery- and natural-origin steelhead in all fisheries.
- Estimating hatchery- and natural-origin pre-spawn mortality, spawning areas, and natural spawning in the Upper Cowlitz Subbasin.
- Identifying the source of natural-origin returns to the hatchery trap.
- Estimating pHOS.
- Estimating natural-origin population productivity (spawner-to-spawner).
- Quantifying the number of smolts produced in the Upper Cowlitz Subbasin.
- Evaluating the ability to differentiate steelhead smolts naturally produced in the Upper Cowlitz Subbasin from those naturally produced in the Tilton River.

At the time of this writing, some of these efforts are incomplete (e.g., spawner escapement is not differentiated from the number of adults transported upstream of Cowlitz Falls Dam, and data are not entered into ISIT for all fisheries), so, while metrics can be calculated, they are inaccurate. Expanded monitoring should include collecting data and samples to enable the runs to be further characterized by age and sex, where appropriate, to enable complete run reconstruction.

Critical factors are those that are most likely to affect a population, positively or negatively, and its progress toward recovery, as well as those metrics that are most important for monitoring the progress of a population toward recovery and our management of that population. For natural populations, population productivity ("spawner-to-spawner" - the number of F_1 generation recruits that survive to spawn for each F_0 generation spawner) is the key monitoring index; thus, the key metric is adult spawners in nature. Other metrics that affect this index, such as numbers of steelhead harvested, strays, natural smolts produced, and steelhead spawned in nature, are also important. These data allow us to calculate the rates and proportions, such as harvest rates and pHOS, which determine hatchery program levels and management actions (see Chapter 9 for more details).

We will track population metrics annually and compare annual and 5-year means with program recovery goals and targets. The consistent availability of data in ISIT is insufficient to examine trends for any metrics at this time. Annual estimates of natural-origin returns to the Upper Cowlitz Subbasin and spawning grounds (spawner abundance) and of hatchery-origin spawners in nature (for pHOS) are the most important metrics to track over time. Harvest of natural-origin steelhead is the primary source of mortality over which we have some control, so harvest rates, overall and for individual fisheries, are also important metrics. The 5-year running means of these variables will be reported each year.

We evaluate our effectiveness in applying the Decision Rules by comparing our goals with the actual results for each year. We examine metrics such as harvest rates and escapement to the spawning grounds/hatchery to evaluate how well we are managing the fisheries. Comparing return abundances allows us to evaluate our ability to predict run size and to improve our ability to do so. Additional metrics are monitored that allow us to develop an even deeper understanding of this population (see Chapters 9 and 11).

For the Upper Cowlitz Subbasin winter steelhead population, spawning in nature by hatchery- and natural-origin steelhead is not reported in ISIT; only numbers of steelhead transported upstream of Cowlitz Falls Dam are reported. Assuming that some losses would occur from natural mortality or exploitation, using this metric overestimates spawning in nature. Natural spawning abundance data are needed to more accurately identify trends and evaluate the performance of recovery efforts.

No estimates of smolt abundance nor the quantity or quality of their habitat are included in the current monitoring effort. While estimates of juvenile passage survival and/or collection efficiency are provided in ISIT, the numbers of natural-origin smolts collected at the Cowlitz Falls Fish Facility are not. Even if smolt collection numbers were provided, not all smolts are collected, so these data may not be an accurate estimate of natural smolt production. Additionally, the data currently available in ISIT are only apportioned by age class in the form of jacks and adults and only for returns to Cowlitz Salmon Hatchery, not for other recovery locations (e.g., harvest or spawning in nature), and numbers transported upstream were only reported for adults. Apportioning returns by age and sex, as well as recovery location, is needed to accurately estimate brood year abundance, survival, productivity, stray rate, and total run year abundance in order to better understand natural and hatchery production.

Directed Studies

Directed studies are designed to diagnose and solve problems associated with achieving FHMP goals. These studies inform future designs, operations, and fish management strategies that will improve the existing FHMP program so that Settlement Agreement goals can be achieved. Metrics that are most likely to provide the greatest added benefit for the FHMP are currently those for which we do not have good information and, as such, are left out of population assessment methodologies. Without that information, data from another population or conglomerate, which may or may not accurately reflect the current population, must be substituted for a parameter value in a life cycle model. Most of the metrics for the Upper Cowlitz Subbasin winter steelhead in the Big Table (Appendix A) currently lack information. Conducting directed studies to address metrics that lack data and have a high potential to affect life cycle model sensitivity would be beneficial. Important areas of study include:

- **Spawning ground surveys**: Scales, hatchery-origin/natural-origin ratio, pre-spawn, genetics, spatial distribution (upper extent), and reach-specific adult densities (sub-sample).
- **Juvenile rearing capacity studies:** Available habitat and habitat-specific (run/riffle/pool) densities.
- **Early life stage survival studies:** Egg to fry, fry to parr, and parr to smolt survival rates.
- **In-river migratory survival and behavior:** Survival of migrating juveniles and movement rates.
- **Reservoir survival:** Predation rate and parasite loadings.

6.2.7. Summary

- Although functionally extirpated from upstream habitats following completion of Cowlitz Falls Dam, genes from the Upper Cowlitz Subbasin population were incorporated into the Lower Cowlitz Subbasin population, providing the founding stock for recovery.
- Although the ESA framework identifies distinct winter steelhead populations in the Cispus and Upper Cowlitz rivers, returning adults cannot be differentiated. Thus, these populations are managed as a combined “Upper Cowlitz Subbasin” population.
- Recovery efforts for winter steelhead have focused on transporting natural-origin steelhead returning to Cowlitz Salmon Hatchery to the Upper Cowlitz Subbasin. Additionally, hatchery-origin adults from the Integrated Hatchery Program have been transported to the Upper Cowlitz Subbasin to supplement natural spawning and harvest opportunity.
- Recent abundance estimates of natural-origin adults transported to the Upper Cowlitz Subbasin are well below abundance targets. Additional releases of hatchery-origin adults from the Integrated Hatchery Program are needed to increase natural production in the Upper Cowlitz Subbasin until a self-sustaining population of natural-origin spawners is established.
- Goals for the Upper Cowlitz Subbasin population will prioritize population recovery while still providing harvest opportunity.

- The Upper Cowlitz Subbasin winter steelhead population is currently in the Recolonization phase of recovery, and over the period covered by this FHMP the focus will be on rebuilding abundance of the natural-origin population by maximizing the numbers of steelhead spawning in nature.
- We will examine opportunities to establish an early-winter run component that more closely emulates the historic run-timing of winter steelhead and also provides for increased recreational/harvest opportunity.
- Adjustments to the Segregated Summer Steelhead Hatchery Program will be evaluated to provide additional recreational/harvest opportunity relative to the recovery of the Upper Cowlitz Subbasin winter steelhead population.
- In the near-term (i.e., the period covered by this FHMP), we will:
    - Increase total abundance (both natural- and hatchery-origin) in the Upper Cowlitz Subbasin to advance recovery.
    - Define triggers (i.e., Decision Rules) for moving from one stage of recovery to another (e.g., adult abundance, spatial distribution, fish passage survival) while considering various recovery strategies.
    - Increase and improve monitoring and evaluation with an emphasis on key population metrics.

Population: Tilton Subbasin Winter Steelhead
Oncorhynchus mykiss

Distinct Population Segment:	Cascade Winter Steelhead Lower Columbia River Steelhead DPS Lower Columbia River Salmon Recovery Region
ESA Listing Status:	Threatened Listed in 1998, revised 2006, reaffirmed in 2011 and 2016
Population Recovery Designation:	Contributing
Population Viability Rating:	
Baseline	Very Low
Objective	Low
Recovery Goal:	200 natural-origin steelhead spawning in the Tilton Subbasin
Current Recovery Phase:	Recolonization
Current Hatchery Program(s):	Cowlitz Trout Hatchery Late Winter Steelhead Integrated Hatchery Program; 48,500 smolts
Proposed Hatchery Program(s):	Cowlitz Trout Hatchery Winter Steelhead Integrated Hatchery Program; 100,000 smolts

6.3. Winter Steelhead: Tilton Subbasin Population

6.3.1. Purpose

This section describes the current status of the Tilton Subbasin winter steelhead population, based on recent and available data. We will identify VSP metrics needed to evaluate the status of this population with regard to recovery under ESA guidelines. Where appropriate, we propose changes to both hatchery and monitoring programs to facilitate progress toward population recovery and our evaluation of that progress.

The Integrated Hatchery Program began in 2012, using primarily natural-origin broodstock to recolonize the Tilton Subbasin by increasing the abundance of natural-origin spawners. Currently, the number of natural-origin returns appears to be approaching the minimum recovery abundance target of 200 spawners in nature. During the period covered by this FHMP, the Integrated Hatchery Program will continue to operate for the recovery and Local Adaptation of the Tilton Subbasin population. In addition, hatchery production will be increased to replace the planned reduction in the Lower Cowlitz Subbasin hatchery production, so that harvest opportunity is maintained both below Mayfield Dam and in the Tilton Subbasin. Annual smolt production will be increased from 48,500 to 100,000 smolts and require the use of both natural- and hatchery-origin broodstock, but with pNOB not exceeding 0.5. In the Tilton Subbasin, we will continue transporting and releasing both hatchery-origin adults that are F_1 progeny of at least one natural-origin parent, and natural-origin adults that are in excess of broodstock requirements. We will not exceed a natural-origin adult mining rate of 0.3.

In addition, we will evaluate opportunities and develop a plan to increase early run timing for the population so that the run timing of the entire Tilton Subbasin natural-origin population more closely emulates the historic run timing of winter steelhead and increases recreation/harvest opportunity. We will continue to evaluate the hatchery program and fisheries management and make refinements or adjustments, as needed to effectively supplement and manage the Tilton Subbasin population.

6.3.2. Population Description

The Tilton Subbasin winter steelhead population includes all natural-origin winter steelhead that occupy the Tilton Subbasin and its tributaries (Figure 6.3-1). The completion of Mayfield Dam in 1963 and the subsequent termination of upstream transport in 1968 resulted in the extirpation of steelhead populations in the Tilton, Cispus, and Upper Cowlitz subbasins. The lower Cowlitz River winter steelhead population has persisted and has been used as the genetic source for reintroductions of steelhead to the Tilton Subbasin. The Tilton Subbasin winter steelhead population was listed as threatened in 1998 under the ESA as part of the lower Columbia River DPS. NMFS (2016) reaffirmed the threatened status of the DPS, which remains at “moderate risk” of extinction. The Tilton Subbasin winter steelhead population is classified as a Contributing population for recovery of the lower Columbia River DPS and must attain some improvement toward its recovery and viability goals for the DPS to be considered recovered (WDFW and LCFRB 2016).

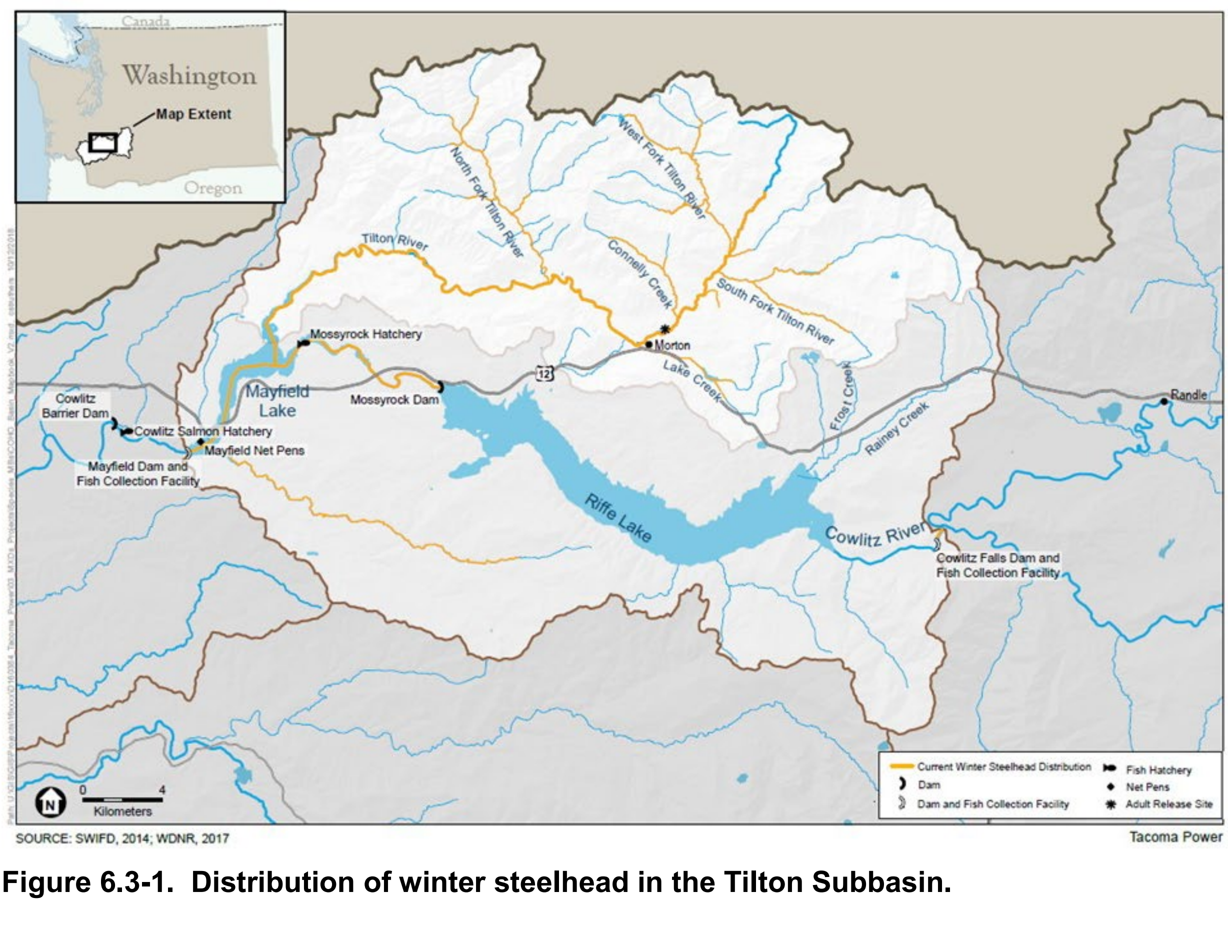


Figure 6.3-1. Distribution of winter steelhead in the Tilton Subbasin.

Table 6.3-1. Mean, minimum, and maximum numbers of all hatchery- and natural-origin winter steelhead from the Tilton Subbasin population that could be accounted for at recovery locations 2012-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

Origin and Recovery Location	Mean	Minimum	Maximum
Hatchery-origin			
Total Run[1]		Not All Data Are Available	
Harvest[2]		Data Not Available	
Ocean harvest		Data Not Available	
Columbia River harvest		Data Not Available	
Lower Cowlitz River harvest		Data Not Available	
Tilton Subbasin harvest		Data Not Available	
Total Return to Cowlitz River[3]		Not All Data Are Available	
Return to Cowlitz Salmon Hatchery[4]	63	0	195
Collected for Broodstock	3	0	11
Transported to Tilton Subbasin	60	0	186
Remain in Tilton Subbasin		Data Not Available	
Natural-origin			
Total Run[1]		Not All Data Are Available	
Harvest[2]		Data Not Available	
Ocean harvest		Data Not Available	
Columbia River harvest		Data Not Available	
Lower Cowlitz River harvest		Data Not Available	
Tilton Subbasin harvest		Data Not Available	
Total Return to Cowlitz River[3]		Not All Data Are Available	
Return to Cowlitz Salmon Hatchery[4]	362	184	500
Collected for Broodstock	49	32	61
Transported to Tilton Subbasin	313	152	445
Remain in Tilton Subbasin		Data Not Available	
Combined Hatchery- and Natural-origin			
Total Run[1]		Not All Data Are Available	
Harvest[2]		Data Not Available	
Ocean harvest		Data Not Available	
Columbia River harvest		Data Not Available	
Lower Cowlitz River harvest		Data Not Available	
Tilton Subbasin harvest		Data Not Available	
Total Return to Cowlitz River[3]		Not All Data Are Available	
Return to Cowlitz Salmon Hatchery[4]	425	218	581
Collected for Broodstock	52	43	61
Transported to Tilton Subbasin	373	175	528
Remain in Tilton Subbasin		Data Not Available	

1 Sum of all harvest below Cowlitz Salmon Hatchery plus numbers returning to Cowlitz Salmon Hatchery.
2 Total of harvest in ocean, Columbia River, Lower Cowlitz Subbasin, and Tilton Subbasin fisheries.
3 Sum of Lower Cowlitz Subbasin harvest plus number returning to Cowlitz Salmon Hatchery.
4 Sum of numbers collected for broodstock plus numbers transported to Tilton Subbasin.
5 ISIT data for numbers transported to Tilton Subbasin exceeded numbers reported for hatchery returns, so unpublished data from Tacoma Power were used for numbers transported.

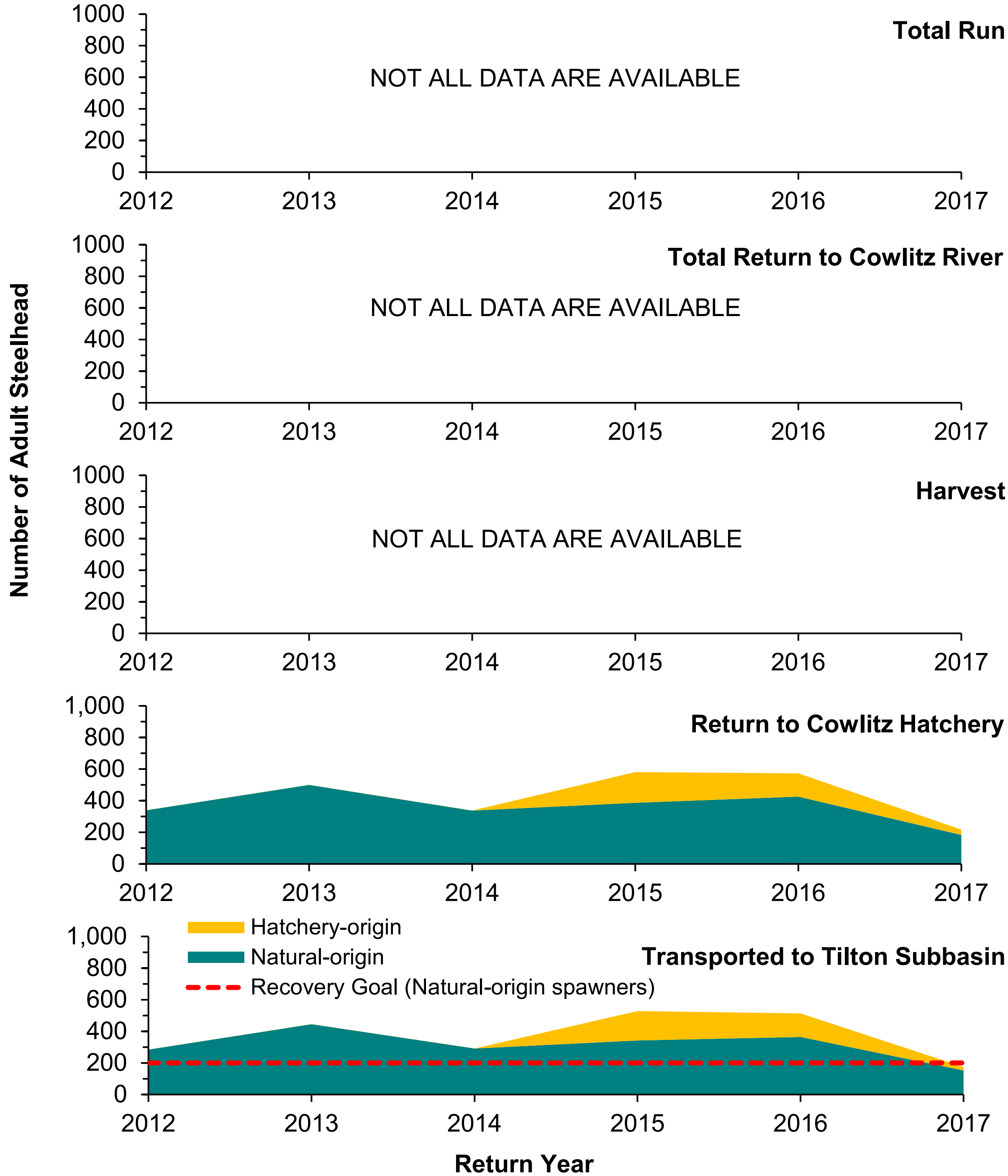


Figure 6.3-2. Estimated total run size for adult natural-origin Tilton Subbasin winter steelhead and the numbers that returned to the Cowlitz River, were harvested, returned to Cowlitz Salmon Hatchery, or were transported to the Tilton Subbasin, 2012-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

6.3.3. Natural Production

Two critical monitoring metrics for steelhead management are the numbers that return at maturation and their disposition (Figure 6.3-2; Table 6.3-1). Tilton Subbasin winter steelhead that survive to maturity may be harvested in commercial, sport, or tribal fisheries in the ocean, lower Columbia River, or lower Cowlitz River. Those escaping harvest may return to Cowlitz Salmon Hatchery or remain on the natural spawning grounds in the Lower Cowlitz Subbasin. Natural-origin winter steelhead from the Tilton Subbasin that are collected at Cowlitz Salmon Hatchery may be retained for broodstock or transported to the Tilton Subbasin for release, along with some hatchery-origin winter steelhead, where they may be harvested, die prior to spawning from predation or disease, or survive to spawn naturally. Monitoring these dispositions allows us to evaluate population health, productivity, and progress toward recovery.

6.3.3.1. Abundance

The recovery goal for the Tilton Subbasin winter steelhead population is an annual abundance of 200 adult natural-origin steelhead spawning in nature (LCFRB 2010). Only natural-origin winter steelhead that were released into the Tilton Subbasin and survive to spawn are counted toward the recovery goal.

Data that are critical to monitoring the Tilton Subbasin winter steelhead population have been only sporadically collected and are incomplete. Although the total number of adult steelhead transported and released in the Tilton Subbasin is accurately and precisely known, estimates of total natural-origin steelhead for the population are subject to error associated with: (1) spawning in the Lower Cowlitz Subbasin of unmarked steelhead that originated from the Tilton Subbasin; (2) the potential collection, transport, and release into the Tilton Subbasin of unmarked steelhead that originated from the Lower Cowlitz Subbasin that are assumed to have originated from upstream of Mayfield Dam; and (3) any collection, transport, and release into the Tilton Subbasin of unmarked steelhead that originated from outside the Cowlitz Basin.

Data are also unavailable for harvest of Tilton Subbasin winter steelhead in the ocean and Columbia River fisheries, so it is not possible to develop an accurate estimate of total run size or returns to the Cowlitz River. Returns to Cowlitz Salmon Hatchery offer a relative indication of total abundance; from 2012-2017, a mean of 362 natural-origin Tilton Subbasin winter steelhead returned to Cowlitz Salmon Hatchery (Figure 6.3-2; Table 6/3-1).

6.3.3.2. Harvest

Tilton Subbasin winter steelhead may be harvested in commercial, sport, or tribal fisheries in the Pacific Ocean, lower Columbia River, and within the Cowlitz Basin. Neither harvest numbers nor the rates for natural-origin steelhead are provided in ISIT.

6.3.3.3. Disposition

From 2012-2017, an annual mean of 313 natural-origin adults collected at Cowlitz Salmon Hatchery were transported and released in the Tilton Subbasin (Figure 6.3-2; Table 6.3-1). It is unclear what percentage of the total Tilton Subbasin run size these steelhead comprise, but of those natural-origin returns to Cowlitz Salmon Hatchery, a mean of 86% were transported upstream to the Tilton Subbasin. Although spawner survey data are not available, the total number of natural-origin steelhead transported annually has exceeded the recovery benchmark for natural spawner abundance every year during this period, except for 2017 (when 175 were transported).

6.3.3.4. Spawning in Nature

Because the total run size cannot currently be estimated, the number of natural-origin steelhead returning to Cowlitz Salmon Hatchery offers the best indication of total natural adult production. These steelhead are either collected as broodstock for the Integrated Hatchery Program or transported to the Tilton Subbasin. From 2012-2017, a mean of 362 natural-origin winter steelhead from the Tilton Subbasin population returned to Cowlitz Salmon Hatchery (Figure 6.3-2; Table 6.3-1). While actual spawning abundance is unknown, the numbers of natural-origin adult returns suggest that the population may be approaching the recovery target for abundance.

6.3.3.5. Smolt Production

From 2013-2017, a mean of 7,419 winter steelhead juveniles were captured at the Mayfield Dam Juvenile Collection Facility, which captures juveniles from the Tilton Subbasin. Of those, a mean of 9 (0.1%) were age-1 and 7,410 (99.9%) were age-2.

6.3.3.6. Natural-origin Survival and Productivity

Survival and productivity are the key metrics for monitoring populations. However, neither SAR nor productivity can be calculated for the Tilton Subbasin winter steelhead population because smolt abundance estimates are imprecise, returns are not documented by age, so a full run reconstruction of each brood year is not possible, and actual numbers of spawners in nature are unknown.

6.3.3.7. Age Composition

For run years 2012-2017, ISIT data indicate that only adult steelhead (i.e., no jacks) were transported upstream of Mayfield Dam. Because we do not have scale data for Tilton River steelhead, we cannot reconstruct the returns by brood year.

6.3.4. Hatchery Production

Hatchery production metrics must be monitored to ensure that production goals are met, evaluate the effectiveness of the program, and to understand the magnitude of hatchery influence on the natural population. Key monitoring metrics are the numbers of steelhead harvested, collected for broodstock, and spawned (by origin, age, and sex); smolts released; and steelhead returning to the Cowlitz River, Cowlitz Salmon Hatchery, and remaining in nature in the Cowlitz Basin and elsewhere. Using these data, we can calculate and monitor smolt-to-adult survival and return rates.

Winter steelhead were reintroduced to the Tilton Subbasin following the 2011 FHMP (Tacoma Power 2011), relying on the Lower Cowlitz Subbasin Late-Winter Steelhead Segregated Hatchery Program as the brood source. As the reintroduction progressed, the Tilton Subbasin winter steelhead Integrated Hatchery Program was initiated. Beginning in 2012, natural-origin winter steelhead that originated from the Tilton Subbasin and returned to Cowlitz Salmon Hatchery were incorporated into the broodstock and supplemented with minimal hatchery-origin broodstock, as needed (i.e., 2015 and 2017). From 2012-2017, broodstock spawned to support this program have consisted of means of 45 natural-origin and 3 hatchery-origin steelhead annually (Table 6.3-2).

Table 6.3-2. Mean, minimum, and maximum hatchery and natural spawning metrics for Tilton Subbasin winter steelhead, 2012-2017 spawn/brood years. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

	2012-2017 Run Years		
Spawning Location, Metric	Mean	Minimum	Maximum
Hatchery Spawning			
Mature Steelhead Collected	52	43	61
Hatchery-origin	3	0	11
Natural-origin	49	32	61
Mature Steelhead Spawned	48	41	58
Hatchery-origin	4	0	11
Natural-origin	45	31	58
Pre-spawn Survival Rate	92%	86%	98%
Total Green Eggs	Data Not Available		
Mean Fecundity	Data Not Available		
Mean Fertility	Data Not Available		
Total Eyed Eggs	Data Not Available		
Smolts Released[1]	43,812	40,030	52,292
Green Egg-to-Smolt Survival	71%	60%	77%
Smolt Productivity (smolts / spawner)[1]	900	776	1,046
Natural Spawning			
Spawners	Data Not Available		
Hatchery-origin	Data Not Available		
Natural-origin	Data Not Available		
Smolts Produced	Data Not Available		
Smolt Productivity (smolts / spawner)	Data Not Available		

1 Brood years 2012-2016.

Since 2012, the goal of the Integrated Hatchery Program has been to produce approximately 48,500 smolts annually that are marked (adipose and left-ventral clip) as the F1 progeny of natural-origin broodstock. These smolts are reared at Cowlitz Trout Hatchery and directly released into the lower Cowlitz River to avoid losses from transiting Mayfield Lake and Dam. In addition to these hatchery-origin returns, unmarked natural-origin adults returning to the hatchery that are in excess of broodstock needs are also transported and released upstream of Mayfield Dam.

6.3.4.1. Abundance

As noted above under *Natural Production*, data that are critical to monitoring the Tilton Subbasin winter steelhead population have been only sporadically collected and are incomplete. Additionally, data are unavailable for harvest of Tilton Subbasin winter steelhead in the ocean and Columbia River fisheries, so it is not possible to develop an accurate estimate of total run size or returns to the Cowlitz River. Returns to Cowlitz Salmon Hatchery offer a relative indication of total abundance; from 2012-2017, a mean of 63 hatchery-origin[1] Tilton Subbasin winter steelhead returned to Cowlitz Salmon Hatchery (Figure 6.3-2; Table 6.3-1).

6.3.4.2. Harvest

As noted above under *Natural Production*, Tilton Subbasin winter steelhead may be harvested in commercial, sport, or tribal fisheries in the Pacific Ocean, lower Columbia River, and within the Cowlitz Basin. While harvest numbers for hatchery-origin steelhead are provided in ISIT, the fishery in which these steelhead were harvested is unclear.

6.3.4.3. Disposition

Excluding the small number used as broodstock in some years, hatchery-origin Tilton Subbasin winter steelhead returning to Cowlitz Salmon Hatchery are transported to the Tilton Subbasin to supplement natural spawning and provide harvest opportunities. Over the 2012-2017 period, an annual mean of 60 hatchery-origin winter steelhead were transported and released in the Tilton Subbasin. However, this practice only began in 2015, after the hatchery-origin progeny from the initial brood year of the Integrated Hatchery Program returned as mature steelhead. Given the small number of hatchery-origin broodstock, most (95%) of the hatchery-origin Tilton Subbasin winter steelhead returning to Cowlitz Salmon Hatchery are transported and released in the Tilton Subbasin (Figure 6.3-2; Table 6.3-1). Hatchery-origin steelhead transported to the Tilton Subbasin are available for harvest, and those that survive may spawn naturally.

6.3.4.4. Hatchery Spawning

As with natural-origin returns, estimates of the total run size for hatchery-origin Tilton Subbasin winter steelhead are precluded by the lack of harvest data below Mayfield Dam. The number of hatchery-origin steelhead returning to Cowlitz Salmon Hatchery offers the best indication of run size. From 2012-2017, a mean of 63 hatchery-origin Tilton Subbasin winter steelhead returned to Cowlitz Salmon Hatchery. A mean of 3 were collected for broodstock, while the remainder were transported and released in the Tilton Subbasin (Table 6.3-1).

6.3.4.5. Hatchery Rearing

From 2012-2017, a mean of 17 females were spawned annually to support the Integrated Hatchery Program. However, ISIT reports neither the number of green nor eyed-eggs, so fecundity and fertility cannot be calculated. From brood years 2012-2016, a mean of 43,812 smolts were released in 2013-2017. Mean green egg-to-smolt survival for brood years 2012-2016 was 71% and mean smolt productivity was 900 smolts/spawner.

6.3.4.6. Age Composition

For run years 2012-2017, ISIT data indicate that only adult steelhead (i.e., no jacks) were transported upstream of Mayfield Dam. Because we do not have scale data for Tilton River winter steelhead, we cannot reconstruct the returns by brood year.

---

[1] For the purposes of this section, hatchery-origin Tilton Subbasin winter steelhead consist of those collected for broodstock at Cowlitz Salmon Hatchery or transported to the Tilton Subbasin; ISIT does not distinguish Tilton Subbasin winter steelhead returns to Cowlitz Salmon Hatchery by origin.

6.3.5. Proportionate Natural Influence

PNI is a useful metric for monitoring both hatchery and natural populations. Changes in PNI can indicate an increase or decrease in the effect of hatchery-origin steelhead on the natural population.

To reduce the effect of hatchery supplementation on the natural population that it supplements, we try to maximize the number (and percentage) of natural-origin steelhead in the hatchery broodstock and minimize spawning by hatchery-origin steelhead in nature. Absent spawning survey data, the best approximation of pHOS is based on the number of steelhead transported to the Tilton Subbasin, minus the number removed through harvest, if the data are available. This approach fails to account for other losses, such as fallback, predation, and pre-spawn mortality and is also constrained by the lack of harvest data for natural-origin steelhead in the Tilton Subbasin. Nonetheless, the resulting estimate of mean pHOS, based on the number of hatchery-origin and natural-origin fish transported, for 2012-2017 was 0.16. While this is below the HSRG standard of <0.3 for a Contributing population with an integrated hatchery program, hatchery-origin adults were not transported to the Tilton Subbasin until 2015; pHOS from 2015-2017 ranged from 0.13-0.35 with a mean of 0.26.

Given the known hatchery broodstock contribution for both natural- and hatchery-origin steelhead, pNOB can be more accurately quantified. From 2012-2017, mean pNOB was 0.95, which exceeds the HSRG standard of pHOS for a Contributing population with an integrated hatchery program. However, hatchery-origin steelhead were not incorporated into the broodstock until the first progeny from the initial brood year of the Integrated Hatchery Program returned as mature steelhead in 2015. From 2015-2017, pNOB ranged from 0.74-1.00 with a mean of 0.86, still consistently well above the HSRG standard.

Because we cannot accurately estimate pHOS, we cannot accurately estimate PNI. Based on these limited data, mean PNI was 0.89 from 2012-2017 and 0.78 from 2015-2017, both of which meet the HSRG standard of >0.5 for a Contributing population with an integrated hatchery program.

6.3.6. Future Management

The Tilton Subbasin winter steelhead population is designated as a Contributing population for achieving MPG and DPS recovery goals, with a minimum abundance target of 200 natural-origin spawners in nature. Population viability was rated as Very Low to Low (LCFRB 2010, WDFW and LCFRB 2016), but natural-origin abundance has improved, with a mean of 362 natural-origin Tilton Subbasin winter steelhead returning to Cowlitz Salmon Hatchery from 2012-2017 (ranging from 184-500). Although the number of natural-origin steelhead spawning in nature is not known, a mean of 313 natural-origin adults are transported to the subbasin annually, indicating that abundance has approached the target of 200 natural-origin spawners in nature. Likewise, since the Integrated Hatchery Program began transporting and releasing hatchery-origin adults in the Tilton Subbasin in 2015, pHOS has been below the HSRG standard of pHOS <0.3 in 2 of the 3 years (2015 pHOS = 0.35). Because the Integrated Hatchery Program has used primarily natural-origin broodstock, natural influence on the population is high.

Because this population appears close to achieving HSRG standards for hatchery influence, we will focus on refining monitoring efforts to validate this assumption (i.e., spawner surveys and estimates of harvest and strays), promoting Local Adaptation of this population, given the early stage of the Integrated Hatchery Program, and evaluating production goals such that increases are consistent with FERC license, ESA, and basin constraints. In addition, to replace the proposed reduction in Lower Cowlitz Subbasin hatchery production and maintain harvest opportunity both below Mayfield Dam and in the Tilton Subbasin, we will increase hatchery production to 100,000 smolts annually.

6.3.6.1. Conservation and Recovery Goals

Progress toward achieving conservation and recovery goals is evaluated through monitoring of standard fisheries management metrics (Table 6.3-4; Appendix A, Full Big Table). The Tilton Subbasin winter steelhead population had an historical abundance of about 1,700 steelhead. In 2010, the abundance and productivity of this population were rated as Very Low (LCFRB 2010). Today, natural-origin abundance has increased compared to when the Recovery Plan (LCFRB 2010) was drafted (i.e., <50). However, adults access the Tilton Subbasin through transport and release, rather than volitionally, and do not possess unique marks/tags identifying their origin. This increases the potential for overestimating the abundance of Tilton Subbasin returns. Likewise, although pHOS is currently thought to be low based on numbers transported to the subbasin, rates of harvest, pre-spawn mortality, and natural spawning of both hatchery- and natural-origin steelhead in the Tilton Subbasin are unknown. As production increases, goals for the number of hatchery-origin adults released in the Tilton Subbasin will be assessed relative to the number of natural-origin returns and the results of monitoring efforts to ensure that pHOS remains low.

- **Long-term Goals:** The goal for this Contributing winter steelhead population is full recovery in the Tilton Subbasin, which would include, but not be limited to:
    - Achieving and verifying adult abundance of >200 natural-origin winter steelhead spawning in nature.
    - Promoting Local Adaptation.
    - Establishing a harvestable population of winter steelhead.
    - Maintaining hatchery influence at or below HSRG thresholds and consistent with proposed recovery phase targets (Table 6.3-3).
- **FHMP Goals:** The goals for the program during the period covered by this FHMP are attainable steps toward population recovery, focusing on increasing abundance of, and reducing hatchery influence on, the natural-origin Tilton Subbasin winter steelhead population based on the following:
    - Increase production within FERC licensing, ESA, and basin constraints, with an initial goal of producing 100,000 hatchery smolts annually with pNOB >0.5. Additional returning hatchery-origin adults will also require increased harvest management in order to manage for high return years.
    - Define the disposition of surplus steelhead and management strategies for high and low return years.
    - Emphasize as key population monitoring metrics:
        - Numbers returning to the Cowlitz River.
        - Numbers of natural-origin steelhead returning to the hatchery trap.
        - Relative numbers of mature natural- and hatchery-origin steelhead transported and released in the Tilton Subbasin.

        - Relative numbers of natural- and hatchery-origin steelhead spawning in nature in the Tilton Subbasin.
        - Relative numbers of hatchery-origin and natural-origin adults spawned in hatchery broodstock.
    - Increase and improve monitoring, evaluation, and data collection, including numbers and age, sex, and origin of all recoveries:
        - Natural smolts produced.
        - Returning to Cowlitz Salmon Hatchery.
        - Retained as broodstock.
        - Transported and released upstream of Mayfield Dam.
        - Hatchery surplus.
        - Hatchery strays to/from outside of the Cowlitz Basin.
        - Actual spawners in nature.
    - Develop a plan within year-one of the FHMP to establish an early-run component for winter steelhead that:
        - Minimizes conflict with restoration of the late winter steelhead run in the Tilton Subbasin.
        - Considers best available science, existing data, and available literature to devise a recovery strategy that does the most good and the least harm to the population.
        - Considers many options, including hatchery rearing strategies, broodstock collection techniques, and other hatchery management practices to modify run- and spawn-timing.
        - Identifies a timeline for initiation of this program.
        - Recognizes the need for some harvest opportunity.
        - Fits within the recovery objectives.

Table 6.3-3. Recovery phase targets for Tilton Subbasin winter steelhead.

Species:	Winter Steelhead
Population Name:	Tilton Subbasin
Recovery Designation:	Contributing
Current Recovery Phase:	Recolonization

	RECOVERY PHASE				
Target Metric	Preser-vation	Recolon-ization	Local Adaptation	Fully Recovered	Last 5 Years
Natural Production					
Natural-origin Spawners in Nature	200	200	200	200	319[1]
Smolt Abundance (below hatchery)	TBD	TBD	TBD	TBD	N/A
Smolt Passage Survival	0.97	0.97	0.97	0.97	0.97
Productivity (5-year mean)	>1	>1	>1	>1	N/A
Hatchery Production					
Type of Hatchery Program	Seg	Seg/Int	Int	Int	N/A
Broodstock to be Collected					
Integrated Hatchery Program	32	64	64	64	52
Hatchery-Origin	16	16	0	0	4
Natural-Origin	16	48	64	64	48
Segregated Hatchery Program	0	0	0	0	0
Smolts to be Produced					
Integrated Hatchery Program	50,000[2]	100,000	100,000	100,000	43,812
Segregated Hatchery Program	0	0	0	0	N/A
Total Smolt-to-Adult Survival	TBD	TBD	TBD	TBD	N/A
Proportionate Natural Influence					
pHOS (<)					
Total	0.3	0.3	0.3	0.3	0.15[1]
Integrated Hatchery Program	0.3	0.3	0.3	0.3	0.15[1]
Segregated Hatchery Program	N/A	N/A	N/A	N/A	N/A
pNOB (>)	1	1	1	1	0.91
PNI (>)	0.5	0.5	0.5	0.5	0.87[1]
Max % of Natural-Origin Return to Cowlitz Salmon Hatchery Collected for Broodstock	30%	30%	30%	30%	14%

[1] Based on numbers transported.
[2] From WDFW and LCFRB (2016).
N/A – not available.

Table 6.3-4. Current values (5-year mean) and FHMP and long-term (recovery) goals of key monitoring metrics for Tilton Subbasin winter steelhead.

Metric	Current (5-Year Mean)	FHMP (Goal	Long-term (Recovery Plan)
Total Adult Abundance	#	#	#
Hatchery-origin	#	#	#
Natural-origin	#	#	#
Total Adults to Mouth of Cowlitz River	#	#	#
Hatchery-origin	#	#	#
Natural-origin	#	#	#
Hatchery Broodstock (spawned; all ages)	#	#	#
Hatchery-origin	# (not %)	# (not %)	# (not %)
Natural-origin	# (not %)	# (not %)	# (not %)
pNOB (Effective = spawned; all ages)	0	0.5	1
Adult Spawners in Nature	# (not %)	# (not %)	# (not %)
Hatchery-origin	# (not %)	# (not %)	# (not %)
Natural-origin	# (not %)	# (not %)	# (not %)
pHOS (Effective = spawners in nature; all ages)	Proportion	<0.4	<0.2
PNI (Effective)	0	>0.55	>0.8
Smolt Abundance	#	#	#
Hatchery-origin (Smolts Released)	#	#	#
Natural-origin (Released into Lower Cowlitz River)	#	#	#
Smolt Collection Efficiency / Passage Survival	NA (%)	NA (%)	NA (%)
Smolt-to-Adult Survival (to hatchery / spawning grounds; excluding Jacks)			
Hatchery-origin	%	%	%
Natural-origin (if unavailable, presumed higher than hatchery-origin)	%	%	%
Mean Age	#	#	#
Hatchery-origin	#	#	#
Natural-origin	#	#	#
Precocious Maturation Rate	%	%	%
Hatchery-origin Jacks	%	%	%
Natural-origin Jacks	%	%	%
Natural-origin Productivity			
Smolts / spawner	Ratio	>1	No decrease?
Adults + Jacks / spawner	Ratio	>1	No decrease?
Total Harvest (from all fisheries)	#	#	#
Hatchery-origin	#	#	#
Natural-origin	#	#	#
Harvest (% of total adult + jack return)	%	%	%
Hatchery-origin	%	%	%
Natural-origin	%	%	%

6.3.6.2. Management Targets

Based on available data, the Tilton Subbasin winter steelhead population appears to be approaching recovery goals for natural-origin abundance and hatchery influence since the initiation of the Integrated Hatchery Program. However, key uncertainties remain regarding the contribution of natural-origin strays from the Lower Cowlitz Subbasin or other downstream populations and the actual number of hatchery and natural-origin adults spawning in nature. To meet conservation goals and retain or expand harvest opportunity in the subbasin, we will refine our monitoring program such that key metrics are available to evaluate program performance.

- **Natural Production:** The goal of population recovery is to develop self-sustaining, naturally reproducing populations. Efforts to improve downstream smolt passage survival continue and recruitment from natural production will increase with the success of these efforts. Likewise, the ability to accurately estimate natural production will improve as collection efficiency at downstream passage facilities improves. Counts of adult steelhead transported to the Tilton Subbasin are reliable, but we are not certain that all natural-origin steelhead transported to the Tilton Subbasin originated there. In addition, pre-spawn mortality (a critical measure for estimating natural production) has not been estimated for steelhead (both hatchery- and natural-origin) spawning in nature, so actual pHOS is unknown. As part of this FHMP, Tacoma Power will develop and being to implement a rigorous monitoring program that is focused on evaluating program effectiveness based on regionally accepted VSP parameters.

  Triggers established in the 2011 FHMP (Tacoma Power 2011) suggest that this population is transitioning from a Recolonization phase to a Local Adaptation phase of recovery. We will continue the Integrated Hatchery Program consistent with established triggers, relying on 100% natural-origin broodstock, as available, while also continuing to transport and release both natural- and hatchery-origin adults in the Tilton Subbasin in numbers that are consistent with meeting established targets for hatchery influence on the population.

  Although the Toutle River is the downstream boundary for Tacoma Power monitoring, we do not know what influence, if any, the Toutle or other rivers have on winter steelhead populations upstream in the Cowlitz Basin. These rivers may provide a location to which mature steelhead may stray, thereby depleting the upstream populations of potential spawners. It is also possible that steelhead from the Toutle River, or the Lower Cowlitz Subbasin, may stray upstream and be captured at Cowlitz Salmon Hatchery and potentially be transported to the Tilton Subbasin. We will adopt a marking/tagging scheme to differentiate natural-origin Tilton Subbasin winter steelhead from strays as a means to do so becomes available.

- **Abundance – Transport and Natural Spawning:** The population appears to be approaching the recovery goal of 200 natural-origin spawners. We will focus our monitoring of abundance on the numbers of hatchery- and natural-origin winter steelhead that return to the Cowlitz River, to Cowlitz Salmon Hatchery, transported to the Tilton River, and of actual spawners in nature each year. These metrics are critical for achieving recovery and the number of spawners is used to calculate recruits/spawner.

- **Smolts Produced in Nature:** Natural-origin smolt production from the Tilton Subbasin is not well known. However, recent improvements in collection efficiency at the Mayfield Collection Facility will improve our ability to estimate natural-origin smolt production in the coming years. Our current state of knowledge focuses on smolts handled at

Mayfield Dam Counting House. Steelhead smolts are collected throughout Mayfield Dam's entire operational window of April-December; however, most of the smolts are collected from April-June. A mean of 5% are collected in April, 60% in May, 33% in June, and the remaining 2% in July – December (years 2012-2019). Total annual smolt collection from 2012-2019 ranged from 5,555 in 2012 to 11,152 in 2015, with an annual mean total of 7,018.

- **Smolt-to-Adult Survival:** Because smolt abundance is not estimated (fish handled at the Counting House are only a fraction of the total population), and returns are not documented by age, SAR cannot be estimated. We will monitor this index as the means to do so become available, through our M&E Program.
- **Productivity (Recruits/Spawner):** Because returns are not documented by age, productivity also cannot be estimated. Productivity (mature natural-origin F_1 recruits / F_0 spawner) is the primary metric for monitoring natural populations, so collection of the necessary data is critical. We will monitor this index as the data become available through our M&E Program.
- **Hatchery Production:** During recovery efforts to date, hatchery influences on the Tilton Subbasin population have consisted of the transport and release of hatchery-origin adults to spawn naturally (mean pHOS = 0.13) and the use of some hatchery-origin broodstock to supplement natural-origin broodstock (mean pNOB = 0.93), resulting in a mean PNI of 0.89. Given that returns of natural-origin adults have exceeded returns of hatchery-origin adults, these metrics of hatchery influence are within recovery targets and natural influence on the Upper Cowlitz Subbasin population is high.

  During this period, we will increase production of the Integrated Hatchery Program to 100,000 smolts annually. This increase in production is intended to offset the proposed reduction in hatchery smolts produced in the Lower Cowlitz Subbasin so that harvest opportunity is maintained in both the Lower Cowlitz and Tilton subbasins. Achieving this goal will require additional egg take, which will be accomplished through the continued use of similar numbers of natural-origin broodstock in addition to an increased number of hatchery-origin broodstock. To ensure that the HSRG standard for PNI >0.5 is strictly adhered to, the number of hatchery-origin broodstock will not exceed the number of natural-origin broodstock and will be further constrained based on the prevailing rates of pHOS (pNOB >0.5). We will also continue transporting hatchery-origin adults to the Tilton Subbasin.

  We will develop and implement a rigorous sampling and monitoring program, along with a database for the hatchery program, to allow the managers to better evaluate and manage the hatchery programs. The numbers of broodstock to be collected, by week, origin, age, and sex, will be set at the Annual Program Review meeting and documented in the Annual Operating Plan (see Chapter 11). The collection schedule will be based on the smolt production needs of each program and the most recent 5-year means of pre-spawn mortality, fecundity, fertility, hatching rates, and survival rates from hatching-to-swim-up fry, fry-to-parr (at marking), and parr-to-smolt survival rates. Improved monitoring of returns will also be needed to estimate stray and smolt-to-adult survival and return rates and evaluate the hatchery programs.

  Hatchery-origin steelhead returning to Cowlitz Salmon Hatchery are transported and released into the Tilton Subbasin for harvest and to supplement natural production, along with natural-origin steelhead collected at the hatchery that are transported into the Tilton Subbasin. Going forward, it will be important to document both the number of hatchery- and natural-origin steelhead released in the Tilton Subbasin. It will also be important to monitor these releases and determine the numbers of steelhead from all groups that survive to spawn in their respective release locations.

- **Harvest:** Decreasing the harvest of natural-origin steelhead would incrementally increase potential natural-origin spawning abundance. Because retention of natural-origin steelhead is prohibited in recreational fisheries, exploitation rates are likely low. Reducing harvest rates further may be an impractical means of substantially increasing natural-origin abundance. However, an important data gap in ISIT is the harvest/exploitation rates for natural-origin steelhead, particularly in terminal fisheries. Gaining a clear understanding of harvest impacts on natural-origin Tilton Subbasin steelhead is critical.
- **Proportionate Natural Influence:** The Integrated Hatchery Program is intended to prioritize recovery of the indigenous Tilton Subbasin population while still providing for harvest opportunity. Harvest opportunity in the Tilton Subbasin is controlled by the number of hatchery-origin adults transported and released in the subbasin. Increases in this number will require careful management to ensure that pHOS remains below the established threshold. This can be accomplished by either concomitant increase in the number of natural-origin spawners in the subbasin, or by managing harvest to ensure that the number of hatchery-origin spawners remains below a critical level.
- **Age Composition:** Because all steelhead returning to the Tilton Subbasin are handled at Cowlitz Salmon Hatchery, the age composition of those transported can be controlled. ISIT reports only "adult" steelhead being transported upstream of Mayfield Dam, but the age composition of these steelhead is not provided. Collecting this information in the future will be important for evaluating potential effects of releasing early maturing steelhead for natural production in the Tilton Subbasin.

6.3.6.3. Monitoring and Evaluation (M&E) and Research

<u>Baseline Studies</u>

Baseline studies are those required to adequately monitor a population so that we can effectively manage it. Baseline monitoring is conducted annually in order to track the population's trajectory and variability and includes the basic data required to operate a one-stage or two-stage life cycle model. Because smolt abundance cannot be reliably monitored for the natural-origin Tilton Subbasin winter steelhead population, year-class abundance is more accurately determined based on the returns of adult steelhead; so, it is anticipated that baseline studies for this population will focus on mature steelhead returns until collection efficiency improves.

Current M&E work for Tilton Subbasin winter steelhead is focused on addressing monitoring needs, such as:

- Estimating harvest rates of hatchery- and natural-origin steelhead in all fisheries.
- Estimating hatchery- and natural-origin pre-spawn mortality, spawning areas, and natural spawning in the Tilton Subbasin.
- Identifying the source of natural-origin returns to the hatchery trap.
- Estimating pHOS and pNOB.
- Estimating natural-origin population productivity (spawner-to-spawner).
- Quantifying the number of smolts produced in the Tilton Subbasin.
- Evaluating the ability to differentiate steelhead smolts naturally produced in the Upper Cowlitz Subbasin from those naturally produced in the Tilton River.

At the time of this writing, some of these efforts are incomplete (e.g., spawner escapement is not differentiated from the number of adults transported upstream to the Tilton Subbasin, and data are not entered into ISIT for all fisheries), so, while metrics can be calculated, they are inaccurate. Expanded monitoring should include collecting data and samples to enable the runs to be further characterized by age and sex, where appropriate, to enable complete run reconstruction.

Critical factors are those that are most likely to affect a population, positively or negatively, and its progress toward recovery, as well as those metrics that are most important for monitoring the progress of a population toward recovery and our management of that population. For natural populations, population productivity ("spawner-to-spawner" - the number of F_1 generation recruits that survive to spawn for each F_0 generation spawner) is the key monitoring index; thus, the key metric is adult spawners in nature. Other metrics that affect this index, such as numbers of steelhead harvested, strays, natural smolts produced, and steelhead spawned in nature, are also important. These data allow us to calculate the rates and proportions, such as harvest rates and pHOS, which determine hatchery program levels and management actions (see Chapter 9 for more details).

We will track population metrics annually and compare annual and 5-year means with program recovery goals and targets. The consistent availability of data in ISIT is insufficient to examine trends for any metrics at this time. Annual estimates of natural-origin returns to the Tilton Subbasin and spawning grounds (spawner abundance) and of hatchery-origin spawners in nature (for pHOS) are the most important metrics to track over time. Harvest of natural-origin steelhead is the primary source of mortality over which we have some control, so harvest rates, overall and for individual fisheries, are also important metrics. The 5-year running means of these variables will be reported every year.

We evaluate our effectiveness in applying the Decision Rules by comparing our goals with the actual results for each year. We examine metrics such as harvest rates and escapement to the spawning grounds/hatchery to evaluate how well we are managing the fisheries. Comparing return abundances allows us to evaluate our ability to predict run size and to improve our ability to do so. Additional metrics are monitored, which allow us to develop an even deeper understanding of this population (see Chapter 9).

For the Tilton Subbasin winter steelhead population, spawning in nature by hatchery- and natural-origin steelhead is not reported in ISIT; only numbers of steelhead transported upstream to the Tilton Subbasin are reported. Because some losses would occur from natural mortality or exploitation, using this metric overestimates spawning in nature. Natural spawning abundance data are needed to more accurately identify trends and evaluate the performance of recovery efforts.

No estimates of smolt abundance, nor the quantity or quality of their habitat, are included in the current monitoring effort. Estimates of juvenile passage survival and/or collection efficiency are not provided in ISIT, nor are the numbers of natural-origin smolts collected at Mayfield Dam. Even if smolt collection numbers were provided, not all smolts are collected, so these data may not be an accurate estimate of natural smolt production. Additionally, the adult data currently available in ISIT are only apportioned by age class in the form of jacks and adults and only for returns to Cowlitz Salmon Hatchery, not for other recovery locations (e.g., harvest or spawning in nature), and numbers transported upstream were only reported for adults. Apportioning returns by age and sex, as well as recovery location, is necessary for accurately estimating brood year abundance, survival, and productivity; stray rate; and total run year abundance in order to better understand natural and hatchery production.

Directed Studies

Directed studies are designed to diagnose and solve problems associated with achieving FHMP goals and to fill management needs and information gaps in the Big Table (Table 6.3-4; Appendix A). Important areas of study for the Tilton Subbasin winter steelhead population include:

- **Spawning ground surveys:** Scales, CWT, hatchery-origin/natural-origin ratio, mortality, pre-spawn, genetics, spatial distribution (upper extent), and reach-specific adult densities (sub-sample).
- **Juvenile rearing capacity studies:** Available habitat and habitat-specific (run/riffle/pool) densities.
- **Early life stage survival studies:** Egg-to-fry, fry-to-parr, and parr-to-smolt survival rates.
- **In-river migratory survival and behavior:** Survival of migrating juveniles and movement rates.
- **Reservoir survival:** Predation rate and parasite loadings.

6.3.7. Summary

- Although functionally extirpated from upstream habitats following the completion of Mayfield Dam, Tilton Subbasin winter steelhead population genes were incorporated into the Lower Cowlitz Subbasin population, providing the founding stock for recovery.
- The Integrated Hatchery Program began in 2012, in which natural-origin winter steelhead returning to Cowlitz Salmon Hatchery are collected and used as broodstock, with little or no use of hatchery-origin steelhead broodstock. Both natural-origin returns in excess of broodstock requirements, and hatchery-origin returns that are the F_1 progeny of natural-origin broodstock are released in the Tilton Subbasin.
- Abundance is approaching the minimum recovery abundance target based on natural-origin returns to Cowlitz Salmon Hatchery and the numbers transported to the Tilton Subbasin.
- Key uncertainties in assessing progress toward recovery goals remain:
    - All untagged natural-origin returns to Cowlitz Salmon Hatchery are assumed to belong to the Tilton Subbasin population, but the proportion that may be unmarked strays from the Lower Cowlitz Subbasin cannot be quantified under the current tagging scheme.
    - Spawner surveys are not conducted in the Tilton Subbasin, so the numbers that actually spawn are unknown. Numbers transported and released in the Tilton Subbasin fail to account for factors such as pre-spawn mortality, harvest, or fallback.
- We will increase production within FERC licensing, ESA, and basin constraints, with an initial goal of producing 100,000 hatchery smolts annually with pNOB >0.5.
- We will examine opportunities to establish an early-winter run component that more closely emulates the historical run-timing of the winter steelhead population and also provides for increased recreational/harvest opportunity.

- Adjustments to the summer steelhead Segregated Hatchery Program to provide additional recreational/harvest opportunity will be evaluated relative to the recovery of the Tilton Subbasin winter steelhead population.
- In the near-term (i.e., this FHMP), we will:
    - Increase and improve monitoring, evaluation, and data collection, with an emphasis on key population metrics including the number, age, sex, and origin of all recoveries.
    - Maintain flexibility to increase production within FERC licensing, ESA, and basin constraints. Additional returning hatchery-origin adults will require increased harvest management to manage for high return years.
    - Define the disposition of surplus salmonids and management strategies for high and low return years.
    - Define triggers (i.e., Decision Rules) for moving from one stage of recovery to another (e.g., adult abundance, spatial distribution, fish passage survival) while considering various recovery strategies.
    - Develop a plan within year-one of the FHMP to establish an early-run component for Tilton Subbasin winter steelhead.

Intentionally blank page

CHAPTER 7:
CUTTHROAT TROUT

Cutthroat Trout *Oncorhynchus clarkii*

ESA Listing

Status:	Not ESA-listed; Species of Concern (federal), Depressed (state)
Distinct Population Segment:	Southwestern Washington/Lower Columbia River Coastal Cutthroat Trout
Major Population Group:	NA
Recovery Region:	NA
Populations and Recovery Designations:	Cowlitz Basin Coastal Cutthroat Trout – not designated
Current Hatchery Program(s):	100,500 yearling (age-2) smolts:
	Cowlitz Trout Hatchery Segregated Hatchery Program - 90,500 smolts
	Friends of the Cowlitz - 10,000 smolts
Proposed Hatchery Program(s):	100,500 yearling (age-2) smolts:
	Cowlitz Trout Hatchery Segregated Hatchery Program - 90,500 smolts
	Friends of the Cowlitz - 10,000 smolts

7.0. Cutthroat Trout

7.0.1. Program Focus

Coastal Cutthroat Trout are not listed under the ESA, nor does the Recovery Plan set specific recovery targets for the species (WDFW and LCFRB 2016). However, coastal Cutthroat Trout are a federal species of concern and the Cowlitz Basin population was classified as Depressed by WDFW (Blakley et al. 2000). Recovery of the natural population is focused on reversing declining trends in adult and smolt abundance and maintaining life history diversity (LCFRB 2010).

Following completion of Mayfield Dam, anadromous Cutthroat Trout were restricted to the Lower Cowlitz Subbasin, while resident forms persisted upstream. The Cowlitz Basin anadromous Cutthroat Trout Segregated Hatchery Program began in 1968 to mitigate for losses caused by dam construction and the current production goal is 100,500 age-2 (yearling) smolts and 5,000 returning adults (LCFRB 2010). Over the period covered by this FHMP, the focus for the Segregated Hatchery Program will be to provide harvest opportunity, while minimizing hatchery impacts on the natural population. As such, we will continue the Segregated Hatchery Program at the same level of annual production.

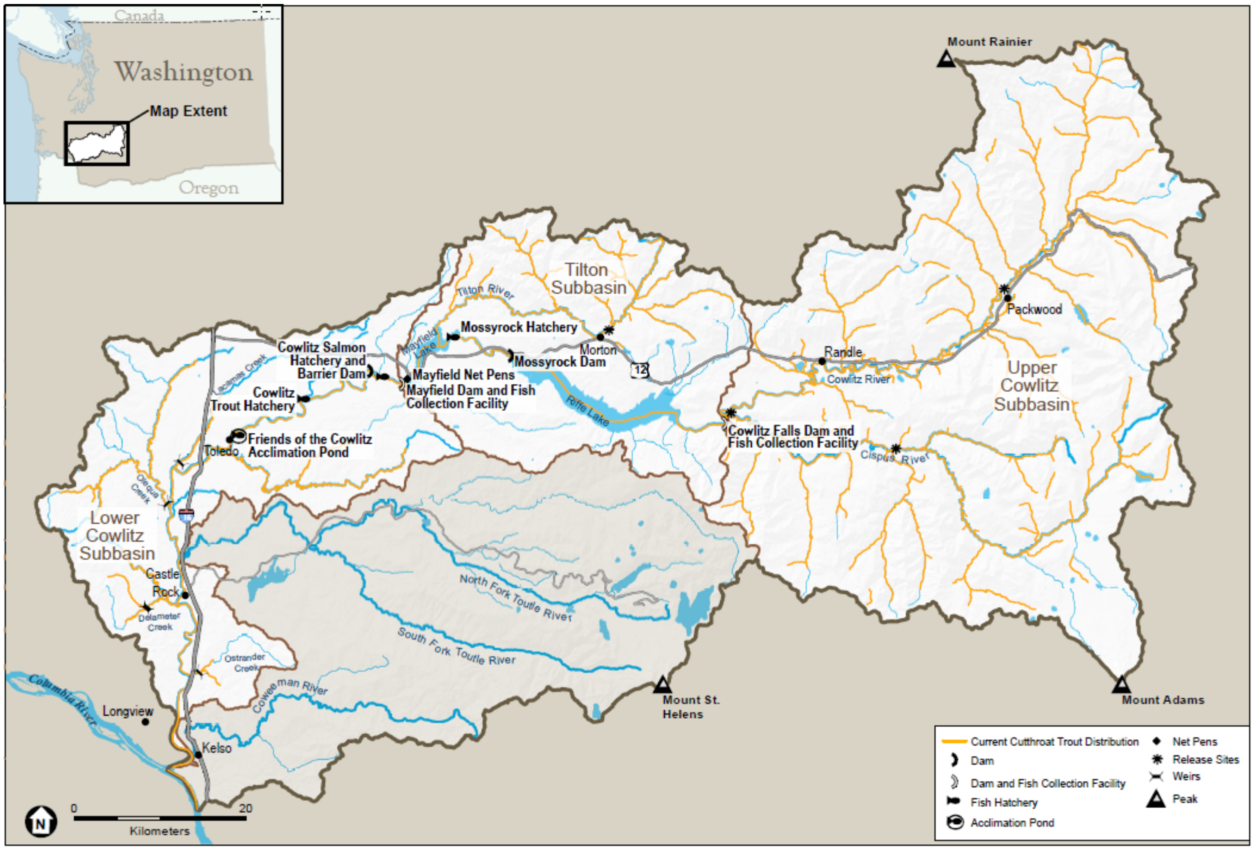


Figure 7.0-1. Distribution of Cutthroat Trout in the Cowlitz Basin, Washington.

7.0.2. Demographically Independent Population

The Cowlitz Basin Cutthroat Trout population is part of the Southwestern Washington/ lower Columbia River Coastal Cutthroat Trout DPS. Based on their geographic spawning distribution (Figure 7.0-1) and genetic sampling, all Cutthroat Trout within the Cowlitz Basin (excluding the populations in the Toutle and Coweeman basins) are considered a single population that is separate from those of other lower Columbia River tributaries (Blakley et al. 2000; LCFRB 2010).

7.0.3. Life History Diversity and Distribution

Cutthroat Trout inhabiting the Cowlitz Basin exhibit three different life history forms: anadromous, resident, and adfluvial (LCFRB 2010). Historically, the anadromous form occurred throughout the basin but was mostly restricted to the Lower Cowlitz Subbasin following construction of Mayfield Dam. However, natural-origin Cutthroat Trout smolts are still captured at the juvenile collection facilities at Cowlitz Falls and Mayfield dams and adults captured at Cowlitz Salmon Hatchery are transported upstream. A resident form that primarily utilizes headwater habitats is found throughout the basin and an adfluvial form resides in the Tilton and Upper Cowlitz subbasins that utilizes larger riverine habitats and the reservoirs created by Mayfield, Mossyrock, and Cowlitz Falls dams (Blakley et al. 2000).

Anadromous natural-origin adults return to the Cowlitz Basin from July to October, with peak returns in August and September (Blakley et al. 2000; LCFRB 2010). Spawning occurs from January through mid-April and smolts outmigrate in the spring, after rearing for 2-3 years in freshwater. Resident and adfluvial Cutthroat Trout are thought to exhibit similar spawn timing as natural-origin anadromous trout and likely hybridize where their ranges overlap. Cowlitz Trout Hatchery produces Cutthroat Trout smolts to supplement the anadromous component of the population. The returning hatchery-origin adults spawn earlier, from November to February, as a result of artificial selection for early-returning trout (Blakley et al. 2000).

7.0.4. History and Recent Abundance

Historically, anadromous Cutthroat Trout were able to access most of the Cowlitz Basin except for the upper portions of tributaries, where steep gradients and high flows limited passage (Blakley et al. 2000). Completion of Mayfield Dam limited anadromy to the Lower Cowlitz Subbasin, while the resident life history form persisted in the Tilton and Upper Cowlitz subbasins and the adfluvial components of the population adapted to reservoirs associated with Mayfield, Mossyrock, and Cowlitz Falls dams (Blakley et al. 2000). By 1990-1994, the 5-year mean number of anadromous Cutthroat Trout returning to Mayfield Dam (1,628 trout) was only 19% of the mean of 8,698 trout from 1962-1966 (LCFRB 2010; Blakley et al. 2000). Recent returns of anadromous adults to Cowlitz Salmon Hatchery remain low; a mean of 1,189 adults returned from 2007-2017, of which 1,049 were hatchery-origin and 140 were natural-origin (Figure 7.0-2; WDFW 2019). No abundance estimates are available for the resident or adfluvial components of the population.

Smolt abundance has been low, with <1,000 smolts typically counted annually at each of Cowlitz Falls and Mayfield Dams from 1978-2006, representing roughly 10% of counts when collections began in the early 1960s (LCFRB 2010). From 2007-2017, a mean of 584 and 810 smolts were collected annually at Cowlitz Falls Dam (Upper Cowlitz Subbasin) and Mayfield Dam (Tilton Subbasin), respectively. Smolt production from the Lower Cowlitz Subbasin has not been estimated.

7.0.5. Harvest

Anadromous Cutthroat Trout are not harvested in commercial, tribal, or recreational ocean fisheries but hatchery-origin trout from the Segregated Hatchery Program are harvested by anglers in mainstem Columbia River and Lower Cowlitz Subbasin fisheries (LCFRB 2010). If caught, natural-origin Cutthroat Trout must be released.

Annual harvest rates for Cowlitz Basin Cutthroat Trout are unknown. However, WDFW established long-term goals for harvest of Cowlitz Basin anadromous Cutthroat Trout in terms of catch numbers, harvest rates, and seasons by fishery (Tacoma Power 2011):

- Preterminal fishery: <1% exploitation rate.
- Lower Cowlitz Subbasin fishery (June-November): in-river catch of 4,500 adults.
- Upper Cowlitz Subbasin fishery: None.
- Tilton Subbasin fishery: None.

These are not necessarily the goals associated with the Settlement Agreement, but rather long-term goals and achieving them may require implementation of measures beyond the scope of the Settlement Agreement.

7.0.6. Natural Production

Natural production of Cutthroat Trout in the Lower Cowlitz Subbasin is provided by anadromous hatchery- and natural-origin adults that are not harvested/exploited and survive to spawn successfully. From 2007-2017, a mean of 127 (86-211) adults (all natural-origin) were transported and released above Mayfield Dam to spawn naturally (Figure 7.0-2). Of those, a mean of 105 (65-162) were released into the Tilton Subbasin and 23 (4-49) into the Upper Cowlitz Subbasin. Some natural production is also provided by resident and adfluvial trout throughout the Cowlitz Basin but the degree to which these spawners contribute to anadromous smolt production is unknown.

Natural-origin smolt production from the Lower Cowlitz Subbasin is unknown and cannot be estimated at present. Smolt monitoring in the Lower Cowlitz Subbasin is conducted using a screw trap in the mainstem Cowlitz River and is difficult due to the large size of the river. Accurate estimates of natural-origin Cutthroat Trout smolt production from the Tilton and Upper Cowlitz subbasins are limited by the collection efficiency at Mayfield and Cowlitz Falls dams. Means of 810 and 584 natural-origin smolts were collected annually from 2007-2017 at Mayfield and Cowlitz Falls dams, respectively.

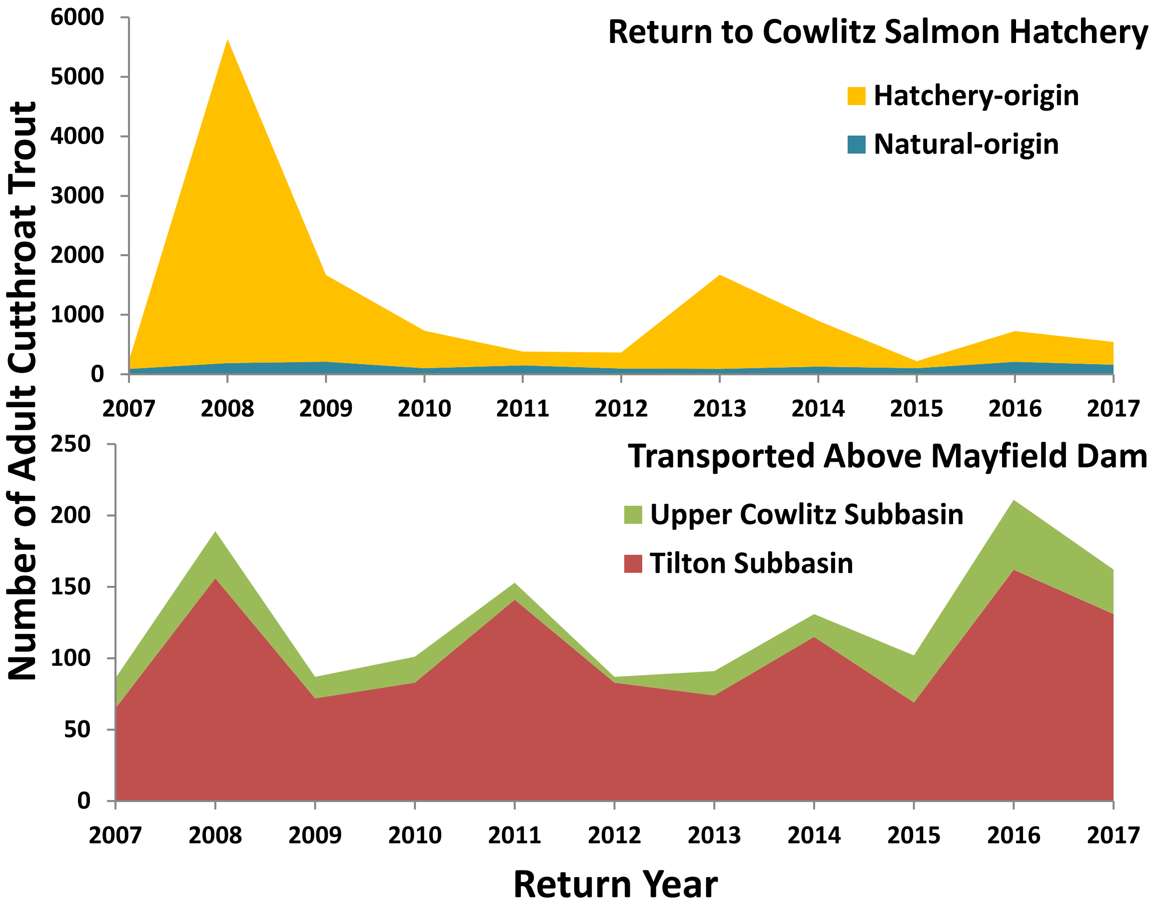


Figure 7.0-2. Numbers of adult Cutthroat Trout of hatchery- and natural-origin returning to Cowlitz Salmon Hatchery and of total adults transported upstream of Mayfield Dam, 2007-2017. Note: data are the most recently available, as compiled by Tacoma Power and WDFW, and may not be complete.

7.0.7. Artificial Production

Since 1968, the Cowlitz Trout Hatchery has produced anadromous Cutthroat Trout through a Segregated Hatchery Program (LCFRB 2010). The current goal of this program is to produce 100,500 age-2 (yearling) smolts to yield an annual return to the hatchery of 5,000 adults. At present 90,500 smolts are produced at Cowlitz Trout Hatchery and 10,000 parr are transported to the Friends of the Cowlitz for final rearing to smolt and release.

We are consistently able to meet our broodstock requirements and production goals. Therefore, we will continue this hatchery program at the same level of production to continue providing harvest opportunity in the lower Cowlitz River terminal fishery. However, we will also explore the efficacy of moving from a Segregated to an Integrated Hatchery Program during this FHMP period.

7.0.8. Management

Management of the Cowlitz Basin Cutthroat Trout population will focus on the anadromous life history and the fishery that it supports. The hatchery program seems to be popular but there is little documentation of this popularity or the actual harvest. To that end, we will improve our monitoring of the fishery, through creel surveys.

We may conduct directed studies focused on improving the efficacy and management of the Cutthroat Trout hatchery program. There is some concern that the large (90 g) hatchery-origin smolts released from Cowlitz Trout Hatchery may prey on juveniles of other anadromous salmonids, particularly spring Chinook Salmon. WDFW conducted a small study to examine the presence of Cutthroat Trout in the lower Cowlitz River and their diet. Annual reports from 2014 (Gleizes et al. 2015) and 2015 (Gleizes et al. 2017) show that only 15.5% and 7.1%, respectively, of the hatchery-origin Cutthroat Trout examined contained fish in their stomachs and only 2.4% and 1.2% contained identifiable juvenile Chinook Salmon. While this study indicated that a low percentage of the Cutthroat Trout examined were piscivorous, it did not estimate the total number of hatchery-origin Cutthroat Trout that had residualized in the lower Cowlitz River nor their potential impact on juvenile anadromous salmonids. Further examination of this issue may be warranted.

Residualization of hatchery-origin Cutthroat Trout is a potential threat to juveniles of other anadromous salmonids but also counter to the focus of this hatchery program. If a substantial proportion of the hatchery-origin smolts are residualizing in the lower Cowlitz River, instead of migrating to the ocean, then the program is not achieving its goal. We may collect scales and/or otoliths from Cutthroat Trout returning to the hatchery to document ocean entry by these trout. We may be able to use these results to spawn only anadromous Cutthroat Trout for the hatchery program. Additionally, if we find that there is substantial residualism, we will examine potential causes, such as the large size of the smolts and test alternative rearing methods to increase anadromy. These studies will improve our ability to produce anadromous Cutthroat Trout, which is the focus of the program.

7.0.9. Summary

- Construction of Mayfield Dam mostly blocked anadromous Cutthroat Trout from using habitat in the Tilton and Upper Cowlitz subbasins.
- A Segregated Hatchery Program was initiated in 1968 to supplement the remaining anadromous Cutthroat Trout in the Lower Cowlitz Subbasin and maintain harvest opportunity.
- We will continue this Segregated Hatchery Program for anadromous Cutthroat Trout, with an annual goal of producing 100,500 age-2 (yearling) smolts.
- We will continue to evaluate the program for harvest opportunity and effectiveness while minimizing hatchery influence on the natural Cutthroat Trout population.

CHAPTER 8:
CHUM SALMON

Chum Salmon *Oncorhynchus keta*

ESA Listing

Status:	Threatened Listed in 1999, reaffirmed in 2011 and 2016
Evolutionarily Significant Unit:	Columbia River Chum Salmon
Major Population Group:	Cascade Chum Salmon
Recovery Region:	Lower Columbia River Salmon
Populations, Recovery Designations, and Abundance Targets (natural-origin adults spawning in nature):	Cowlitz Basin Summer - Contributing, 900 Cowlitz Basin Fall - Contributing, 900
Current Hatchery Program(s):	None
Proposed Hatchery Program(s):	None

8.0. Chum Salmon

Chum Salmon in the Cowlitz Basin are considered by the Recovery Plan to be part of a single, larger population that is comprised of those produced naturally in the Lower Cowlitz, Toutle, and Coweeman subbasins (LCFRB 2010; WDFW and LCFRB 2016). As part of the Columbia River Chum Salmon ESU, this population was listed as threatened in 1999. Historically, the Cowlitz Basin Chum Salmon population was the largest in the Lower Columbia Subbasin, producing from 300,000-500,000 adults; however, recent estimates of returns (<150 salmon; LCFRB 2010) and baseline escapement (<300 salmon; WDFW and LCFRB 2016) are currently Very Low, and the population is considered to be at a High to Very High Risk of extinction (Table 8.0-1).

No hatchery releases of Chum Salmon occurred historically in the Cowlitz Basin, nor is there a current or proposed hatchery program. However, four hatchery programs in the lower Columbia River (Grays River, Big Creek, Lewis River, and Washougal hatcheries) currently release juvenile Chum Salmon (NMFS 2016) and could potentially influence the Cowlitz Basin population through straying. The dramatic and persisting declines in abundance are attributed to the severe and long-term degradation of Chum Salmon habitat in the Lower Cowlitz Subbasin (LCFRB 2010). While historic harvest rates have also contributed to reduced abundance, current fisheries impacts on the population are thought to be minimal because harvest of Chum Salmon in Columbia River and terminal fisheries is prohibited and ESA restrictions on incidental harvest in other fisheries is limited to <5% of the annual return (LCFRB 2010).

The Cowlitz Basin Chum Salmon population is managed as a single population but is the combination of two separate populations recognized during ESA recovery planning: a predominant fall run and a summer run that was identified based on returning adults recovered in the Cowlitz River and at Cowlitz Salmon Hatchery (LCFRB 2010). Genetic analysis following the 1999 listing of the population suggested that this summer run existed historically and occupied the upper reaches of the Chum Salmon distribution in the Cowlitz Basin (Ford et al. 2011). Concluding that the Cowlitz Basin summer run represents a unique life history of the ESU and an important component of diversity, the 2011 NOAA Fisheries Status Review (Ford et al. 2011) suggested adding Cowlitz Basin summer Chum Salmon as a new population.

Table 8.0-1. Recovery priority, baseline viability status, viability and abundance objectives, and productivity improvement targets for Cowlitz Basin Chum Salmon populations (from LCFRB 2010).

	Demographically Independent Population	
	Lower Cowlitz Subbasin	Lower Cowlitz Subbasin
Run	Fall	Summer
Recovery Priority Designation[1]	Contributing	Contributing
Abundance		
Historic[2]	195,000	unknown
Current (last 5 years)[3]	<300	unknown
Target[4]	900	900
Baseline Viability[5]		
Abundance & Productivity	Very Low	Very Low
Spatial Structure	High	Low
Diversity	Low	Low
Net Viability Status	Very Low	Very Low
Viability Improvement[6]	>500%	>500%
Recovery Viability Objective[5]	Medium	Medium
Proportionate Natural Influence		
pHOS	<0.1	<0.1
pNOB	NA	NA
PNI	NA	NA

[1] Primary, Contributing, and Stabilizing designations reflect the relative contribution of the population to Major Population Group recovery goals.
[2] Historic population size was mean number, inferred from presumed habitat conditions using EDT Model and NMFS back-of-envelope calculations.
[3] Approximate current mean annual number of naturally produced Chum Salmon returning to the watershed. Note that these values are 5-year means and are not necessarily consistent with mean values over various intervals that are presented elsewhere.
[4] Abundance targets were estimated by population viability simulations based on viability goals.
[5] Viability status is based on Technical Recovery Team viability rating approach. Viability objective is based on the scenario contribution. Very Low (>60% chance of extinction); Low (26-60% chance of extinction); Medium (6-25% chance of extinction); High (1-5% chance of extinction); Very High (<1% chance of extinction).
[6] Improvement is the relative increase in population abundance and productivity required to reach the prescribed viability goal.

The current size of both runs is poorly understood, and estimates are limited to the small numbers collected at Cowlitz Salmon Hatchery (typically less than 20 adults per year; LCFRB 2010). ISIT does not provide any data regarding the abundance of Cowlitz Basin Chum Salmon. Both summer and fall Cowlitz Basin Chum Salmon are considered Contributing populations for recovery of the ESU; the recovery goal is to achieve an abundance of 1,800 natural-origin spawners; 900 for each of the summer and fall runs (LCFRB 2010).

Historically, Chum Salmon are thought to have migrated upstream past the site of Mayfield Dam. The current distribution of Cowlitz Basin Chum Salmon includes production from the lower mainstems of the Cowlitz (downstream of Cowlitz Salmon Hatchery), Toutle, and Coweeman rivers, as well as limited spawning in the lower reaches of Ostrander, Arkansas, Salmon, Olequa, and Lacamas creeks (LCFRB 2010; Figure 8.0-1). Fall Chum Salmon return to the Cowlitz Basin from mid-October through November, with peak spawning in late November; summer Chum Salmon return earlier although specific run and spawn timing are unclear. Following spawning and incubation, fry emerge in early spring and migrate downstream as age-1 (sub-yearling) smolts from March to May (LCFRB 2010).

During the period covered by this FHMP, no hatchery programs will be operated for the production of Cowlitz Basin Chum Salmon. However, establishing viable Chum Salmon populations within the Cascade stratum remains a recovery challenge, so keeping the door open for approaches that may involve some form of recovery support is important. Therefore, this FHMP does not preclude any entity from conducting Chum Salmon production through supplemental production efforts, such as remote site incubators, as long as these efforts are consistent with WDFW and Conservation and Sustainable Fisheries guidelines.

As part of the overall programmatic efforts described for the other species in this FHMP, we will increase and improve data collection for monitoring and evaluation, which will provide managers with a better understanding of the abundance and biology of Cowlitz Basin Chum Salmon and progress toward meeting population recovery goals.

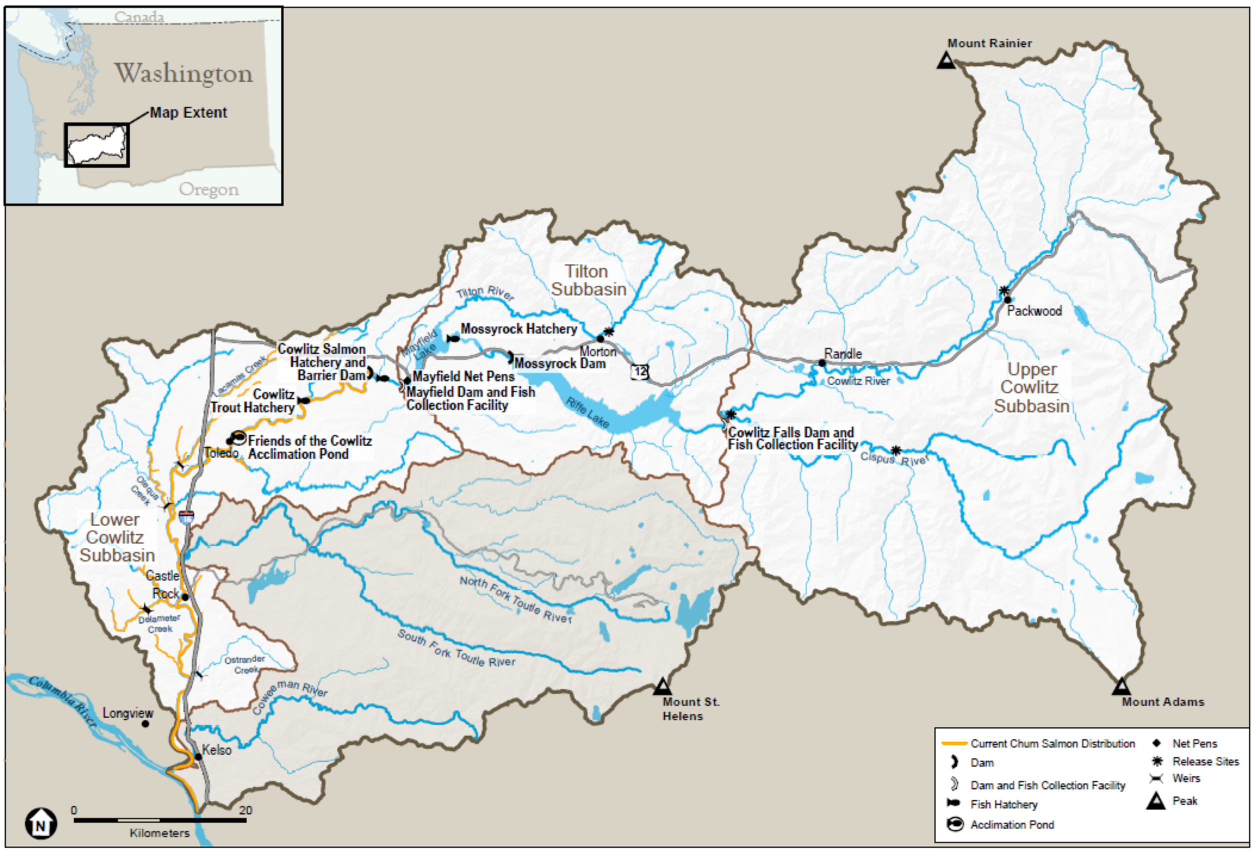


Figure 8.0-1. Current distribution of Chum Salmon in the Cowlitz Basin, Washington.

CHAPTER 9:
MONITORING & EVALUATION

9.0. Monitoring & Evaluation (M&E)

9.1. Purpose

Monitoring & Evaluation (M&E) data provide the basis for management and operation decisions. The M&E chapter of the FHMP describes our current state of knowledge about populations throughout the Cowlitz Basin, our ongoing M&E work, and pressing data gaps that need to be addressed over the time frame of this FHMP. Baseline data collected feeds directly into decisions about hatchery programs and fish dispositions, while directed study data address pressing data gaps that would improve fish or population management. In a broader perspective, this M&E chapter describes the parameters that characterize and allow managers to better understand the impact of Tacoma Power's hatchery programs on natural populations and if those natural populations are properly progressing toward recovery.

This chapter does not focus on individual studies by species and population; instead, it serves as a road map for all species and populations by identifying parameters of interest for salmonids in the Cowlitz Basin. The chapter focuses on describing the measures necessary to describe this program through both baseline and directed studies, as well as how they differ, rather than the content of a specific study. The Monitoring Plan, which is briefly described in this chapter, contains additional detail on measures identified for each baseline and directed study and some potential implementation methods. Regardless of the study type, the ultimate goal of FHMP studies is to gather the data required to inform parameter estimates that can be input into a life cycle model to understand current and potential future population performance. The M&E chapter also defines how and when M&E data gathered will be summarized and inform the Annual Program Review process.

9.2. Overview of Baseline and Directed Studies

Throughout this chapter, we, refer to both baseline and directed studies, as defined below.

Baseline Studies are basic monitoring activities and are examined and assessed on a regular basis (e.g., annually, every 5 years, when specific events occur) in order to track how closely the Settlement Agreement goals are being achieved under varying conditions.

Directed Studies are designed to diagnose problems identified from baseline information—for example, if hatchery adult returns are low but the juvenile production goal is consistently being met, a directed study to examine juvenile migration survival from the facility to the mouth of the Toutle River might be implemented. Directed studies are intended to inform future actions, designs, and operations that will improve program performance of the topic of interest so that goals of the Settlement Article can be achieved. The focus and level of effort assigned to these studies each year will vary based on an annual evaluation, conducted by the M&E group and FTC, of data gaps to be filled to define the most efficient path forward.

9.3. Monitoring Plan

The Monitoring Plan is designed to provide the information needed for the Annual Program Review decision making process described in Chapter 11 of this FHMP. For any given run size, the Decision Rules will calculate the management targets in terms of natural escapement abundance and composition (pHOS), harvest, and hatchery broodstock abundance and composition (pNOB). The 5-year mean of these management targets will then determine the action plan for the coming season. These Decision Rules and management targets are designed to drive the system toward biological targets, which, in turn, are the basis for the metrics that define resource goals. Given this path, monitoring should focus on critical uncertainties within the key metrics and the triggers found in the Decision Rules. In addition, we must monitor the management and biological targets to determine if progress is being made (i.e., status and trends). However, the actions proposed in the Monitoring Plan are based on a set of key assumptions that are consistent with current scientific knowledge and the available information. The sensitivity of the expected outcomes from actions and the uncertainty of these assumptions are the drivers for M&E priorities that most directly affect management decisions.

A draft Monitoring Plan that describes the baseline and directed studies contains detail regarding the necessary data and corresponding potential methodologies that could currently be utilized to gather the information. The Monitoring Plan is not meant to mandate the data required or the way in which the data are collected, but rather serves as guidance and a starting/reference point to meet the data need. It is not possible to know all the potential analytical and methodological techniques that will be available as time progresses, or what developments in species/population status will necessitate directed studies. The Monitoring Plan currently details both baseline studies and directed studies.

9.3.1. Current Knowledge Base and Gaps

ISIT is the existing data warehouse system for Cowlitz M&E data and forms the basis of our knowledge used to inform hatchery program management. M&E efforts have made considerable improvements in recent years and over the term of the last FHMP. In this FHMP, we have introduced the “Big Table,” which serves as a source of data and a way to easily identify existing data gaps by species, population, and origin. Numerous metrics are identified in the Big Table, and data are not available for many of them; these are the data gaps that the selected directed studies will address and fill.

9.3.2. Current Efforts

Current M&E efforts in the Cowlitz Basin primarily focus on “fish-in, fish-out” metrics, which are important for tracking the achievement of annual and generational goals, as well as progress toward recovery. For most species and populations, this occurs related to returning adults and migrating juveniles. The exception is for Lower Cowlitz Subbasin populations, for which it is not currently possible to accurately estimate the resultant juvenile production due to logistical constraints and difficulties with sampling methodologies. In addition, we currently have a limited understanding of the abundance and productivity of the populations above Mayfield Dam.

9.3.2.1. Lower Cowlitz Subbasin

Currently, the highest effort and most complicated area from an M&E perspective is the lower Cowlitz River. All species, populations, and stages are present in this area at one point or another and potentially interact with one another. Because of this complication in the lower river, data for populations in the subbasin can only estimate production from adult to adult. This does not mean that the juvenile life stage is ignored in the lower river, but rather that it is not emphasized to the same degree for populations above Mayfield Dam, and there is less overall confidence in any of the estimates of spawner abundance. Current efforts in the Lower Cowlitz Subbasin have included spawning ground surveys for all species, creel surveys and catch record cards to understand natural-origin/hatchery-origin encounter rates, weirs for broodstock collection, pHOS management, mark-recapture surveys for spawner estimates in specified areas, and broodstock biosampling, as well as operating a screw trap to characterize the timing of juvenile migration in the lower Cowlitz River.

9.3.2.2. Above Mayfield Dam (Tilton River/Cispus River/Upper Cowlitz River)

Fish Transported Upstream

In the upper basins (Tilton River/Cispus River/upper Cowlitz River), most information comes from fish collected at the Barrier Dam and transported upstream (adults collected at the Barrier Dam) by truck to a release site above Mayfield Dam. The number and hatchery-origin/natural-origin composition of the salmon to be released at each site, as well as targets for harvest rates and subsequent pHOS of actual spawners, are determined in the Annual Operating Plan. Through 2019, the number of jacks and adults transported upstream has been treated as a proxy for the number of spawners, as no additional data have been available.

Fish Transported Downstream

Data on juveniles from the Upper Cowlitz and Tilton subbasins primarily come from juvenile migrants that are collected at the juvenile collection facilities (Mayfield Counting House and Cowlitz Falls Fish Facility). These facilities allow staff to count or estimate from subsample all juvenile salmon passing through the facility, implant CWT or other tags as appropriate, take scales and genetic samples, and measure and weigh salmon. At Cowlitz Falls Fish Facility, only juveniles collected through the flumes or the North Shore Collector are transported downstream. Fish that are not collected and bypass by Cowlitz Falls Dam through spill or the turbines end up in Riffe Lake, where they are considered to be lost to anadromy. At Mayfield Dam, downstream migrants not captured at the Counting House pass through the turbines. Those that survive turbine passage continue their migration in the lower Cowlitz River, passing over the Barrier Dam and eventually making their way to the Columbia River and then the Pacific Ocean.

9.3.3. Monitoring Priorities

The main determination questions are:

- Does the parameter affect our program decisions?
- Is there significant uncertainty about the assumed value?
- Can the parameter be estimated and/or uncertainty around the assumed value be resolved in a reasonable time?
- Does the cost impact other program efforts?

If a topic answers "no" to all four of these questions, it will no longer be considered for assessment/monitoring. Any topic scoring from one to four will be considered for priority ranking. The focus will be on natural populations classified as Primary or Contributing in the

Lower Columbia Fish Recovery Plan (LCFRB 2010). Although Stabilizing populations will not be ignored, they are not the focus for monitoring priorities. All hatchery populations will be monitored with respect to their effects on conservation and harvest as well as performance effectiveness.

The previous FHMP (Tacoma Power 2011) identified ten monitoring priorities:

1. Monitor natural and hatchery fish production (from all populations upstream of the mouth of the Toutle River).
2. Implement a juvenile fish tagging and marking program for the Cowlitz Basin.
3. Further refine credit mechanism for reducing hatchery production as natural production increases.
4. Measure fish passage survival (FPS).
5. Measure Fish Collection Efficiency.
6. Measure recruits per spawner (R/S) for all natural-origin populations.
7. Implement and test innovative rearing and release strategies.
8. Conduct studies of adult passage in the Cowlitz Basin.
9. Implement a Disease Management Plan for Cowlitz Hatcheries.
10. Conduct monitoring in the lower Cowlitz River.

9.4. Baseline Studies

Baseline studies fulfil the data needs for basic life cycle models. These models can be as complex or simple. In their simplest form, and most common for salmonids, a single-stage adult-to-adult model is implemented. Depending on the species and whether it is of hatchery- or natural-origin, scales are frequently taken for cohort reconstruction. For all stocks/populations above Mayfield Dam, we will strive to collect enough information to run a simple two-stage life cycle model. The benefit of using a two-stage life cycle model, rather than a single-stage model, is that you can compartmentalize covariates to the adult and the juvenile stages and test additional hypotheses, while use of a single stage life cycle model dictates the assumption that a covariate is affecting the species or population at some point from adults returning to the progeny of those adults returning as adults.

Juvenile abundance will be estimated for all populations in the Tilton Subbasin, as well as the Upper Cowlitz Subbasin (above Cowlitz Falls Dam). These estimates will serve as early indicators of juvenile production and as the starting point for SAR estimates for all populations.

The Big Table and Condensed Big Table in each population section identifies the most recent 5-year means, FHMP goals, and recovery goals for all of the parameters necessary to complete a two-stage life cycle model (Table 9-1). Additionally, the data gathered to populate the Big Table makes it possible to calculate and understand VSP metrics (abundance/productivity/spatial structure/diversity) for each population. It is not currently possible to collect all the necessary data to operate a two-stage life cycle model for all species and populations in the Cowlitz Basin. For species and their corresponding populations in the Lower Cowlitz Subbasin, an adult-to-adult frame will be used due to difficulties associated with estimating juvenile abundance.

9.5. Directed Study Examples

Directed studies are projects that can address uncertainty or key issues/data gaps with a single or multiyear study; however, they are not ongoing work that will be continued in perpetuity. A good example of a directed study would be an assessment of water quality (ozonated water, untreated river water, and diluted river water) on the rearing of steelhead at the Cowlitz Trout Hatchery. The study would address a current data gap of concern, the duration would be on the order of 1-3 years, and a specific recommendation would result from completion of the study.

Another major focus of directed studies is to assess ways to address best practices for program management issues. Ideally, we would assess several strategies to manage a perceived program issue to determine the approach that has the greatest efficacy and is the most efficient use of resources.

Many directed study topics have already been identified and included in the Monitoring Plan. Another way to think about directed studies would be through examination of the entire Big Table (Table 9-2), which details all of the metrics of interest for each population and, where data are available, the most recent 5-year means, FHMP goals, and recovery goals for those metrics. Many metrics in the table have no data available and the metric/parameter cannot be derived from other available data, and illustrate where directed studies could be beneficial. If the parameter has not been identified as a baseline study, we would consider it to be a directed study.

The topics of greatest uncertainty and potential to affect the program are:

- Population identification.
- Hatchery Program performance.
- pHOS management tactics.
- Issues that will require multiple years of data collection before initial results are available.

9.6. Annual Work Product

The annual work product from the M&E efforts will be data inputs into the Condensed Big Table, Big Table, and the FHMP Annual Status Update Report that describes the results of the previous year's monitoring effort throughout the basin. The preliminary results from the M&E efforts will be disseminated in early spring to inform the Annual Program Review (APR) and future fisheries management, hatchery management, and M&E strategy. This annual APR process will use the information collected each year and test it against FHMP Decision Rules and fish management strategies. Additional data needs will be identified from this annual process (as further described in Chapter 11) as necessary.

The Big Table will primarily serve as a "data warehouse." While the FHMP Annual Status Update will not be available until December, the Big Table will be updated continuously, as the data are collected, to ensure that the most current data are available to all managers and interested parties.

Table 9-1: Values included in the Condensed Big Table are summarized data that could be used to create a two-stage life cycle model.

Metric	Current (5-year Mean) HOR/NOR	FHMP Goal HOR/NOR	Long-term (Recovery Plan) HOR/NOR
Total Adult Abundance	61,519	#	#
Hatchery-origin	46,281	#	#
Natural-origin	15,238	#	#
Total Adults to Mouth of Cowlitz River	28,360	#	#
Hatchery-origin	16,721	#	#
Natural-origin	11,639	#	#
Hatchery Broodstock (spawned; all	829	#	#
Hatchery-origin	274	# (not %)	# (not %)
Natural-origin	556	# (not %)	# (not %)
pNOB (Effective = spawned; all	0.695	>0.5	1
Adult Spawners in Nature	10,641	# (not %)	# (not %)
Hatchery-origin	8,131	# (not %)	# (not %)
Natural-origin	2,510	# (not %)	# (not %)
pHOS (Effective = spawners in	0.761	<0.4	<0.2
PNI (Effective)	0.448	>0.55	>0.8
Smolt Abundance	1,087,693	#	#
Hatchery-origin (Smolts Released)	958,815	#	#
Natural-origin (Released into Lower Cowlitz River)	128,878	#	#
Smolt Collection Efficiency / Passage	76%	%	%
Smolt-to-Adult Survival (to hatchery/ spawning grounds; excluding Jacks)			
Hatchery-origin	?	%	%
Natural-origin (if unavailable, presumed higher than HORs)	?	%	%
Mean Age			
Hatchery-origin	?	#	#
Natural-origin	?	#	#
Precocious Maturation Rate			
Hatchery-origin	?	%	%
Natural-origin	?	%	%
Natural-origin Productivity			
Smolts / spawner	18.8	>1 No decrease?	
Adults + Jacks / spawner	?	Density dependence?	
Total Harvest (from all fisheries)	27,987	#	#
Hatchery-origin	25,687	#	#
Natural-origin	2,299	#	#
Harvest (% of total adult return)	64%	%	%
Hatchery-origin	75%	%	%
Natural-origin	19%	%	%

Table 9-2: Screen shot of the Big Table (full version of Big Table attached in excel file). The intent of the Big Table is to capture as much data about the population as possible and be able to identify metrics/topics/areas where no data are available.

					Last 5 Years Mean	6 Year Goal	Recovery Goal	Summary Stats	"By" Variables			Data Source
	Data to be Collected											
Mature Returns (Numbers)												
Totals								Total Survivors to Maturity	Origin	Age	Sex	Sum of below
								Total Escapement to Cowlitz River	Origin	Age	Sex	Sum of below
Harvest	Fishery Location	Ocean	Commercial					Total Cowlitz River Harvest in Ocean Fisheries	Origin	Age	Sex	CWT/Scales
			Tribal Fishery						Origin	Age	Sex	CWT/Scales
			Sport Fishery						Origin	Age	Sex	CWT/Scales&Creel
		Columbia River	Commercial					Total Cowlitz River Harvest in Columbia River Fisheries	Origin	Age	Sex	CWT/Scales
			Tribal Fishery						Origin	Age	Sex	CWT/Scales
			Sport Fishery						Origin	Age	Sex	CWT/Scales&Creel
		Lower Cowlitz River	Commercial					Total Cowlitz River Harvest in Lower Cowlitz River Fisheries	Origin	Age	Sex	CWT/Scales
			Tribal Fishery						Origin	Age	Sex	CWT/Scales
			Sport Fishery						Origin	Age	Sex	CWT/Scales&Creel
	Fishery Type	Commercial						Total Cowlitz River Harvest in Commercial Fisheries	Origin	Age	Sex	CWT/Scales&Creel
		Tribal						Total Cowlitz River Harvest in Tribal Fisheries	Origin	Age	Sex	CWT/Scales&Creel
		Sport						Total Cowlitz River Harvest in Sport Fisheries	Origin	Age	Sex	CWT/Scales&Creel
		Total						Total Cowlitz River Harvest in All Fisheries	Origin	Age	Sex	CWT/Scales&Creel
Straying	Stray Origin	Cowlitz River Population	Outside Cowlitz Basin					Cowlitz River Strays in other streams (e.g., Kalama River)	Origin	Age	Sex	CWT/Scales
			In Cowlitz Basin					Total Cowlitz River Strays in Cowlitz Basin (Cowlitz River tributaries)	Origin	Age	Sex	CWT/Scales
		Other Population Strays in Cowlitz River						Total Out-of-Program Strays Inside Cowlitz Basin	Origin	Age	Sex	CWT/Scales
Trapping	Disposition	Total						Total Cowlitz River Trapped	Origin	Age	Sex	Trap data
		Hatchery Broodstock Collected						Total Cowlitz River Broodstock Collected	Origin	Age	Sex	Trap data
		Released Below Dams						Total Cowlitz River Released Below Dams	Origin	Age	Sex	Trap data
		Released Above Dams	Hatchery					Total Cowlitz River Released Above Dams	Origin	Age	Sex	Trap data
			Natural									
		Surplus (Food Bank, Nutrient Enhancement, etc.)						Total Cowlitz River Surplus	Origin	Age	Sex	Trap data
Nature	Location	Below Dams	Lower Cowlitz River	Cowlitz River				Total in Lower Cowlitz River	Origin	Age	Sex	SGS
				Out-of-Program								SGS&CWT/Scales
		Above Dams	Tilton River	Hatchery				Total Released	Origin	Age	Sex	Release data
				Natural								
			Upper Cowlitz/Cispus Rivers	Hatchery				Total Released	Origin	Age	Sex	Release data
				Natural				Total Released	Origin	Age	Sex	Release data

CHAPTER 10:
OTHER RELATED ISSUES

10. Other Related Issues

10.1 Resident Fish

Article 5.b of the Settlement Agreement states that:

"Through 2004, the Licensee will provide funding for 50,000 pounds of trout production. Subsequent to 2004, future trout production will be based upon a review by the FTC of the success or failure of the program and any impacts on listed stocks."

Rainbow Trout provided by Tacoma Power will be released into the Cowlitz Basin, consistent with the tenets of the Washington Department of Fish and Wildlife Statewide Steelhead Management Plan: Statewide Policies, Strategies, and Actions (WDFW 2008), which states:

1) *Protect wild steelhead stocks from potential interactions with hatchery-origin Rainbow Trout:*
    a) *Hatchery-origin Rainbow Trout shall not be released in anadromous waters.*
    b) *Hatchery-origin Rainbow Trout shall not be released in lakes if the release would result in significant negative impact to wild steelhead.*
2) *Protect wild steelhead stocks from importation, dissemination, and amplification of pathogens by adhering to the "Salmonid Disease Control Policy of the Co-managers of Washington State."*

WDFW's Statewide Steelhead Management Plan limits releases of hatchery-origin Rainbow Trout into anadromous waters; therefore, WDFW will investigate and/or develop release sites to benefit local communities in the Tilton and Upper Cowlitz subbasins. Additionally, the entity providing the Rainbow Trout must adhere to all WDFW disease transfer protocols and provisions.

It is vitally important that Rainbow Trout from the Resident Fish Program do not interact (spawn) with natural-origin steelhead. As necessary, WDFW should develop and implement a program (e.g., creel surveys) to monitor the key metrics for assessing the presence and estimate abundance of planted Rainbow Trout in locations used by and during the timing of natural-origin winter steelhead spawning (e.g., annual estimates of terminal harvest rates). All Rainbow Trout released will be marked to distinguish them from natural-origin steelhead.

WDFW will develop and present the annual stocking schedule for FTC review before the Annual Program Review meeting. Specific management targets (e.g., production and harvest) will be developed at the Annual Program Reviews and included in each year's Annual Operating Plan.

10.2 Nutrient Enhancement

10.2.1. History

Prior to the initiation of extractive fisheries in mid-to late-19th century, the Cowlitz River watershed received an annual influx of marine-derived nutrients, which are an important component of Pacific Northwest anadromous salmonid ecosystems that fueled the entire watershed ecosystem (Stockner 2003). Initiation of extractive fisheries and construction of dams led to the dramatic reduction in the amount of marine-derived nutrients delivered to the Cowlitz Basin (Stockner and Ashley 2003). As a result, the productivity and capacity of aquatic and terrestrial ecosystems within the Cowlitz Basin were diminished, as they are directly correlated with the amount of marine-derived nutrients brought to the basin by spawning salmon.

10.2.2. Nutrient Delivery

WDFW has developed a protocol for the design, implementation, monitoring, and reporting of the distribution of carcasses to restore nutrient levels in streams. Currently, nutrients are being delivered by hatchery- and natural-origin salmon on the spawning grounds. In the future, managers may decide to use further nutrient enhancement as a tool to increase juvenile abundance and condition in specific streams.

10.2.3. Proposed Actions

If carcasses are distributed into streams for nutrient enhancement, the FTC will develop protocols for that action. Tacoma Power and WDFW, along with Regional Fishery Enhancement Groups and other volunteers, will coordinate and conduct the carcass distribution.

While live salmon are the best way to achieve a more even distribution, some of the required nutrients may need to be delivered via salmon carcasses (from hatchery spawning and surplus; carcass analogs may be used, if available). In some instances, HSRG guidelines may be used as an indicator to determine that existing limits on pHOS levels for some species preclude maximizing nutrient enhancement using live salmon. Additionally, current WDFW policy directs all food-quality salmon carcasses in excess of broodstock needs to be distributed to food banks, which may limit the availability of carcasses available for nutrient enhancement projects.

10.3 Off-Station Programs

WDFW has a long history of providing salmonid eggs and/or juveniles to volunteer groups for Remote Site Incubators (RSI) and net pen programs throughout Washington, including the Cowlitz Basin. These programs have long been used to advance community interest in salmon/steelhead abundance, engage stakeholders in the propagation of natural resources, and, in some cases, increase harvest. However, they may also pose a risk to recovery of listed species. Three types of off-station programs have been supported by the Cowlitz Salmon and Cowlitz Trout hatcheries:

- **In-basin**
  1. Remote site incubators (RSIs)
  2. Net pens/smolt acclimation sites
- **Out-of-basin**
  3. Egg transfers (for Select Area Fishery Enhancement Program net pens)

The use of RSIs, in which eggs are collected at the hatchery and placed in stream-side incubators where they are allowed to hatch and rear in the natural environment, can pose a risk to natural-origin populations (depending on the size and location of program). Risks include directly competing with natural-origin salmon for rearing space and food supply, particularly for those species that rear for extended periods in freshwater and in cases where large numbers of salmon are released.

RSIs have been shown to be a benefit to Chum Salmon (a listed species in the Cowlitz Basin) and Pink Salmon populations, especially as a means of reintroduction. Chum and Pink Salmon do not rear in freshwater, so competition between RSI juveniles and natural-origin salmon is minimal.

In-basin net pens are used, where hatchery-origin juveniles are reared (usually until smolted) and then released into the natural environment to continue their outmigration, to produce returning adults that are imprinted to a location different than normal hatchery-origin adults. As such, these adults do not return to the hatchery with the same level of homing fidelity (they have a higher stray rate), so they may pose a genetic risk to natural populations because they generate more hatchery-origin salmon on the spawning grounds (increased pHOS) than salmon that are directly released from the hatchery.

The HSRG made the following observations regarding the use of net pens and the practice of outplanting salmonid juveniles (HSRG 2004):

> "*Tagging and genetic studies have shown that outplanting and net pen programs promote stray rates that far exceed natural levels...*"

The HSRG further noted that:

> "…*Outplanting and net pen releases from segregated hatchery programs are especially problematic because of the potentially high level of genetic divergence between the hatchery stock and natural populations where straying and natural spawning may occur. Although the natural spawning success of hatchery-origin fish may be less than that of natural-origin fish when they occur in the same stream, those same data indicate that significant numbers of hatchery-origin fish from nonnative or long-standing "domesticated" populations do indeed spawn successfully and can contribute significant numbers of progeny to naturally spawning populations..."*

Historically, the Cowlitz Salmon Hatchery has also provided an egg source for out-of-basin net pens. During this FHMP period, plans will be developed to prioritize in-basin programs focused on recovery and harvest prior to consideration to export gametes to out-of-basin programs at the possible detriment of Settlement Agreement and FHMP goals.

10.3.1. Actions

During this FHMP period, existing or new in-basin RSI programs in the Cowlitz Basin will be evaluated for their conservation benefit. Operations will need to be evaluated to determine their impact on naturally produced populations, their recovery benefit through reintroduction to vacant or underutilized habitat, and their potential benefits to other species (based on location), such as chum.

During this FHMP period, existing in-basin smolt acclimation net-pen programs will be evaluated for conservation and harvest benefits. If new smolt acclimation net-pen programs are proposed, the benefits to bio programming at the hatchery, recovery efforts within the basin, and risks associated with straying will be balanced prior to implementation.

Out-of-basin egg, juvenile, or adult transfers may continue in the future, subject to agreement between Tacoma Power and WDFW on the benefits and risks of these transfers. Plans will be developed prior to any further export of gametes from the Cowlitz Basin and will be characterized in the Annual Operating Plan. The effects of such transfers must not be detrimental to achieving the recovery goals for Cowlitz Basin populations, which is the first and most important priority of the Settlement Agreement.

CHAPTER 11:
ADAPTIVE MANAGEMENT

11.0 Adaptive Management: Annual Program Review and Annual Operating Plan

[Placeholder. Chapter in preparation as of October 17, 2019]

CHAPTER 12:
REFERENCES

12. References

Bartron, M. L., N. M. Sard, and K. T. Scribner. 2018. Evaluation of effective number of breeders and coancestry among progeny produced using common hatchery mating strategies. Transactions of the American Fisheries Society 147:185-194.

Birtchet, R., and E. LeMier. 1955. Summary of weir and trap observations on several lower Columbia streams January through April 1955. Washington Department of Fisheries, Olympia, WA. Available from WDF, 115 General Administration Building, Olympia, WA 98504.

Blakley, A., B. Leland, and Ames, J. (eds). 2000. 2000 Washington state salmonid stock inventory: coastal Cutthroat Trout. Washington Department of Fish and Wildlife, Olympia, WA.

Bryant, F. G. 1949. A survey of the Columbia River and its tributaries with special reference to its fishery resources - Part 11. Washington streams from the mouth of the Columbia to and including the Klickitat River (Area I). Special Scientific Report 62, U.S. Fish and Wildlife Service, Washington DC.

Busack, C., and C. M. Knudsen. 2007. Using factorial mating designs to increase the effective number of breeders in fish hatcheries. Aquaculture 273:24-32.

Busby, P. J., T. C. Wainwright, G. J. Bryant, L. J. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino. 1996. Status review of West Coast steelhead from Washington, Idaho, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-27.

Campton, D. E. 2004. Sperm competition in salmon hatcheries - the need to institutionalize genetically benign spawning protocols. Transactions of the American Fisheries Society 133:1277-1289.

FERC (Federal Energy Regulatory Commission). 2001. Draft environmental impact statement. Cowlitz River Hydroelectric Project, Washington (FERC No. 2016). Federal Energy Regulatory Commission, Washington, DC.

FERC (Federal Energy Regulatory Commission). 2002. Order approving settlement and issuing new license. Issued 13 March 2002 to City of Tacoma, Washington. Project No. 2016-044. Federal Energy Regulatory Commission, Washington, DC.

FERC (Federal Energy Regulatory Commission). 2004. Order amending new license. Issued 9 July 2004 to City of Tacoma, Washington. Project No. 2016-071.

FERC (Federal Energy Regulatory Commission). 2006. Order modifying and approving Fisheries and Hatchery Management Plan, Article 6. Issued 6 April 2006 to City of Tacoma, Washington. Project No. 2016-071.

Flagg, T. A., and C. E. Nash (editors). 1999. A conceptual framework for conservation hatchery strategies for Pacific salmonids. NOAA Technical Memorandum NMFS-NWFSC-38. Northwest Fisheries Science Center, National Marine Fisheries Service, U.S. Department of Commerce, Seattle.

Ford, M. J. (Ed.), T. Cooney, P. McElhany, N. Sands, L. Weitkamp, J. Hard, M. McClure, R. Kope, J. Myers, A. Albaugh, K. Barnas, D. Teel, P. Moran, and J. Cowen. 2011. Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Pacific Northwest. U.S. Department of Commerce. NOAA Technical Memorandum NMFS-NWFSC-113. November 2011.

Fuss, H., J. Byrne, and C. Ashbrook. 1998. Stock characteristics of hatchery-reared salmonids at Washington Dept. of Fish and Wildlife Columbia River hatcheries. Hatcheries Program Annual Report. H98-03. Washington Department of Fish and Wildlife, Olympia, WA.

GAIA Northwest, Inc. 1994. Cowlitz Falls Project fisheries management plan: anadromous fish reintroduction program.

Galbreath, P. F., C. A. Beasley, B. A. Berejikian, R. W. Carmichael, D. E. Fast, M. J. Ford, J. A. Hesse, L. L. McDonald, A. R. Murdoch, C. M. Peven, and D. A. Venditti. 2008. Recommendations for broad scale monitoring to evaluate the effects of hatchery supplementation on the fitness of natural salmon and steelhead populations. Final report of the Ad Hoc Supplementation Monitoring and Evaluation Workgroup.

Gleizes, C., J. Serl, M. Zimmerman, B. Glaser, and W. Dammers. 2014. Lower Cowlitz River Monitoring and Evaluation, 2013. FPA14-10. Washington Department of Fish and Wildlife, Olympia.

Gleizes, C., J. Serl, M. Zimmerman, and B. Glaser. 2015. Lower Cowlitz River monitoring and evaluation - 2014. Washington Department of Fish and Wildlife, Olympia.

Gleizes, C., C. Nissell, J. Serl, M. Zimmerman, and B. Glaser. 2017. Lower Cowlitz River monitoring and evaluation - 2015. Washington Department of Fish and Wildlife, Olympia.

Hager, R. C. 1973. Cowlitz River salmon hatchery and reservoir production and evaluation program annual report, 1970. Washington Department of Fisheries, Olympia.

Hager, R. C., and M. De Cew. 1970. Cowlitz River salmon hatchery and reservoir production and evaluation program annual report, 1969. Washington Department of Fisheries, Olympia.

HSRG (Hatchery Scientific Review Group). 2004. Hatchery reform: principles and recommendations of the HSRG. Prepared by L. Mobrand, J. Barr, L. Blankenship, D. Campton, T. Evelyn, T. Flagg, C. Mahnken, R. Piper, P. Seidel, L. Seeb, and B. Smoker. Long Live the Kings, Seattle (available from www.hatcheryreform.org).

HSRG (Hatchery Scientific Review Group). 2009. Columbia River hatchery reform system-wide report. Peter Paquet (chair), Andrew Appleby, John Barr, Lee Blankenship, Don Campton, Mike Delarm, Trevor Evelyn, David Fast, Tom Flagg, Jeffrey Gislason, Paul Kline, Des Maynard (alternate), George Nandor, Paul Seidel, and Stephen Smith. Available at: www.hatcheryreform.us.

HSRG (Hatchery Scientific Review Group). 2014. On the Science of Hatcheries: An updated perspective on the role of hatcheries in salmon and steelhead management in the Pacific Northwest. A. Appleby, H.L. Blankenship, D. Campton, K. Currens, T. Evelyn, D. Fast, T. Flagg, J. Gislason, P. Kline, C. Mahnken, B. Missildine, L. Mobrand, G. Nandor, P. Paquet, S. Patterson, L. Seeb, S. Smith, and K. Warheit. Available at: www.hatcheryreform.us.

HSRG (Hatchery Scientific Review Group). 2017. Implementation of hatchery reform in the context of recovery planning using the AHA-ISIT tool. Prepared for the Washington Department of Fish and Wildlife, Olympia.

IHOT (Integrated Hatchery Operations Team). 1995. Policies and procedures for Columbia Basin anadromous salmonid hatcheries, annual report 1994. Contract No. 1992BI60629, Project No. 199204300. Bonneville Power Administration, Portland.

Klett, K. J., C. E. Torgersen, J. A. Henning, and C. J. Murray. 2013. Spatial consistency of Chinook Salmon redd distribution within and among years in the Cowlitz River, Washington. North American Journal of Fisheries Management, 33:508-518.

Larsen, D. A., B. R. Beckman, and K. Cooper. 2010. Examining the conflict between smolting and precocious male maturation in spring (stream-type) Chinook Salmon. Transactions of the American Fisheries Society 139:564-578.

Larsen, D. A., D. L. Harstad, C. R. Strom, M. V Johnston, C. M. Knudsen, D. E. Fast, T. N. Pearsons, and B. R. Beckman. 2013. Early life history variation in hatchery- and natural-origin spring Chinook Salmon in the Yakima River, Washington. Transactions of the American Fisheries Society 142:540-555.

LCFRB (Lower Columbia Fish Recovery Board). 2010. Washington Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan. Lower Columbia Fish Recovery Board, Olympia, WA.

Lichatowich, J. A. 2001. Salmon hatcheries: Past, present and future. Oregon Business Council Report, Portland, Oregon.

McElhany, P, M. Ruckleshaus, M. J. Ford, T. C. Wainright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionary significant units. NOAA Technical Memorandum NMFS-NWFSC-42, Northwest Fisheries Science Center, National Oceanic and Atmospheric Administration, U. S. Department of Commerce, Seattle.

McElhany, P., T. Backman, C. Busack, S. Heppell, S. Kolmes, A. Maule, J. Myers, D. Rawding, D. Shively, A. Steel, C. Steward, and T. Whitesel. 2003. Interim report on viability criteria for Willamette and Lower Columbia basin Pacific salmonids. Northwest Fisheries Science Center, National Marine Fisheries Service, U.S. Department of Commerce, Seattle.

McElhany, P., M. Chilcote, J. Myers, and R. Beamesderfer. 2007. Viability Status of Oregon Salmon and Steelhead Populations in the Willamette and Lower Columbia Basins. Report Prepared for Oregon Department of Fish and Wildlife and National Marine Fisheries Service.

Moore, M. 1948. Testimony to the Washington State Department of Conservation and Development, 15-16 December 1948.

Moore, M., and D. Clarke. 1946. A report on the fisheries problems in connection with the proposed hydro-electric development of the Cowlitz River, Lewis County, Washington. Washington Department of Fisheries and Washington Department of Game, Olympia, WA.

Myers, J., C. Busack, D. Rawding, A. Marshall, D. Teel, D. Van Doornik, and M. Maher. 2006. Historical population structure of Pacific salmonids in the Willamette and lower Columbia River basins. NMFS-NWFSC-73, National Marine Fisheries Service, Seattle.

Nehlsen, W., J. E. Williams, and J. A. Lichatowich. 1991. Pacific salmon at the crossroads: Stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16(2):4-21.

NFSC (Northwest Fisheries Science Center). 2015. Status Review Update for Pacific Salmon and Steelhead Listed under the Endangered Species Act: Pacific Northwest. National Marine Fisheries Service, Seattle.

NMFS (National Marine Fisheries Service). 2013. ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead. Northwest Region. 503 p.

NMFS (National Marine Fisheries Service). 2016. 2016 5-year review: summary & evaluation of Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, Lower Columbia River Coho Salmon, Lower Columbia River Steelhead. West Coast Region, Portland.

NOAA Fisheries (National Oceanic and Atmospheric Administration, National Marine Fisheries Service). 2004. Endangered Species Act Section 7 (a)(2) Consultation, Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Consultation: Operation of the Cowlitz River Hydroelectric Project (FERC No. 2016) through 2038. National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Seattle.

NOAA Fisheries (National Oceanic and Atmospheric Administration, National Marine Fisheries Service). 2013. ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead. Northwest Region, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Seattle, WA.

NPPC (Northwest Power Planning Council). 2001. Performance standards and indicators for the use of artificial production for anadromous and resident fish populations in the Pacific Northwest. Northwest Power and Conservation Council, Portland.

NWFSC (Northwest Fisheries Science Center). 2015. Status Review Update for Pacific Salmon and Steelhead Listed under the Endangered Species Act: Pacific Northwest. National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Seattle, WA. December 21, 2015.

Paquet, P. J., T. Flagg, A. Appleby, J. Barr, L. Blankenship, D. Campton, M. Delarm, T. Evelyn, D. Fast, J. Gislason, P. Kline, D. Maynard, L. Mobrand, G. Nandor, P. Seidel, and S. Smith. 2011. Hatcheries, conservation, and sustainable fisheries—achieving multiple goals: results of the Hatchery Scientific Review Group's Columbia River Basin review. Fisheries 36:547-561.

Piper, R. G., I. B. McElwain, L. E. Orme, J. P. McCraren, L. G. Fowler, and J. R. Leonard. 1982. Fish hatchery management. U.S. Fish and Wildlife Service, Washington, DC.

Richey, E. P. 1956. The Skimmer, a part of the downstream migrant system, Mayfield Fish Facilities. Department of Public Utilities, City of Tacoma.

Sandercock, F. K. 1991. Life history of Coho salmon (*Oncorhynchus kisutch*). Pages 395-446 *in* C. Groot and L. Margolis, editors, Pacific salmon life histories. University of British Columbia Press, Vancouver.

Seidel, P. R., and C. W. Hopley. 1978. Cowlitz salmon hatchery and reservoir production and evaluation program, 1974 and 1975. Progress Report No. 47. Wash. State Dept. of Fish. p. 41.

Serl. J. D., and C. F. Morrill. 2011. Summary Report for the 1996-2009 seasonal operation of the Cowlitz Falls Fish Facility and related Upper Cowlitz River Watershed anadromous fish reintroduction efforts. Washington Department of Fish and Wildlife, Olympia.

Spangenberg, D. K., D. A. Larsen, R. Gerstenberger, C. Brun, and B. R. Beckman. 2014. The effects of variation in rearing conditions on growth, smolt development, and minijack rate in yearling Chinook Salmon: a hatchery scale experiment. Transactions of the American Fisheries Society 143:1220-1230.

Spangenberg, D. K., D. A. Larsen, R. Gerstenberger, C. Brun, D. L. Harstad, S. Nance, L. Raohrback, and B. R. Beckman. 2015. Stock differences in growth, smolting, and early male maturation in hatchery spring Chinook Salmon: a common-garden experiment. North American Journal of Fisheries Management 35:1090-1100.

Stober, Q. J. 1986. Reintroduction of anadromous fish runs to the Tilton and upper Cowlitz rivers. Final report to Washington Department of Fisheries and Washington Department of Game. Fisheries Research Institute, School of Fisheries, University of Washington, Seattle.

Stockley, C. E. 1961. The migration of juvenile salmon past the Mayfield Dam site, Cowlitz River, 1955 and 1956.

Stockner, J.G. 2003. Nutrients in salmonid ecosystems: sustaining production and biodiversity. American Fisheries Society, Symposium 34. Bethesda, Maryland.

Stockner, J. G., and K. I. Ashley. 2003. Salmon nutrients: Closing the circle. Pages 3- 16 in J. G. Stockner, editor. Nutrients in salmonid ecosystems; sustaining production and biodiversity. American Fisheries Society, Symposium 34, Bethesda, Maryland.

Strunk, W. L., and C. L. Hubbs. 1950. A survey report of the Cowlitz River with special reference to fish facilities at proposed dam sites. Submitted to Light Division, Department of Public Utilities, City of Tacoma.

Tacoma Power. 2002. Order approving settlement and issuing new license. Tacoma Public Utilities, City of Tacoma.

Tacoma Power. 2011. Cowlitz River Project FERC No. 2016, Fisheries and Hatchery Management Plan Update: Final.

Tacoma Power. 2013. Annual Project Review Procedures Manual.

Tacoma Power, Washington Department of Fish and Wildlife, Washington Department of Ecology, Washington State Parks and Recreation Commission, U.S. Fish and Wildlife service, National Marine Fisheries Service, U.S. Forest Service, Interagency Committee for Outdoor Recreation, Lewis County, Confederated Tribes and Bands of the Yakama Nation, Washington Council of Trout Unlimited, Sport Fishing Guides of Washington, and American Rivers. 2000. Cowlitz River Hydroelectric Project Settlement Agreement. Tacoma Public Utilities, City of Tacoma.

Thompson, J. S., and L. Rothfus. 1969. Biological observations of salmonids passing Mayfield Dam. Washington Department of Fisheries, Olympia.

Wade, G. 2000. Salmon and steelhead habitat limiting factors, WRIA 26 (Cowlitz). Washington Department of Ecology, Olympia.

WDF (Washington Department of Fisheries). 1951. Lower Columbia River Fisheries Development Program, Cowlitz area, Washington. Washington Department of Fisheries, Olympia.

WDF (Washington Department of Fisheries) and WDG (Washington Department of Game). 1948. A report on the fisheries problems in connection with the proposed hydro-electric development of the Cowlitz River, Lewis County, Washington. Washington Department of Fisheries and Washington Department of Game. Olympia.

WDF (Washington Department of Fisheries), WDG (Washington Department of Game), and WWTIT (Western Washington Treaty Indian Tribes). 1993. 1992 Washington salmon and steelhead stock inventory (SASSI). Washington Department of Fisheries, Olympia,

WDFW (Washington Department of Fish and Wildlife). 1993. 1992 Washington state salmon and steelhead stock inventory. Washington Department of Fish and Wildlife, Olympia, WA.

WDFW (Washington Department of Fish and Wildlife). 2002. Washington state salmon and steelhead stock inventory. Washington Department of Fish and Wildlife, Olympia.

WDFW (Washington Department of Fish and Wildlife). 2004. Future brood document. Olympia, WA.

WDFW (Washington Department of Fish and Wildlife). 2008. Statewide Steelhead Management Plan: Statewide Policies, Strategies, and Actions. Available: https://wdfw.wa.gov/sites/default/files/publications/00149/wdfw00149.pdf. February 29, 2008.

WDFW (Washington Department of Fish and Wildlife). 2009. Hatchery action implementation plans (HAIP). Washington Department of Fish and Wildlife, Olympia, WA.

WDFW (Washington Department of Fish and Wildlife). 2014a. Hatchery and Genetic Management Plan for Cowlitz River Spring Chinook Salmon Program.

WDFW (Washington Department of Fish and Wildlife). 2014b. Hatchery and genetic management plan for Cowlitz River Fall Chinook salmon program. Washington Department of Fish and Wildlife, Olympia.

WDFW (Washington Department of Fish and Wildlife). 2014c. Hatchery and Genetic Management Plan (HGMP): Cowlitz River Type N Coho (Segregated and Integrated).

WDFW (Washington Department of Fish and Wildlife). 2018. SalmonScape application, http://wdfw.wa.gov/mapping/salmonscape/. Accessed August 27, 2018. Washington Department of Fish and Wildlife, Olympia, WA.

WDFW (Washington Department of Fish and Wildlife). 2019. Cowlitz Coastal Cutthroat Trout Population Details. Washington Department of Fish and Wildlife, Olympia. Website, accessed 26 July 2019: https://fortress.wa.gov/dfw/score/score/species/population_details.jsp?stockId=7780.

WDFW (Washington Department of Fish and Wildlife) and LCFRB (Lower Columbia Fish Recovery Board). 2016. Lower Columbia Conservation and Sustainable Fisheries Plan. Washington Department of Fish and Wildlife, Olympia, WA.

Wedemeyer, G.A. 2002. Fish hatchery management, second edition. American Fisheries Society, Bethesda, Maryland.

Williams, R. N., J. A. Lichatowich, P. R. Mundy, and M. Powell. 2003. Integrating artificial production with salmonid life history, genetic, and ecosystem diversity: a landscape perspective. Issue Paper for Trout Unlimited, West Coast Conservation Office, Portland.

APPENDIX A:
BIG TABLE

[provided as digital file]