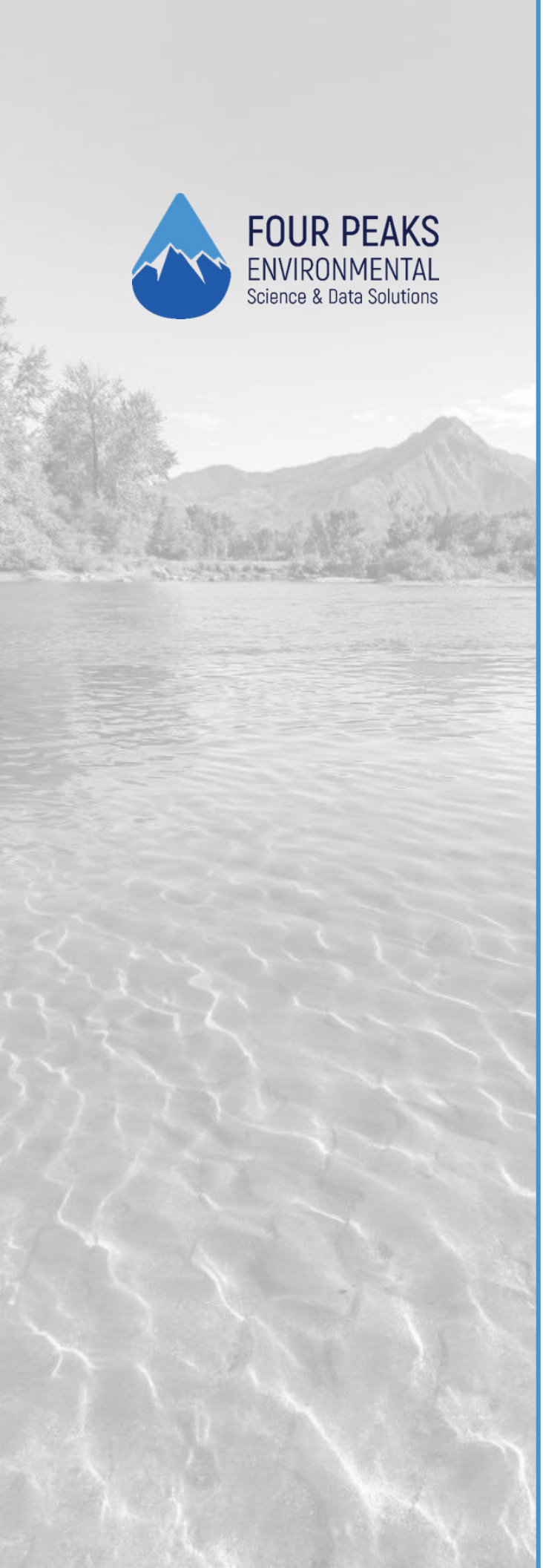

FOUR PEAKS ENVIRONMENTAL
Science & Data Solutions

COWLITZ FISHERIES AND HATCHERIES MANAGEMENT PLAN: COWLITZ MONITORING AND EVALUATION PLAN

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Acronyms and Abbreviations

Acronym	Definition
AOP	Annual Operating Plan
APR	Annual Program Review
CFFF	Cowlitz Falls Fish Facility
CV	coefficient of variation
CWT	coded wire tags
DPS	distinct population segment
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FCE	fish collection efficiency
FERC	Federal Energy Regulatory Commission
FGE	fish guidance efficiency
FHMP	Fisheries and Hatchery Management Plan
FPS	fish passage survival
FTC	Cowlitz River Fisheries Technical Committee
GSI	gonadal-somatic index
HOR	hatchery origin return
HOS	hatchery origin spawner
HRR	hatchery return rate
HSRG	Hatchery Scientific Review Group
M&E	monitoring and evaluation
NOR	natural origin return
NOS	natural origin spawner
NRR	natural return rate
pHOB	proportion of hatchery-origin broodstock
pHOS	proportion of hatchery-origin spawners
PIT	passive integrated transponder
Plan	Monitoring and Evaluation Plan
PNI	proportionate natural influence
pNOB	proportion of natural-origin broodstock
PTAGIS	Columbia Basin PIT Tag Information System
RMIS	Regional Mark Information System
SA	Cowlitz River Hydroelectric Project Settlement Agreement
SAR	smolt to adult return
SCoRE	Salmon Conservation and Reporting Engine
TSAR	total smolt to adult return
VSP	Viable Salmonid Population
WDFW	Washington Department of Fish and Wildlife

1 Introduction

The Cowlitz River Hydroelectric Project Settlement Agreement (SA; Tacoma Power et al. 2000) outlined a Fish Monitoring Plan to be developed (Article 6) to assess the Fisheries and Hatchery Management Plan (FHMP; Tacoma Power 2020). The emphasis of the SA is restoration and recovery of wild indigenous salmon runs to harvestable levels (excerpted from the SA, Article 6.1.1: Tacoma Power et al. 2000):

> *"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."*

The SA further specifies fish passage requirements, habitat restoration, and artificial production implemented under an adaptive management framework (SA, Article 6.1.2: Tacoma Power et al. 2020):

> *"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."*

Although harvest and fisheries are important, recovery of wild populations is paramount (SA, Article 6.1.6: Tacoma Power et al. 2020):

> *"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."*

This Monitoring and Evaluation Plan (Plan) is designed to provide the information needed to track population status toward recovery objectives and for the Annual Program Review (APR) decision making process. The Plan builds upon previous work elements and descriptions of monitoring and evaluation (M&E) work in past FHMPs (Tacoma Power 2011, 2020) and the Fish Monitoring Plan (Tacoma Power 2014) and includes the following details:

- Descriptions of the baseline and directed studies that have been identified to assess the population and management actions in the Cowlitz Basin
- Details regarding the necessary data and analyses required to perform the assessment
- Updated methods, priorities, and work elements to address data gaps
- Characterization of the critical data necessary to assess status and trends associated with the recovery phases of the populations

This Plan will be reviewed annually as part of the Annual Program Review process to ensure that the most efficient methods are being implemented to obtain unbiased and precise estimates, and that the methodologies used to collect and analyze these data will remain flexible to enable practitioners to adapt to shifting priorities and advances in fisheries science technology and analytical methods. Analytical methods and data collection will be updated as necessary based on current management and assessment needs and field protocols. Changes to the Plan will be made following a predetermined procedure.

The Plan has the following objectives:

- Provide a framework for monitoring, analyses, and protocols to generate key information to inform management decisions.
- Track the status and trends of populations toward FHMP and recovery objectives.
- Evaluate performance relative to goals and expectations and adjust conduct of hatchery programs and recovery actions according to the adaptive management plan. Indicators of program success include abundance, productivity, distribution, composition of naturally produced populations, and benefits to fisheries.
- Test key assumptions and adjust the assumptions accordingly.
- Provide critical information to set management targets and decision rules

Decision rules (Tacoma Power 2020) will be used to assess the findings from analysis in terms of management decisions and population status. Decision rules use established management targets to determine the efficacy of management strategies or the status of a population. Often these targets are structured on a tiered or sliding scale based on population size. The key decision rules address management targets for natural escapement abundance, spawner composition (proportion of hatchery-origin spawners [pHOS]), harvest, hatchery broodstock collection and composition (proportion of natural-origin broodstock [pNOB]), or other targets determined appropriate through the APR process. The 5-year mean of the metrics, or other time frames as appropriate, in this Plan will be compared to management targets to determine future required actions. The decision rules and management targets will be designed to drive the system toward management, recovery, or harvest objectives.

Given resource management goals and the objectives therein, this Plan focuses on metrics designed to evaluate the performance of management strategies and population status to determine if progress is being made (i.e., status and trends) toward meeting management objectives, recovery, or harvest goals. In addition, this Plan focuses on critical uncertainties that have been identified to better understand and manage the populations. The metrics included in this 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 of management actions and the uncertainty of the underlying assumptions are the drivers to prioritize M&E priorities that most directly affect management decisions (Figure 1).

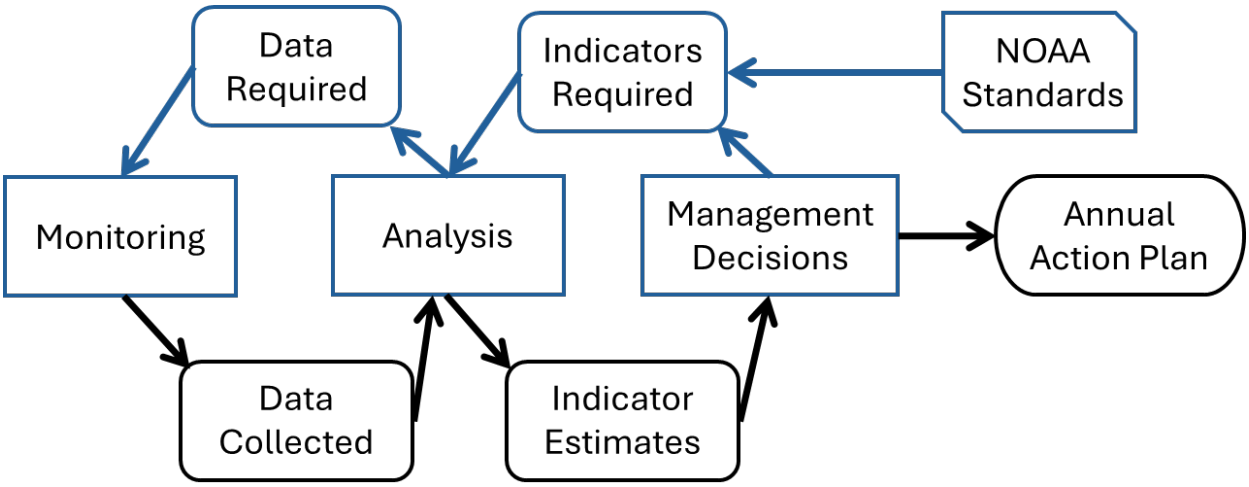

Figure 1. Steps in the monitoring and evaluation and decision-making processes

Abundance is a critical metric required to evaluate management actions and population viability; therefore, this is the most common type of data collected and includes total run size, number of spawners in nature, number harvested, number collected for broodstock, number of broodstock spawned, and numbers of smolts produced in nature and in the hatchery. These data are typically population- or program-specific and will include origin, age, and sex (as applicable). 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. Based on this, management actions can be taken to alleviate a limiting factor, thereby improving survival and increasing abundance. These data may be used to reconstruct salmonid return abundance and predict future returns to the Columbia and Cowlitz systems, which is important for establishing management strategies. Data collection methods and the abundance, productivity, and survival estimates they produce must be unbiased and be made with enough precision to make meaningful assessments and decisions.

The Plan describes metrics and associated data important for providing insight into the status and condition of the populations. The metrics focus on key diagnostic points in the life cycle of a population (Figure 2) when abundance can be obtained by direct counts or estimation to monitoring abundance, and growth, condition, and survival can be estimated. Derived data or metrics may be calculated or modeled from the collected data to further describe the status of the population and are important for adaptive management. Without adequate monitoring data, a population cannot be effectively assessed or managed.

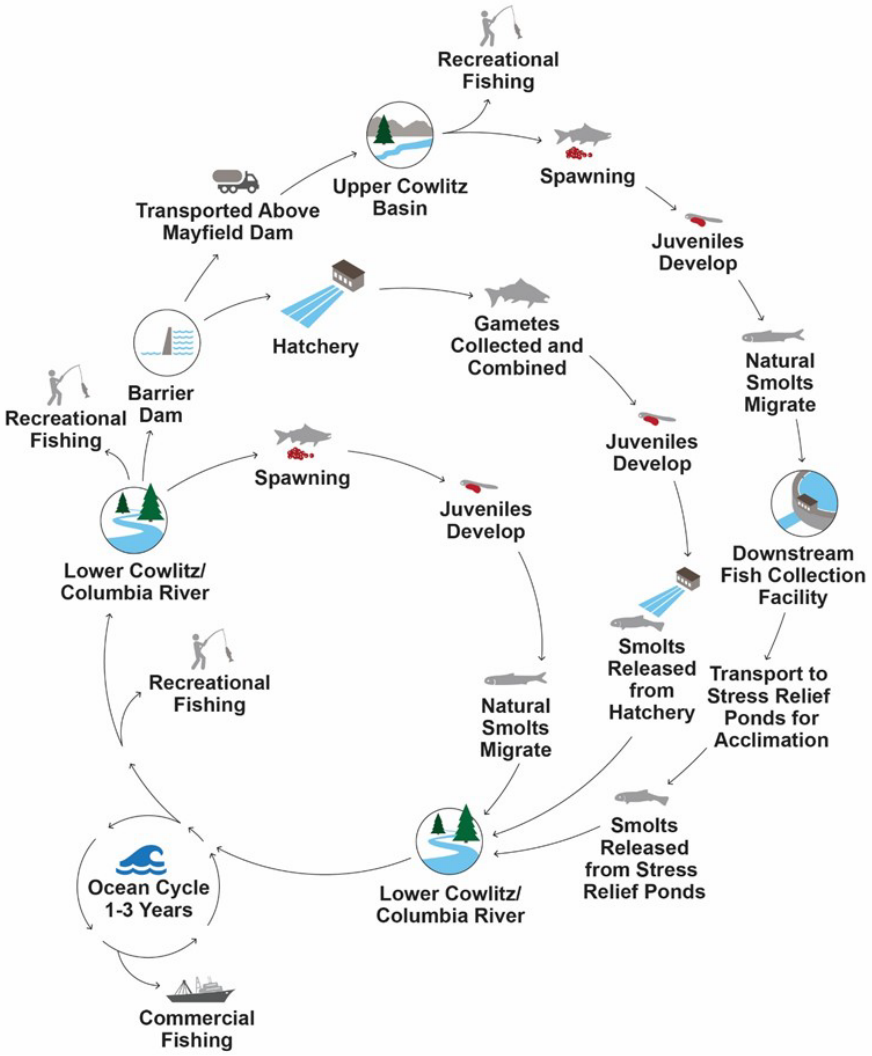

Figure 2. The general life cycle and fish handling points of Upper Cowlitz River salmon and steelhead (excerpted from Tacoma Power 2020).

The Plan focuses on metrics consistent with the Viable Salmond Populations (VSP) parameters (McElhany et al. 2000) and that will serve as inputs to life cycle models. Life cycles models can be used to better understand the status, population dynamics, and limiting factors or life stages of the populations, and to assess management actions. VSP parameters inform the status of the populations toward recovery under the Endangered Species Act (ESA). M&E of the Upper Cowlitz subbasin and Tilton River populations has primarily focused on abundance of adults transported and collection efficiency of emigrating smolts, which are important for tracking the achievement of annual and cohort abundance, productivity, and survival, as well as progress toward recovery. The long-term M&E strategy for the Upper Cowlitz subbasin is under development and will be included in future revisions of this plan. M&E of the Lower Cowlitz subbasin populations focuses on generating VSP metrics, including improved information on abundance, productivity, distribution, and diversity. The Plan's overall focus is on abundance and origin of returning adults, abundance, origin, and spatial distribution of spawners, and abundance of migrating juveniles.

2 Adaptive Management and the Annual Program Review

Adaptive management is a resource management approach that seeks to improve the management of biological resources through a process where management actions and strategies are adjusted based on new information, which comes from monitoring data that are properly collected and rigorously evaluated (Tacoma Power 2020; HSRG 2009). It is a cyclical, structured, and iterative process of decision making. The following five steps are conducted during each decision-making cycle (Figure 3):

1. Conduct program and collect data related to:
    a. Assessment of hatchery operations
    b. Assessment of management activities
    c. Successful implementation of the Plan
    d. Assessment of the Plan applicability to management actions
2. Data analysis following the Plan
3. Report results via:
    a. Cowlitz River Annual Science Conference
    b. Annual Washington Department of Fisheries and Wildlife M&E reports
    c. Upstream passage report
    d. Annual Cowlitz Falls North Shore Collector Downstream Fish Passage Evaluation reports
    e. Directed study reports
4. Decision Making through the APR
5. Planning through the Annual Operating Plan (AOP)

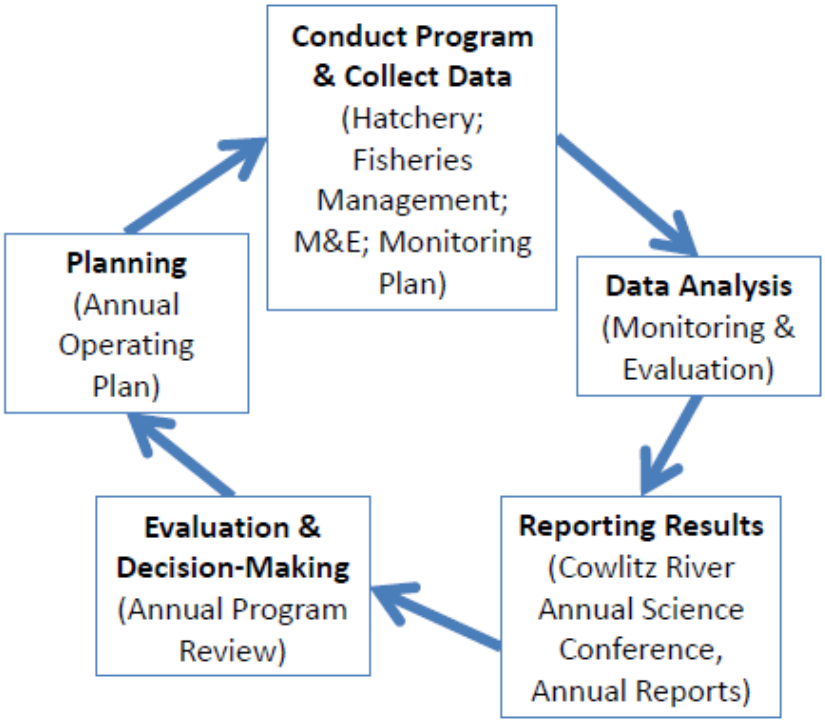

Figure 3. The annual adaptive management cycle (excerpted from Tacoma Power 2020).

Because new information is brought into each cycle, M&E is emphasized. The process of adaptive management involves setting management goals, formulating questions related to achieving the goals, selecting alternative management strategies to test these questions, and implementing these techniques to test them for meeting objectives. Care is taken to measure those system responses that best tell whether the system is moving toward or meeting management objectives, and results are fed back into the decision process (Morghan et al. 2006). Therefore, management actions are designed, implemented, and monitored as experiments, so that even if they fail, useful information is obtained that can be used to improve future programs and strategies. The adaptive management process allows managers to better understand the interaction of different elements of the system, to better monitor program status, and when necessary and depending on the response of the population, adjust specific parts of programs (e.g., broodstock collection, hatchery production targets, or number of adults transported to upstream locations), thereby maintaining the management trajectory toward the ultimate goal of population recovery to healthy and harvestable levels. Annual reports document the program's results for each year and the success of the program in achieving the goals set in the AOP and, more broadly, progress toward achieving long-term program goals.

Adaptive management is applied in the APR. The APR is a process that allows managers to examine how the program is performing each year, make appropriate changes, and plan for the coming year and beyond, which is documented in the AOP. AOP development comprises the following four steps that lead to the development of a scientifically defensible plan (Figure 4):

6. Update Key Metrics – Compile empirical data from program M&E activities.
7. Update Status and Trends – Evaluate the direction of key program metrics and progress toward achieving long-term program goals.

    Information from Steps 1 and 2 will be presented at the Cowlitz River Annual Science Conference, in annual reports from the Washington Department of Fish and Wildlife (WDFW) and other contractors to Tacoma Power, and in annual reports from Tacoma Power to Federal Energy Regulatory Commission (FERC).

8. Perform the APR – Review progress toward meeting objectives and, if necessary, update Decision Rules and set annual management targets for the coming year.
9. Write the AOP – An annual operation plan developed by Tacoma Power and the M&E subgroup that details the management strategies for achieving the management goals (e.g., recovery of populations, pHOS maxima, broodstock collection targets, pNOB minima, hatchery production targets, harvestable stocks) for the coming season for each population. This is the guiding document for all management activities (hatchery production, harvest, and population management actions) to be conducted in the next year.

Information obtained during the implementation of an AOP may be used to adaptively change management activities. In summary, the APR is the process used to develop the AOP, and M&E is the tool for producing the information required to inform the APR process, allowing managers to adaptively manage the programs and the populations they support.

The first two steps in this process include updating key metrics—the findings or assumptions used for planning purposes—and status and trend information that shows progress toward achieving goals. This

is followed by reviewing and updating a set of Decision Rules (triggers) that prescribe the appropriate management action given the goals, the assumptions, and the forecast for the coming season. These management actions and programs will be adaptively managed as directed by the SA and FERC license, and as recommended by the Cowlitz River Fisheries Technical Committee (FTC; HSRG 2009; NMFS 2013; WDFW and LCFRB 2016).

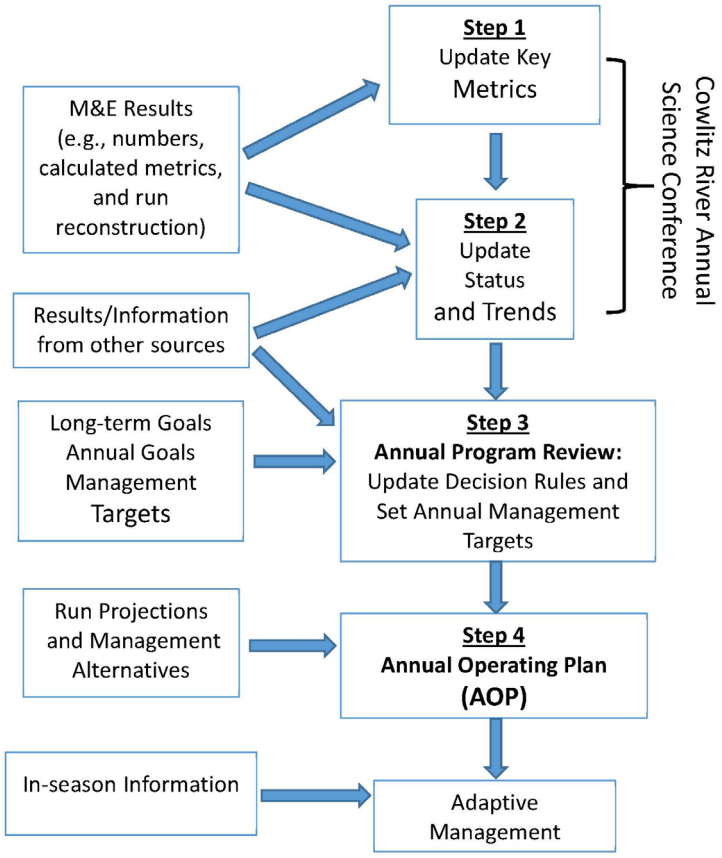

Figure 4. Components of the Annual Program Review and development of the Annual Operating Plan (excerpted from Tacoma Power 2020).

The key to implementing the APR adaptive management process and achieving resource goals over time is to perform the following tasks (Tacoma Power 2011):

- Assemble the most recent and relevant information
- Use this information to manage and operate fisheries, hatcheries, and the monitoring and evaluation program in a manner that is consistent with the established guidelines

The purpose of the APR is to evaluate the Cowlitz River fisheries programs, make necessary and appropriate changes, and produce an AOP that guides the program through the coming year, thereby ensuring progress toward the long-term goals for recovery (healthy and harvestable) of these natural-origin anadromous salmonid populations. The AOP incorporates information from the M&E Program and from outside sources, to complete the adaptive management loop (Figure 3), ensuring that the most recent information is used to guide decisions. The APR process also provides an important opportunity to inform and engage the public.

3 Management Objectives

The most recent management objectives are provided for spring Chinook Salmon *Oncorhynchus tshawytscha*, fall Chinook Salmon, Coho Salmon *O. kisutch*, and winter-run steelhead *O. mykiss* in the Transition Plans (Tacoma Power 2021a-d) and in the 2020 FHMP (Tacoma Power 2020). The most recent management objectives for summer-run steelhead, Chum Salmon *O. keta*, and Cutthroat Trout *O. clarkii* are provided in the 2020 FHMP (Tacoma Power 2020; Table 1). Recovery objectives may be found in the *ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead* (NMFS 2013). The programs for each population will be evaluated for their progress toward achieving the management and recovery objectives through the APR as described in Chapter 12 of the 2020 FHMP (Tacoma Power 2020) and will be altered as warranted through the adaptive management process. The Hatchery Scientific Review Group (HSRG) evaluation guidelines (2009) will also be assessed for applicability during each step of recovery.

Table 1. Sources of the most recent management objectives for each management species population in the Cowlitz Basin.

Species	Population[1]	Management Objectives Sources	Citations
Coho	Lower Cowlitz	• Coho Salmon Transition Plan • 2020 FHMP • ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead	• Tacoma Power 2021a • Tacoma Power 2020 • NMFS 2013
	Tilton		
	Upper Cowlitz		
	Cispus		
Fall Chinook	Lower Cowlitz	• Fall Chinook Salmon Transition Plan • 2020 FHMP • ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead	• Tacoma Power 2021b • Tacoma Power 2020 • NMFS 2013
	Upper Cowlitz (Tilton, Upper Cowlitz, and Cispus)		
Spring Chinook	Tilton	• Spring Chinook Salmon Transition Plan • 2020 FHMP • ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead	• Tacoma Power 2021c • Tacoma Power 2020 • NMFS 2013
	Upper Cowlitz		
	Cispus		
Winter Steelhead	Lower Cowlitz	• Winter Steelhead Salmon Transition Plan • 2020 FHMP • ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead	• Tacoma Power 2021d • Tacoma Power 2020 • NMFS 2013
	Tilton		
	Upper Cowlitz		
	Cispus		
Summer Steelhead	No recognized population	• Fisheries and Hatchery Management Plan (FHMP): Final	Tacoma Power 2020
Chum Salmon	Cowlitz – Fall Cowlitz - Summer	• Fisheries and Hatchery Management Plan (FHMP): Final • ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River	Tacoma Power 2020

Species	Population[1]	Management Objectives Sources	Citations
		Chum Salmon, and Lower Columbia River Steelhead	
Coastal Cutthroat	Cowlitz	• Fisheries and Hatchery Management Plan (FHMP): Final	Tacoma Power 2020

Notes:
1. 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. Prepared by the National Marine Fisheries Service, Northwest Region.

4 Cowlitz Basin Geography and Fisheries Management Attributes

The Cowlitz River Basin is divided into the Upper and Lower Cowlitz subbasins. The Barrier Dam (rkm 81) located 3 km downstream of Mayfield Dam, is the dividing line between upper and lower subbasins and is the terminus for volitional upstream migration. Adult fish are trapped and transported upstream to the waters in the Upper Cowlitz subbasin. The Upper Cowlitz subbasin is further divided into the Tilton River and its tributaries (above Mayfield Lake) and above Cowlitz Falls Dam, the Upper Cowlitz River, and Cispus River. The three hydroelectric dams, Mayfield, Mossyrock, and Cowlitz Falls form the impoundments Mayfield Lake, Riffe Lake, and Lake Scanewa, respectively. All are located upstream of the Lower Cowlitz subbasin. Downstream fish collection facilities are located at Cowlitz Falls Dam and Mayfield Dam (Figure 5).

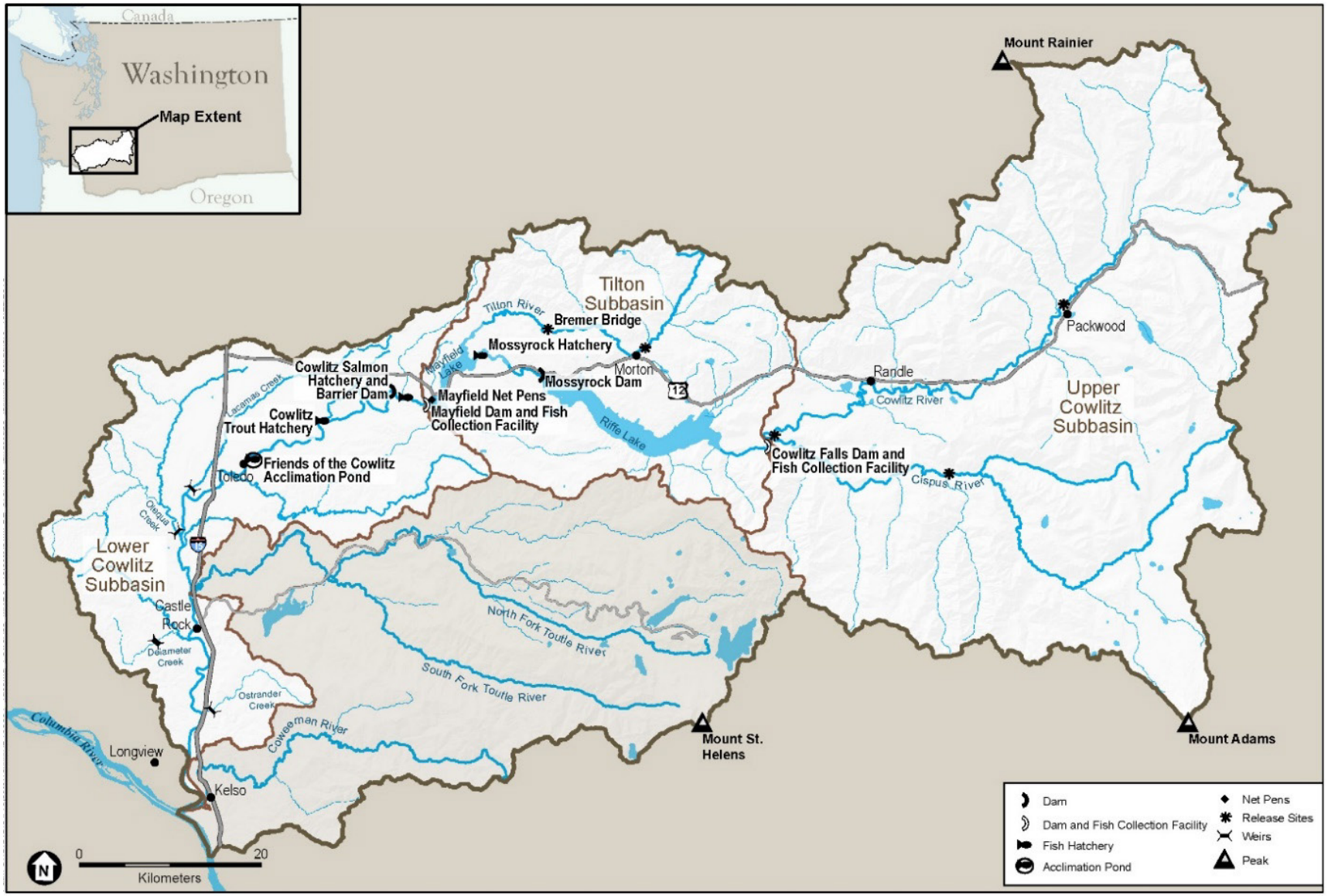

Figure 5. Cowlitz Basin, Washington, with the Lower Cowlitz, Cispus, Upper Cowlitz, and Tilton subbasins and important fisheries management sites (excerpted from Tacoma Power 2020).

4.1 Lower Cowlitz Subbasin

The Lower Cowlitz subbasin encompasses the mainstem Cowlitz River and tributaries, including Salmon, Lacamas, Olequa, Delameter, and Ostrander creeks, downstream of the Barrier Dam at rkm 81. The Coweeman and Toutle rivers also flow into the Lower Cowlitz subbasin but are not considered part of the project area for the purposes of this Plan. All management species (Table 1), and all life stages are present in the Lower Cowlitz subbasin. Because of this complicated fish assemblage, abundance and productivity indicators for specific populations in the subbasin are currently limited to estimates of adult-to-adult production. A smolt trap was operated in the lower Cowlitz River (2015 to 2020) and provided sufficient data for fall Chinook Salmon to estimate juvenile migration timing and to develop an index of juvenile abundance. Smolt trap estimates for Coho Salmon and winter steelhead were considered unreliable due to low capture efficiencies on yearling smolts and inability to determine the origin of unmarked smolts (i.e., Upper Cowlitz, Lower Cowlitz, Tilton River) (Sturza et al. 2020). Smolt trapping was suspended by Tacoma Power during the COVID pandemic due to financial constraints and has not been resumed. Adult productivity (adult recruits/spawner) is now used to monitor populations in the Lower Cowlitz subbasin. However, resumption of Lower Cowlitz smolt monitoring may be useful in the future if the freshwater phase is thought to be limiting a population and further information is needed to fill data gaps. Monitoring efforts in the Lower Cowlitz subbasin currently include spawning ground surveys for all species, creel surveys, and catch record cards to understand natural-origin/hatchery-origin encounter rates in fisheries, returns to the Barrier Dam adult separator, weirs for population assessment on select tributaries, pHOS management, development of mark-recapture surveys for spawner estimates in specified areas, and hatchery broodstock biosampling.

4.2 Upper Cowlitz Subbasin

The Upper Cowlitz subbasin includes the Tilton, Upper Cowlitz, and Cispus rivers. The National Oceanic and Atmospheric Administration designated individual populations of spring Chinook Salmon, fall Chinook Salmon, Coho Salmon, and winter steelhead in the Upper Cowlitz and Cispus rivers as threatened. The Tilton River is geographically separated and generally managed independently from the Upper Cowlitz and Cispus rivers with the exception of fall Chinook Salmon. Adult salmon and steelhead must be transported upstream of the Barrier Dam to access these rivers. Therefore, the number of adult returns (escapement) to these rivers is known. Production of juveniles is assessed at downstream migrant trapping facilities located at the Mayfield and Cowlitz Falls dams. Migrants captured at Cowlitz Falls Dam are transported to the lower Cowlitz River while migrating smolts at Mayfield Dam are either bypassed to the tailrace or pass through the turbines to continue their oceanward migration. Current M&E efforts in the Upper Cowlitz subbasin primarily focus on Fish Passage Survival and “fish-in, fish-out” metrics, which are important for tracking the achievement of annual and generational goals, as well as progress toward recovery.

4.2.1 Fish Transported Upstream

Due to the utilization of a trap-and-haul system in the upper basin (Tilton River/Cispus River/Upper Cowlitz River), most information on adult returns and spawner abundance comes from fish collected at the Barrier Dam and transported upstream by truck to release sites upstream of Mayfield Dam. The number and hatchery-origin/natural-origin composition of the fish to be released at each site, as well as targets for harvest rates are determined in the AOP. The number of jacks and adults transported

upstream, adjusted for harvest and pre-spawn mortality (if known), is treated as a proxy for the number of spawners in the absence of spawning ground surveys. The natural and hatchery origin composition of adults and jacks transported upstream for a particular population (management unit) may be adjusted to not exceed the pHOS target for each population.

4.2.2 Tilton River/Mayfield Dam Counting House

Data on juvenile salmonids from the Tilton River come from migrants that are collected at the Mayfield Dam Counting House. The facility allows staff to count, or estimate from subsampling, all juvenile salmon passing through the facility, implant coded wire tags (CWT) or other tags/marks as appropriate, collect scales and genetic samples, and measure and weigh migrating juveniles. At Mayfield Dam, downstream migrants not guided by the louver system into the bypass system pass the dam through the turbines or spillways. Those that survive turbine or spillway passage continue their migration into the lower Cowlitz River, passing over the Barrier Dam and eventually making their way to the Columbia River and then the Pacific Ocean.

4.2.3 Upper Cowlitz Basin/Cowlitz Falls Fish Facility

Data on juvenile salmonids from the Upper Cowlitz subbasin come from migrants that are collected at the Cowlitz Falls Fish Facility (CFFF). This facility allows staff to count, or estimate from a subsample, all juvenile salmonids collected through the collection system, implant them with CWT or other tags/marks as appropriate, collect scales and genetic samples, and measure and weigh juveniles. At the CFFF, juveniles collected through the spillway flumes or the North Shore Collector are transported downstream for release in the lower Cowlitz River. Fish that are not collected at the CFFF pass Cowlitz Falls Dam via spill or through the turbines and end up in Riffe Lake, where they are considered lost to anadromy.

5 Populations

For fisheries management purposes, the Cowlitz Basin is separated into the Lower and Upper Cowlitz subbasins. The Upper Cowlitz subbasin, upstream of Barrier Dam, includes the Tilton, Upper Cowlitz, and Cispus rivers. The Lower Cowlitz is located downstream of the Barrier Dam and consists of the mainstem and tributaries. However, the Toutle and Coweeman rivers are not included in this M&E Plan. Management strategies vary among species regarding the geographic composition of the managed units.

Species covered under the Plan include fall and spring Chinook Salmon, Coho Salmon, summer and winter steelhead, summer-run and fall-run Chum Salmon, and coastal Cutthroat Trout. Table 2 provides the species name, evolutionary significant unit (ESU) or distinct population segment (DPS), the population as defined by NMFS in the recovery plan (NMFS 2013), the location(s) within the Cowlitz Basin where the population occurs, the management units that are currently employed in the Cowlitz Basin management strategy, and ESA status, recovery designation, and recovery phase for each population (Table 2; Tacoma Power 2020, 2021a-d).

Coho Salmon are managed in the Lower Cowlitz River, Tilton River, and as an aggregate population in the Upper Cowlitz and Cispus rivers in the interim until a monitoring program is initiated. Fall Chinook Salmon are managed in the Lower Cowlitz River and as an aggregate population that includes the Tilton, Upper Cowlitz, and Cispus rivers. However, reintroduction and recovery of fall Chinook Salmon is currently focused only on the Tilton River. Spring Chinook Salmon are managed in the Lower Cowlitz River, the Tilton River, and, as in the short term, an aggregate population in the Upper Cowlitz and Cispus rivers. However, reintroduction of spring Chinook Salmon in the Upper Cowlitz subbasin is currently focused only on the Upper Cowlitz and Cispus rivers. Winter steelhead are managed in the Lower Cowlitz River, Tilton River, and as an aggregate population in the Upper Cowlitz and Cispus rivers. There is no recognized population of summer steelhead and the hatchery program is managed for recreational fishing opportunity in the Lower Cowlitz River. Summer-run and fall-run Chum Salmon are listed by NMFS as separate populations in the Cowlitz Basin and management is currently confined to the Lower Cowlitz River. Coastal Cutthroat Trout are a federal species of concern, and the Cowlitz Basin population was classified as Depressed by WDFW (WDFW 2000). Anadromous, adfluvial, and resident life history forms of coastal Cutthroat Trout are present. 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).

Table 2. Cowlitz Basin salmon species, steelhead, and Cutthroat Trout populations status.

Species	ESU or DPS	Population	Location	Management Unit	ESA Status	Recovery Designation[1]	Recovery Phase[2]
Coho	Lower Columbia River Coho Salmon ESU	Lower Cowlitz	Lower Cowlitz	Lower Cowlitz Coho Salmon[12]	Threatened[5]	Primary	Local Adaptation
		Tilton	Tilton	Upper Cowlitz Basin Coho Salmon[12]		Stabilizing	Recolonization
		Upper Cowlitz	Upper Cowlitz & Cispus			Primary	
		Cispus					
Fall Chinook	Lower Columbia River Chinook Salmon ESU	Lower Cowlitz	Lower Cowlitz	Lower Cowlitz Fall Chinook Salmon[13]	Threatened[6]	Contributing	Local Adaptation
		Upper Cowlitz	Tilton	Upper Cowlitz Fall Chinook Salmon[3; 13]		Stabilizing	
			Upper Cowlitz & Cispus	Habitat Not Currently Utilized			
Spring Chinook[3]	Lower Columbia River Chinook Salmon ESU	No NMFS recognized population	Lower Cowlitz	Lower Cowlitz Spring Chinook Salmon[3; 14]	NA	NA	NA
		Tilton	Tilton	Habitat Not Currently Utilized	Threatened[7]	Stabilizing	NA (Extirpated)
		Upper Cowlitz	Upper Cowlitz & Cispus	Upper Cowlitz Spring Chinook Salmon[14]		Primary	Recolonization
		Cispus					
Winter Steelhead	Lower Columbia River Steelhead DPS	Lower Cowlitz	Lower Cowlitz	Lower Cowlitz Winter Steelhead[15]	Threatened[8]	Contributing	Local Adaptation
		Tilton	Tilton	Tilton River Winter Steelhead[15]		Contributing	Recolonization
		Upper Cowlitz	Upper Cowlitz & Cispus	Upper Cowlitz Subbasin Winter Steelhead[15]		Primary	
		Cispus					
Summer Steelhead	NA	No recognized population	Lower Cowlitz	Lower Cowlitz Summer Steelhead[9]	NA[9]	NA	NA
Chum	Columbia River Chum Salmon ESU	Cowlitz – Summer[4]	Lower Cowlitz	Cowlitz Basin Chum Salmon[9]	Threatened[10]	Contributing	Not Defined
			Upper Cowlitz	NA[9]			
		Cowlitz – Fall[4]	Lower Cowlitz	Cowlitz Basin Chum Salmon[9]			
			Upper Cowlitz	NA[9]			
Coastal Cutthroat	Southwestern Washington/ Lower Columbia River Coastal Cutthroat Trout DPS	Cowlitz	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout[9]	Not ESA Listed[11]	NA	NA
			Tilton				
			Upper Cowlitz				
			Cispus				

Notes:
1. NMFS 2013.
2. Tacoma Power 2020.

3. Spring Chinook Salmon reintroduction is focused on the Upper Cowlitz and Cispus rivers. Fall Chinook Salmon reintroduction is focused on the Tilton River.
Summer-Run and Fall-Run Chum Salmon are managed as an aggregate population although both are identified in the ESA listing. Chum Salmon are confined to the Lower Cowlitz River currently.
4. NMFS 2005, 2022: Classified as Threatened in 2005.
5. NMFS 1999a, 2005, 2022: Classified as Threatened in 1999, re-classified as Threatened in 2005.
6. NMFS 1999a, 2005, 2022: Classified as Threatened in 1999, re-classified as Threatened in 2005.
7. NMFS 1998, 2006, 2022: Classified as Threatened in 1998, re-classified as Threatened in 2006.
8. Tacoma Power 2020.
9. NMFS 1999b, 2005, 2022: Classified as Threatened in 1999, re-classified as Threatened in 2005.
10. Tacoma Power 2020: Coastal Cutthroat Trout are a federal species of concern and the Cowlitz Basin population was classified as Depressed by WDFW.
11. Tacoma Power 2021a.
12. Tacoma Power 2021b.
13. Tacoma Power 2021c.
14. Tacoma Power 2021d.

6 Hatchery Programs

Hatchery programs are managed under an adaptive management plan that allows adjustment of the programs to respond to new information, meet management objectives, and respond to changing population status and environmental conditions. Two hatcheries produce the fish in the Cowlitz Basin: Cowlitz Salmon Hatchery and Cowlitz Trout Hatchery. Full details of the management plans for these hatcheries are available in the FHMP and Transition Plans (Tacoma Power 2020, 2021a-d). Table 3 provides an overview of program release goals for 2018 through 2024 and prior to the 2011 FHMP (Tacoma Power 2012). Hatchery production targets are adjusted annually, as necessary, through the APR process and development of the AOP.

Table 3. Hatchery Program overview: Annual Program Review production goals.

Species	Before 2011 FHMP Update	2018 Goal	2019 Goal	2020 Goal	2021 Goal	2022 Goal	2023 Goal	2024 Goal
Fall Chinook	4,800,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000
Spring Chinook	959,800	1,738,529	1,738,529	1,738,529	1,738,529	1,738,529	1,678,000	1,678,000
Coho	2,835,000	2,178,000	2,178,000	2,178,000	2,178,000	2,178,000	2,178,000	2,178,000
Winter Steelhead	690,000	647,000	647,000	647,000	647,000	647,000	647,000	644,500
Summer Steelhead	550,000	625,000	650,000	650,000	650,000	650,000	650,000	650,000
Cutthroat	160,000	100,599	100,599	100,599	100,599	100,599	100,599	100,599

Most M&E efforts within the hatcheries are focused on data collection such as broodstock biological sampling, fecundity, tracking the loss of fish during the rearing period (between green egg and release), life stage specific survivals, estimating the number of fish released, and assessing results from CWT adult returns. Moving forward, greater emphasis should be put on developing methods to evaluate rearing and release strategies to improve survival and age composition. Before any such actions are taken, it is critical to fully understand the performance of the existing programs based on adult return estimates (primarily via counts at the Barrier Dam fish separator, estimates of spawner abundance, and CWT return data). The broodstock biological sampling provides data for the hatchery programs and for the natural-origin populations when the hatchery program is integrated. Fish are sampled for scales (age), genetics, length, and sexed. This process is especially important for natural-origin spring Chinook Salmon, Coho Salmon, and winter steelhead because it is often difficult to recover carcasses from the spawning grounds. Finally, the tracking of survival from green eggs to smolt release is critical to understand the performance of juveniles in the hatchery.

Table 4 provides hatchery program details. For complete program descriptions and adaptive management information, see the FHMP and Transition Plans (Tacoma Power 2020, 2021a-d).

Table 4. Hatchery program details.

Species	Hatchery Program	Type	Program Goal	Broodstock	Hatchery
Coho	Upper Cowlitz Coho Salmon	Integrated	Conservation/ Harvest	Upper Cowlitz natural origin and hatchery origin	Cowlitz Salmon Hatchery
Fall Chinook	Upper Cowlitz Fall Chinook	Integrated	Conservation/ Harvest	Tilton River natural origin and hatchery origin; Lower Cowlitz natural origin as backup	Cowlitz Salmon Hatchery
Spring Chinook	Upper Cowlitz Spring Chinook	Segregated moving to Integrated	Harvest/ Conservation	Cowlitz hatchery origin (current) with future use of natural origin	Cowlitz Salmon Hatchery
Winter Steelhead	Lower Cowlitz Winter Steelhead	Segregated	Harvest	Lower Cowlitz hatchery origin	Cowlitz Trout Hatchery
	Upper Cowlitz Winter Steelhead	Integrated	Conservation/ Harvest	Upper Cowlitz natural origin and hatchery origin	Cowlitz Trout Hatchery
	Tilton Winter Steelhead	Integrated	Conservation/ Harvest	Tilton natural origin and hatchery origin	Cowlitz Trout Hatchery
Summer Steelhead	Lower Cowlitz Summer Steelhead	Segregated	Harvest	Cowlitz hatchery origin Summer Steelhead (derived from Skamania stock)	Cowlitz Trout Hatchery
Coastal Cutthroat	Cutthroat	Segregated	Harvest	Cowlitz hatchery origin	Cowlitz Trout Hatchery

7 Marking and Tagging

Hatchery program fish are marked and/or tagged according to management requirements. Natural-origin juvenile emigrants are marked at the Mayfield Fish Collector and the Cowlitz Falls Fish Facility. Fish marked at the Mayfield Fish Collector are from the Tilton River and fish marked at the CFFF are from the Upper Cowlitz or Cispus rivers. Table 5 provides the current marking and tagging plan for hatchery produced fish and Table 6 provides the current marking and tagging plan for naturally produced fish, organized by management unit. Juveniles in the Lower Cowlitz are not currently sampled so marking and tagging of naturally produced juveniles is confined to the Upper Cowlitz Basin at the Mayfield Fish Collector and the Cowlitz Falls Fish Facility.

Table 5. Marking and Tagging Plan[1, 2]: Cowlitz Basin juvenile salmon, steelhead, and Cutthroat Trout hatchery programs.

Hatchery Program	Mark	Tag-Location	Geographic Location	Notes
Upper Cowlitz Coho Salmon	Ad-Clip	--	Cowlitz Salmon Hatchery	Upper Cowlitz, Cispus, and Tilton rivers; all fish receive an adipose-clip.
	Ad-Clip	CWT-Snout	Cowlitz Salmon Hatchery	A portion of the fish receive a CWT – as determined by M&E needs.
Upper Cowlitz Fall Chinook	Ad-Clip	--	Cowlitz Salmon Hatchery	All fish receive an adipose-clip.
	Ad-Clip	CWT-Snout	Cowlitz Salmon Hatchery	A portion of the fish receive a CWT – as determined by M&E needs.
Cowlitz Spring Chinook	Ad-Clip	CWT-Snout	Cowlitz Salmon Hatchery	Upper Cowlitz and Cispus rivers; a portion of fish in each release strategy will be CWT. Marking strategy to be revisited when integrated programs begin.
Lower Cowlitz Winter Steelhead	Ad-Clip	--	Cowlitz Trout Hatchery	
Tilton Winter Steelhead	Ad-Clip + LV	--	Cowlitz Trout Hatchery	Other low impact marking approach may be used.
Upper Cowlitz Winter Steelhead	Ad-Clip	CWT-Snout	Cowlitz Trout Hatchery	Upper Cowlitz and Cispus rivers; other low impact marking approach may be used.
Lower Cowlitz Summer Steelhead	Ad-Clip	--	Cowlitz Trout Hatchery	
Cutthroat	Ad-Clip	--	Cowlitz Trout Hatchery	

Notes:
1. See the transition plans for each species for more information on marking strategies (Tacoma Power 2020, 2021a-d).
2. Codes: Ad-Clip = Adipose Fin Clip; LV = Left Ventral Fin Clip; CWT = Coded Wire Tag

Table 6. Marking and Tagging Plan[1, 2, 3]: Cowlitz Basin juvenile salmon, steelhead, and Cutthroat Trout natural-origin management units.

Management Unit	Mark	Tag-Location	Geographic Location	Notes
Lower Cowlitz Coho Salmon	--	--	NA	Juveniles from this management unit are not currently sampled in the Cowlitz River.
Upper Cowlitz Basin Coho Salmon	UM	CWT-Snout	Mayfield Fish Collector	Coho are tagged only at the Mayfield Fish Collector (Tilton River migration). Coho are not CWT-tagged at the Cowlitz Falls Fish Facility.
	UM	--	Cowlitz Falls Fish Facility	
Lower Cowlitz Fall Chinook Salmon	--	--	NA	Juveniles from this management unit are not currently sampled in the Cowlitz River.
Upper Cowlitz Fall Chinook Salmon	UM	CWT-Snout	Mayfield Fish Collector	Tagging is performed at Mayfield Fish Collector.
	--	--	Cowlitz Falls Fish Facility	Not currently transporting adult Fall Chinook above Cowlitz Falls
Lower Cowlitz Spring Chinook Salmon	--	--	NA	Juveniles from this management unit are not currently sampled. This is not a NMFS-identified population.
Upper Cowlitz Spring Chinook Salmon	--	--	Mayfield Fish Collector	Upper Cowlitz and Cispus rivers; a subsample of out-migrating juveniles are PIT-tagged at Cowlitz Falls Fish Facility.
	UM	PIT-Abdomen	Cowlitz Falls Fish Facility	
Lower Cowlitz Winter Steelhead	--	--	--	Juveniles from this management unit are not currently sampled in the Cowlitz River.
Tilton River Winter Steelhead	UM	CWT-Dorsal Sinus	Mayfield Fish Collector	
Upper Cowlitz Subbasin Winter Steelhead	UM	CWT-Snout	Cowlitz Falls Fish Facility	Upper Cowlitz and Cispus rivers emigrants
Lower Cowlitz Summer Steelhead	--	--	NA	No recognized population. Juveniles from this management unit are not currently sampled.
Cowlitz Chum Salmon	--	--	NA	Juveniles from this management unit are not currently sampled.
Cowlitz Basin Coastal Cutthroat Trout	UM	CWT-Dorsal Sinus	Mayfield Fish Collector	Tilton River emigrants tagged at the Mayfield Fish Collector. Upper Cowlitz and Cispus rivers emigrants tagged at the Cowlitz Falls Fish Facility. Lower Cowlitz juveniles are not sampled or tagged.
	UM	CWT-Snout	Cowlitz Falls Fish Facility	

Notes:
1. See the transition plans for each species for more information on marking strategies (Tacoma Power 2020, 2021a-d).
2. See the Cowlitz Falls North Shore Collector Downstream Fish Passage Evaluation Annual Reports for information on PIT tagging for these studies.
3. Codes: Ad-Clip = adipose clip; CWT = Coded Wire Tag; UM = Unmarked; PIT = Passive Integrated Transponder

8 Monitoring and Evaluation Components

This section provides an overview of the components of the Plan. These components include a description of the monitoring levels described by Crawford and Rumsey (2011) and their integration in this Plan as Baseline and Directed Studies. The concepts and composition of baseline and directed studies are described. Baseline and Directed studies are employed to characterize and allow managers to better understand the impact of Tacoma Power's hatchery programs on natural populations and if those natural populations are progressing toward recovery. The data collected and analyzed within these studies are intended to provide Tacoma Power and the FTC with information necessary to manage programs and hatcheries effectively, with the goal of achieving population recovery and harvest objectives (Tacoma Power 2020).

8.1 Monitoring Levels

Monitoring and evaluation serve multiple purposes to inform different areas of management and assess population status. Crawford and Rumsey (2011) describe three levels of monitoring:

1. **Status and trend monitoring** assesses changes in the condition of a metric important for tracking progress in a population or listing factor. It is the main monitoring necessary to determine the biological condition of the species and the status of specific statutory listing factors and threats.
2. **Implementation monitoring** is used to evaluate whether elements of the recovery plan have been implemented and whether activities are in compliance with sections of the ESA.
3. **Effectiveness monitoring** tests whether management actions have been effective in creating the intended outputs of the management action at the project scale and validates that the management action or cumulative management actions resulted in the intended outcome. This monitoring maintains accountability for management decisions and provides the basis for adaptive management decisions and actions.

This Plan is structured with two overarching M&E approaches, baseline studies and directed studies, to address the three levels of monitoring described by Crawford and Rumsey (2011). The baseline studies address status and trend monitoring, implementation monitoring, and effectiveness monitoring. However, more intensive studies may sometimes be required to address specific management questions or data gaps within in these monitoring levels, necessitating a directed study.

8.2 Overview of Baseline and Directed Studies

Throughout this Plan, baseline and directed studies are defined as follows:

- **Baseline Studies** are basic monitoring activities and are completed on a regular basis (e.g., annually, every 5 years, when specific events occur) to track population progress toward recovery and management objectives, including how closely SA obligations are being achieved under varying conditions.
- Baseline studies should fulfill the data needs for VSP (McElhany et al. 2000) monitoring (abundance, productivity, spatial and temporal structure, and diversity), hatchery performance, contribution of hatchery programs to recreational and commercial fisheries, and to assess performance of hydroelectric project facilities (see Section 4.2). The ultimate goal of the baseline 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 and trajectory.

- **Directed Studies** are designed to diagnose specific questions or issues identified from baseline studies information to address management objectives and decision making. Directed studies are intended to inform future actions, program design, management decisions, hatchery operations, and facility operations that will improve program performance related to the topic of a directed study to support management decisions, progress towards recovery, and so that goals of the SA can be achieved. The focus and level of effort assigned to a directed study will vary based on specific needs as identified within the APR process.

8.3 Baseline Studies

The M&E Baseline Studies are organized by the types of metrics that are used to assess the status of the populations, performance of the hatchery facilities, effectiveness of the fish passage and collection facilities, and contribution to harvest by the hatchery programs. The baseline studies are presented in Table 7 through Table 10. Population metrics are categorized according to the metric category and the life stages and fish origins to which they apply. VSP and population-oriented metrics are provided in Table 7. Baseline studies are described in detail in Section 15.

Table 7. Viable salmonid population and population assessment metrics.

Category	Metric Name	Origin	Life Stage
VSP & Population	Abundance of Spawners	Natural and Hatchery	Adult
VSP & Population	Smolt Abundance – Population Estimate	Natural	Smolt
VSP & Population	Adult-to-Adult Replacement	Natural	Spawner and Adult
VSP & Population	Smolts per Spawner Recruitment	Natural	Smolt and Adult
VSP & Population	Spatial Distribution of Spawning – Spatial Structure	Natural and Hatchery	Adult
VSP & Population	Population Genetics – Sampling	Natural	Smolt and Adult
VSP & Population	Population Genetics – Analyses	Natural	Smolt and Adult
VSP & Population	Age at Return – Adult Age Structure	Natural and Hatchery	Adult
VSP & Population	Adult Return Timing	Natural and Hatchery	Adult
VSP & Population	Adult Spawn Timing	Natural and Hatchery	Adult
VSP & Population	Juvenile Migration Timing	Natural	Juvenile
VSP & Population	Age at Smolt Migration	Natural	Smolt
VSP & Population	Mean Age of Adult Returns	Natural and Hatchery	Adult
VSP & Population	Abundance of Adults Returns to Target River	Natural and Hatchery	Adult
VSP & Population	Abundance at Mouth of Cowlitz	Natural and Hatchery	Adult
VSP & Population	Smolt-to-Adult Return rate (SAR)	Natural	Adult
VSP & Population	Pre-Spawn Mortality	Natural and Hatchery	Adult
VSP & Population	Stray Rate within Basin	Natural and Hatchery	Adult
VSP & Population	Stray Rate outside of Basin	Natural and Hatchery	Adult
VSP & Population	Stray Rate into Basin	Natural and Hatchery	Adult

Metrics for assessment of hatchery performance are organized by life stage and are focused on documenting hatchery production, fish quality, survival within the hatchery, VSP-Diversity metrics related to the hatchery program, and hatchery program performance (Table 8).

Table 8. In-hatchery metrics.

Category	Metric Name	Origin	Life Stage
Hatchery Assessment	Broodstock Sampling – Biological Data	Natural and Hatchery	Adult
Hatchery Assessment	pHOS	Natural and Hatchery	Adult
Hatchery Assessment	pNOB & pHOB	Natural and Hatchery	Adult
Hatchery Assessment	PNI	Natural and Hatchery	Adult
Hatchery Assessment	Number Hatchery Smolts Released	Hatchery	Smolt
Hatchery Assessment	Precocious Maturation Rate	Hatchery	Juvenile
Hatchery Assessment	In-Hatchery Survival by Life Stage	Hatchery	All Life Stages
Hatchery Assessment	Population Genetics - Sampling	Hatchery	Broodstock and Juvenile
Hatchery Assessment	Population Genetics - Analyses	Hatchery	Broodstock and Juvenile
Hatchery Assessment	Demographic Replacement	Natural and Hatchery	Adult
Hatchery Assessment	Size at Release	Hatchery	Smolt
Hatchery Assessment	Date(s) of Release	Hatchery	Smolt
Hatchery Assessment	Growth Conversion	Hatchery	Juvenile
Hatchery Assessment	Broodstock Collected - Numerical	Natural and Hatchery	Adult
Hatchery Assessment	Broodstock Spawned - Numerical	Natural and Hatchery	Adult
Hatchery Assessment	Release Location(s)	Hatchery	Smolt

Metrics to assess juvenile fish collection efficiency (FCE), juvenile fish passage survival (FPS), and fallback of adults at the Cowlitz Falls and Mayfield hydroelectric projects and trapping facilities are organized by life stage and origin (Table 9). Note that FCE and FPS at the CFFF are estimated under a sperate analysis and reporting effort from the M&E program that produces the Cowlitz Falls North Shore Collector Downstream Fish Passage Evaluation Annual Report as directed by the 2014 Draft Adaptive Management Plan (e.g., Four Peaks 2024). These reports also provide the annual Mayfield Fish Collector numbers; however, studies to estimate FCE at this facility are not currently being conducted. Fallback of adults to collection facilities is reported in the Cowlitz Falls North Shore Collector Downstream Fish Passage Evaluation Annual Report for the Cowlitz Falls and Mayfield projects.

Table 9. Trapping and facility assessment metrics for the Cowlitz Falls and Mayfield hydroelectric projects.

Category	Metric Name	Origin	Life Stage
Hydroelectric Project Facility Assessment	Fish Collection Efficiency (Cowlitz Falls)	Natural	Smolt (primarily)
Hydroelectric Project Facility Assessment	Fish Guidance Efficiency (Mayfield)	Natural	Smolt (primarily)
Hydroelectric Project Facility Assessment	Fish Passage Survival	Natural	Smolt (primarily)
Hydroelectric Project Facility Assessment	Adult Fallback	Natural and Hatchery	Adult

Metrics to assess the contribution to harvest by hatchery programs and effects of harvest on the naturally reproducing populations are expressed by the estimated number of fish harvested annually and the estimated percentage of the adult return population harvested annually (Table 10). The harvest metrics are reported by species and hatchery program, population, or management unit.

Table 10. Harvest assessment metrics.

Category	Metric Name	Origin	Life Stage
Harvest	Harvest – Numerical	Natural and Hatchery	Adult
Harvest	Harvest – Percentage of Run	Natural and Hatchery	Adult

8.3.1 Identification of Baseline Studies

Identification of the monitoring components included in the baseline studies is based on VSP parameters, data used in life cycle modeling, and data used to inform management decisions. These parameters can be used to assess the viability of populations, progress toward recovery, and identify limiting life stages. Additional monitoring focuses on assessing compliance with ESA terms and conditions and reasonable and prudent measures; effectiveness of management actions; and consistency with recovery plan elements. These parameters are considered using the following criteria for identification of the metrics in this Plan:

1. Is the information needed to evaluate population viability and progress toward recovery?
2. Does the parameter affect program management decisions?
3. Is there significant uncertainty about the assumed value?
4. Can the parameter be estimated within the timeline required for the management need?
5. What are the estimated costs of the study relative to the benefits it provides, and is it a priority in relation to existing evaluation efforts? Are there sufficient resources and funding available to accomplish the new study, or do other studies have a greater priority?

If a topic or metric answered “no” to all five of these questions, it will not be considered for assessment/monitoring. Table 7 through Table 10 presents the baseline studies included in this Plan.

8.3.2 Baseline Studies Applicability and Implementation Frequency

Baseline studies are designed to be broadly applicable to each species, but not all baseline studies apply to every management unit or hatchery program, and baseline studies may differ in their implementation frequency (e.g., annually, periodically) among species and management units. The applicability and frequency of implementation may be adjusted over time, as necessary, to effectively and efficiently assess management and recovery objectives. Table 11 though Table 15 provide the applicability and implementation frequency of each objective for each species and management unit.

The focus of the Plan is generally on natural populations classified as Primary or Contributing in the Lower Columbia ESA Recovery Plan (NMFS 2013). In some cases, such as Fall Chinook, a stabilizing population or associated hatchery program may be the focus of monitoring and evaluation when recovery is reliant on that population. Therefore, stabilizing populations are not ignored but are typically not the focus of monitoring. All hatchery programs will be monitored with respect to their effects on conservation and contribution to fisheries, as well as their performance effectiveness.

Table 11. Chinook Salmon baseline studies applicability and implementation frequency.

Category	Metric	Origin	Fall Chinook Salmon		Spring Chinook Salmon	
			Lower Cowlitz	Upper Cowlitz; Cispus; Tilton	Tilton	Upper Cowlitz; Cispus
VSP & Population	Abundance of Spawners	N and H	Annual	Annual	NA	Annual
VSP & Population	Smolt Abundance – Population Estimate	N	Periodic	Annual	NA	Annual
VSP & Population	Adult-to-Adult Replacement	N	Annual	Annual	NA	Annual
VSP & Population	Smolts per Spawner Recruitment	N	Periodic	Annual	NA	Annual
VSP & Population	Spatial Distribution of Spawning – Spatial	N and H	Annual	Periodic	NA	Periodic
VSP & Population	Population Genetics – Sampling	N	Annual	Annual	NA	Annual
VSP & Population	Population Genetics – Analyses	N	TBD	TBD	TBD	TBD
VSP & Population	Age at Return – Adult Age Structure	N and H	Annual	Annual	NA	Annual
VSP & Population	Adult Return Timing	N and H	Annual	Annual	NA	Annual
VSP & Population	Adult Spawn Timing	N and H	Annual	Annual	NA	Annual
VSP & Population	Juvenile Migration Timing	N	Periodic	Annual	NA	Annual
VSP & Population	Age at Smolt Migration	N	Periodic	Annual	NA	Annual
VSP & Population	Mean Age of Adult Returns	N and H	Annual	Annual	NA	Annual
VSP & Population	Abundance of Adults Returns to Target River	N and H	Annual	Annual	NA	Annual
VSP & Population	Abundance at Mouth of Cowlitz	N and H	Annual	Annual	NA	Annual
VSP & Population	Smolt-to-Adult Return rate (SAR)	N	Periodic	Annual	NA	Annual
VSP & Population	Pre-Spawn Mortality	N and H	Annual	Periodic	NA	Periodic
VSP & Population	Stray Rate within Basin	H	Annual	Annual	NA	Periodic
VSP & Population	Stray Rate outside of Basin	H	Annual	Annual	NA	Periodic
VSP & Population	Stray Rate into Basin	H	Annual	Annual	NA	Periodic
In-Hatchery	Broodstock Sampling – Biological Data	N and H	NA	Annual	NA	Annual
In-Hatchery	pHOS	N and H	Annual	Annual	NA	Annual
In-Hatchery	pNOB & pHOB	N and H	NA	Annual	NA	Annual
In-Hatchery	PNI	N and H	NA	Annual	NA	Annual
In-Hatchery	Number Hatchery Smolts Released	N and H	NA	Annual	NA	Annual
In-Hatchery	Precocious Maturation Rate	H	NA	Annual	NA	Annual
In-Hatchery	In-Hatchery Survival by Life Stage	H	NA	Annual	NA	Annual
In-Hatchery	Population Genetics – Sampling	H	NA	Annual	NA	Annual
In-Hatchery	Population Genetics – Analyses	N and H	NA	Periodic	NA	Periodic
In-Hatchery	Demographic Replacement	N and H	NA	Annual	NA	Annual
In-Hatchery	Size at Release	H	NA	Annual	NA	Annual
In-Hatchery	Date(s) of Release	H	NA	Annual	NA	Annual
In-Hatchery	Growth Conversion	H	NA	Annual	NA	Annual

Category	Metric	Origin	Fall Chinook Salmon		Spring Chinook Salmon	
			Lower Cowlitz	Upper Cowlitz; Cispus; Tilton	Tilton	Upper Cowlitz; Cispus
In-Hatchery	Broodstock Collected – Numerical	N and H	NA	Annual	NA	Annual
In-Hatchery	Broodstock Spawned – Numerical	N and H	NA	Annual	NA	Annual
In-Hatchery	Release Location(s)	H	NA	Annual	NA	Annual
Facility Assessment	Fish Collection Efficiency; Fish Guidance Efficiency	N	NA	Annual	NA	Annual
Facility Assessment	Fish Passage Survival	N	NA	Annual	NA	Annual
Facility Assessment	Adult Fallback	N and H	NA	Annual	NA	Annual
Harvest	Harvest – Numerical	N and H	Annual	Annual	NA	Annual
Harvest	Harvest – Percentage of Run	N and H	Annual	Annual	NA	Annual

Notes:
H = hatchery origin
N = natural origin

Table 12. Coho Salmon baseline studies applicability and implementation frequency.

Category	Metric	Origin	Coho Salmon		
			Lower Cowlitz	Tilton	Upper Cowlitz; Cispus
VSP & Population	Abundance of Spawners	N and H	Annual	Annual	Annual
VSP & Population	Smolt Abundance – Population Estimate	N	Periodic	Annual	Annual
VSP & Population	Adult-to-Adult Replacement	N	Annual	Annual	Annual
VSP & Population	Smolts per Spawner Recruitment	N	Periodic	Annual	Annual
VSP & Population	Spatial Distribution of Spawning – Spatial Structure	N and H	Annual	Periodic	Periodic
VSP & Population	Population Genetics – Sampling	N	Annual	Annual	Annual
VSP & Population	Population Genetics – Analyses	N	TBD	TBD	TBD
VSP & Population	Age at Return – Adult Age Structure	N and H	Annual	Annual	Annual
VSP & Population	Adult Return Timing	N and H	Annual	Annual	Annual
VSP & Population	Adult Spawn Timing	N and H	Annual	Annual	Annual
VSP & Population	Juvenile Migration Timing	N	Periodic	Annual	Annual
VSP & Population	Age at Smolt Migration	N	Periodic	Annual	Annual
VSP & Population	Mean Age of Adult Returns	N and H	Annual	Annual	Annual
VSP & Population	Abundance of Adults Returns to Target River	N and H	Annual	Annual	Annual
VSP & Population	Abundance at Mouth of Cowlitz	N and H	Annual	Annual	Annual
VSP & Population	Smolt-to-Adult Return rate (SAR)	N	Periodic	Annual	Annual
VSP & Population	Pre-Spawn Mortality	N and H	Annual	Periodic	Periodic

Category	Metric	Origin	Coho Salmon		
			Lower Cowlitz	Tilton	Upper Cowlitz; Cispus
VSP & Population	Stray Rate within Basin	H	Annual	Annual	Periodic
VSP & Population	Stray Rate outside of Basin	H	Annual	Annual	Periodic
VSP & Population	Stray Rate into Basin	H	Annual	Annual	Periodic
In-Hatchery	Broodstock Sampling – Biological Data	N and H	NA	Annual	Annual
In-Hatchery	pHOS	N and H	Annual	Annual	Annual
In-Hatchery	pNOB & pHOB	N and H	NA	Annual	Annual
In-Hatchery	PNI	N and H	NA	Annual	Annual
In-Hatchery	Number Hatchery Smolts Released	N and H	NA	Annual	Annual
In-Hatchery	Precocious Maturation Rate	H	NA	Annual	Annual
In-Hatchery	In-Hatchery Survival by Life Stage	H	NA	Annual	Annual
In-Hatchery	Population Genetics – Sampling	H	NA	Annual	Annual
In-Hatchery	Population Genetics – Analyses	N and H	NA	Periodic	Periodic
In-Hatchery	Demographic Replacement	N and H	NA	Annual	Annual
In-Hatchery	Size at Release	H	NA	Annual	Annual
In-Hatchery	Date(s) of Release	H	NA	Annual	Annual
In-Hatchery	Growth Conversion	H	NA	Annual	Annual
In-Hatchery	Broodstock Collected – Numerical	N and H	NA	Annual	Annual
In-Hatchery	Broodstock Spawned – Numerical	N and H	NA	Annual	Annual
In-Hatchery	Release Location(s)	H	NA	Annual	Annual
Facility Assessment	Fish Collection Efficiency; Fish Guidance Efficiency	N	NA	Annual	Annual
Facility Assessment	Fish Passage Survival	N	NA	Annual	Annual
Facility Assessment	Adult Fallback	N and H	NA	Annual	Annual
Harvest	Harvest – Numerical	N and H	Annual	Annual	Annual
Harvest	Harvest – Percentage of Run	N and H	Annual	Annual	Annual

Table 13. Steelhead baseline studies applicability and implementation frequency.

Category	Metric	Origin	Winter Steelhead			Summer Steelhead
			Lower Cowlitz	Tilton	Upper Cowlitz; Cispus	Lower Cowlitz
VSP & Population	Abundance of Spawners	N and H	Annual	Annual	Annual	Annual
VSP & Population	Smolt Abundance – Population Estimate	N	Periodic	Annual	Annual	NA
VSP & Population	Adult-to-Adult Replacement	N	Annual	Annual	Annual	NA
VSP & Population	Smolts per Spawner Recruitment	N	Periodic	Annual	Annual	NA

Category	Metric	Origin	Winter Steelhead			Summer Steelhead
			Lower Cowlitz	Tilton	Upper Cowlitz; Cispus	Lower Cowlitz
VSP & Population	Spatial Distribution of Spawning – Spatial	N and H	Periodic	Periodic	Periodic	Periodic
VSP & Population	Population Genetics – Sampling	N	Annual	Annual	Annual	NA
VSP & Population	Population Genetics – Analyses	N	Periodic	Periodic	Periodic	NA
VSP & Population	Age at Return – Adult Age Structure	N and H	Annual	Annual	Annual	Annual
VSP & Population	Adult Return Timing	N and H	Annual	Annual	Annual	Annual
VSP & Population	Adult Spawn Timing	N and H	Annual	Annual	Annual	Annual
VSP & Population	Juvenile Migration Timing	N	Periodic	Annual	Annual	NA
VSP & Population	Age at Smolt Migration	N	Periodic	Annual	Annual	NA
VSP & Population	Mean Age of Adult Returns	N and H	Annual	Annual	Annual	Annual
VSP & Population	Abundance of Adults Returns to Target River	N and H	Annual	Annual	Annual	Annual
VSP & Population	Abundance at Mouth of Cowlitz	N and H	Annual	Annual	Annual	Annual
VSP & Population	Smolt-to-Adult Return rate (SAR)	N	Periodic	Annual	Annual	NA
VSP & Population	Pre-Spawn Mortality	N and H	Annual	Periodic	Periodic	NA
VSP & Population	Stray Rate within Basin	H	Annual	Annual	Periodic	Periodic
VSP & Population	Stray Rate outside of Basin	H	Annual	Annual	Periodic	Periodic
VSP & Population	Stray Rate into Basin	H	Annual	Annual	Periodic	Periodic
In-Hatchery	Broodstock Sampling – Biological Data	N and H	Annual	Annual	Annual	Annual
In-Hatchery	pHOS	N and H	Annual	Annual	Annual	Annual
In-Hatchery	pNOB & pHOB	N and H	NA	Annual	Annual	NA
In-Hatchery	PNI	N and H	NA	Annual	Annual	NA
In-Hatchery	Number Hatchery Smolts Released	N and H	Annual	Annual	Annual	Annual
In-Hatchery	Precocious Maturation Rate	H	Annual	Annual	Annual	Annual
In-Hatchery	In-Hatchery Survival by Life Stage	H	Annual	Annual	Annual	Annual
In-Hatchery	Population Genetics – Sampling	H	Annual	Annual	Annual	Annual
In-Hatchery	Population Genetics – Analyses	N and H	Periodic	Periodic	Periodic	NA
In-Hatchery	Demographic Replacement	N and H	NA	Annual	Annual	NA
In-Hatchery	Size at Release	H	Annual	Annual	Annual	Annual
In-Hatchery	Date(s) of Release	H	Annual	Annual	Annual	Annual
In-Hatchery	Growth Conversion	H	Annual	Annual	Annual	Annual
In-Hatchery	Broodstock Collected – Numerical	N and H	Annual	Annual	Annual	Annual
In-Hatchery	Broodstock Spawned – Numerical	N and H	Annual	Annual	Annual	Annual
In-Hatchery	Release Location(s)	H	Annual	Annual	Annual	Annual
Facility Assessment	Fish Collection Efficiency; Fish Guidance Efficiency	N	NA	Annual	Annual	NA
Facility Assessment	Fish Passage Survival	N	NA	Annual	Annual	NA

Category	Metric	Origin	Winter Steelhead			Summer Steelhead
			Lower Cowlitz	Tilton	Upper Cowlitz; Cispus	Lower Cowlitz
Facility Assessment	Adult Fallback	N and H	NA	Annual	Annual	NA
Harvest	Harvest – Numerical	N and H	Annual	Annual	Annual	Annual
Harvest	Harvest – Percentage of Run	N and H	Annual	Annual	Annual	Annual

Table 14. Coastal Cutthroat Trout baseline studies applicability and implementation frequency.

Category	Metric	Origin	Coastal Cutthroat Trout			
			Lower Cowlitz	Tilton	Upper Cowlitz	Cispus
VSP & Population	Abundance of Spawners	N and H	NA	Annual	Annual	Annual
VSP & Population	Smolt Abundance – Population Estimate	N	Periodic	Annual	Annual	Annual
VSP & Population	Adult-to-Adult Replacement	N	NA	Annual	Annual	Annual
VSP & Population	Smolts per Spawner Recruitment	N	Periodic	Annual	Annual	Annual
VSP & Population	Spatial Distribution of Spawning – Spatial Structure	N and H	Periodic	Periodic	Periodic	Periodic
VSP & Population	Population Genetics – Sampling	N	NA	NA	NA	NA
VSP & Population	Population Genetics – Analyses	N	NA	NA	NA	NA
VSP & Population	Age at Return – Adult Age Structure	N and H	Annual	Annual	Annual	Annual
VSP & Population	Adult Return Timing	N and H	Annual	Annual	Annual	Annual
VSP & Population	Adult Spawn Timing	N and H	Annual	Annual	Annual	Annual
VSP & Population	Juvenile Migration Timing	N	Periodic	Annual	Annual	Annual
VSP & Population	Age at Smolt Migration	N	Periodic	Annual	Annual	Annual
VSP & Population	Mean Age of Adult Returns	N and H	Annual	Annual	Annual	Annual
VSP & Population	Abundance of Adults Returns to Target River	N and H	NA	Annual	Annual	Annual
VSP & Population	Abundance at Mouth of Cowlitz	N and H	NA	Annual	Annual	Annual
VSP & Population	Smolt-to-Adult Return rate (SAR)	N	NA	Annual	Annual	Annual
VSP & Population	Pre-Spawn Mortality	N and H	NA	Periodic	Periodic	
VSP & Population	Stray Rate within Basin	H	Annual	NA	NA	NA
VSP & Population	Stray Rate outside of Basin	H	Annual	NA	NA	NA
VSP & Population	Stray Rate into Basin	H	Annual	NA	NA	NA
In-Hatchery	Broodstock Sampling – Biological Data	N and H	Annual	NA	NA	NA
In-Hatchery	pHOS	N and H	NA	NA	NA	NA
In-Hatchery	pNOB & pHOB	N and H	NA	NA	NA	NA
In-Hatchery	PNI	N and H	NA	NA	NA	NA

Category	Metric	Origin	Coastal Cutthroat Trout			
			Lower Cowlitz	Tilton	Upper Cowlitz	Cispus
In-Hatchery	Number Hatchery Smolts Released	N and H	Annual	NA	NA	NA
In-Hatchery	Precocious Maturation Rate	H	Annual	NA	NA	NA
In-Hatchery	In-Hatchery Survival by Life Stage	H	Annual	NA	NA	NA
In-Hatchery	Population Genetics – Sampling	H	Annual	NA	NA	NA
In-Hatchery	Population Genetics – Analyses	N and H	Periodic	NA	NA	NA
In-Hatchery	Demographic Replacement	N and H	NA	NA	NA	NA
In-Hatchery	Size at Release	H	Annual	NA	NA	NA
In-Hatchery	Date(s) of Release	H	Annual	NA	NA	NA
In-Hatchery	Growth Conversion	H	Annual	NA	NA	NA
In-Hatchery	Broodstock Collected – Numerical	N and H	Annual	NA	NA	NA
In-Hatchery	Broodstock Spawned – Numerical	N and H	Annual	NA	NA	NA
In-Hatchery	Release Location(s)	H	Annual	NA	NA	NA
Facility Assessment	Fish Collection Efficiency; Fish Guidance Efficiency	N	NA	Annual	Annual	Annual
Facility Assessment	Fish Passage Survival	N	NA	Annual	Annual	Annual
Facility Assessment	Adult Fallback	N and H	NA	Annual	Annual	Annual
Harvest	Harvest – Numerical	N and H	Annual	Annual	Annual	Annual
Harvest	Harvest – Percentage of Run	N and H	Annual	Annual	Annual	Annual

Table 15. Chum Salmon baseline studies applicability and implementation frequency.

Category	Metric	Origin	Chum Salmon			
			Lower Cowlitz	Tilton	Upper Cowlitz	Cispus
VSP & Population	Abundance of Spawners	N	Annual	NA	NA	NA
VSP & Population	Smolt Abundance – Population Estimate	N	Periodic	NA	NA	NA
VSP & Population	Adult-to-Adult Replacement	N	Annual	NA	NA	NA
VSP & Population	Smolts per Spawner Recruitment	N	Periodic	NA	NA	NA
VSP & Population	Spatial Distribution of Spawning – Spatial Structure	N	Periodic	NA	NA	NA
VSP & Population	Population Genetics – Sampling	N	Periodic	NA	NA	NA
VSP & Population	Population Genetics – Analyses	N	Periodic	NA	NA	NA
VSP & Population	Age at Return – Adult Age Structure	N	Annual	NA	NA	NA
VSP & Population	Adult Return Timing	N	Annual	NA	NA	NA
VSP & Population	Adult Spawn Timing	N	Annual	NA	NA	NA
VSP & Population	Juvenile Migration Timing	N	Periodic	NA	NA	NA
VSP & Population	Age at Smolt Migration	N	Periodic	NA	NA	NA

Category	Metric	Origin	Chum Salmon			
			Lower Cowlitz	Tilton	Upper Cowlitz	Cispus
VSP & Population	Mean Age of Adult Returns	N	Annual	NA	NA	NA
VSP & Population	Abundance of Adults Returns to Target River	N	Annual	NA	NA	NA
VSP & Population	Abundance at Mouth of Cowlitz	N	Annual	NA	NA	NA
VSP & Population	Smolt-to-Adult Return rate (SAR)	N	Annual	NA	NA	NA
VSP & Population	Pre-Spawn Mortality	N	Annual	NA	NA	NA
VSP & Population	Stray Rate within Basin	N	NA	NA	NA	NA
VSP & Population	Stray Rate outside of Basin	N	NA	NA	NA	NA
VSP & Population	Stray Rate into Basin	N	NA	NA	NA	NA
In-Hatchery	Broodstock Sampling – Biological Data	NA	NA	NA	NA	NA
In-Hatchery	pHOS	N	NA	NA	NA	NA
In-Hatchery	pNOB & pHOB	NA	NA	NA	NA	NA
In-Hatchery	PNI	NA	NA	NA	NA	NA
In-Hatchery	Number Hatchery Smolts Released	NA	NA	NA	NA	NA
In-Hatchery	Precocious Maturation Rate	NA	NA	NA	NA	NA
In-Hatchery	In-Hatchery Survival by Life Stage	NA	NA	NA	NA	NA
In-Hatchery	Population Genetics – Sampling	NA	NA	NA	NA	NA
In-Hatchery	Population Genetics – Analyses	NA	NA	NA	NA	NA
In-Hatchery	Demographic Replacement	NA	NA	NA	NA	NA
In-Hatchery	Size at Release	NA	NA	NA	NA	NA
In-Hatchery	Date(s) of Release	NA	NA	NA	NA	NA
In-Hatchery	Growth Conversion	NA	NA	NA	NA	NA
In-Hatchery	Broodstock Collected – Numerical	NA	NA	NA	NA	NA
In-Hatchery	Broodstock Spawned – Numerical	NA	NA	NA	NA	NA
In-Hatchery	Release Location(s)	NA	NA	NA	NA	NA
Facility	Fish Collection Efficiency; Fish Guidance Efficiency	N	NA	NA	NA	NA
Facility	Fish Passage Survival	N	NA	NA	NA	NA
Facility	Adult Fallback	N	NA	NA	NA	NA
Harvest	Harvest – Numerical	N	Annual	NA	NA	NA
Harvest	Harvest – Percentage of Run	N	Annual	NA	NA	NA

9 Status and Trends

Status and trend monitoring assesses changes in the condition of a metric important for tracking progress in a population or listing factor. It is the main monitoring necessary to determine the biological condition of the species (Crawford and Rumsey 2011). Status and trend monitoring allows managers to evaluate whether the annual goals have been met and whether these populations are progressing toward (and at a satisfactory rate) the minimum viability abundance targets and recovery goals. The results of status and trend monitoring also provide critical information to the annual review and adaptive management processes. Time series of observed values for hatchery performance and population status, including smolt-to-adult returns, hatchery effects on life stage survival, number of hatchery fish released, and fish husbandry practices, as well as harvest, natural-origin abundance and productivity, pHOS, and proportionate natural influence (PNI), will demonstrate progress toward goals provided that key metrics and assumptions about them are reasonable and accurate.

Relevant considerations for status and trend monitoring include statistical power analysis to determine sample size required to detect a meaningful change in a population, consideration of the temporal and spatial attributes of the study design, and identification of an appropriate model for analysis. For salmonid populations, status and trend monitoring normally requires many years of data collection to be able perform an assessment. Status and trend assessment is ongoing in the monitoring and evaluation program. Formal descriptions of preferred analytical approaches for the applicable metrics will be documented and included in the Plan in the future.

10 Data Collection, Quality Assurance and Control, Data Management, and Data Gaps

Rigorous monitoring and collection of the necessary data are the key to effectively monitoring a population. Effective adaptive management requires monitoring data for the most recent available year, as well as past years, so that the appropriate management questions can be addressed in prescribed timeframes (typically annually) and decisions made. This information informs managers whether the populations are meeting trigger values for each metric associated with a management objective or recovery phase. In addition, these data and analyses may provide insight to potential explanations of why meeting an objective succeeds or fails. The recent year's data provide the current condition of the population, and the historical data (as much as are available) provide context and trend information.

10.1 Data Collection and Quality Control and Quality Assurance

The critical M&E data collection is designed to inform VSP metrics (McElhany et al. 2000) and considers the monitoring guidance for listed Pacific Northwest salmon and steelhead provided by Crawford and Rumsey (2011). Crawford and Rumsey (2011) outline the following recommendations:

VSP Spawner Abundance

1. Incorporate a robust, unbiased adult spawner abundance sampling design that has known precision and accuracy
2. Monitor the ratio of marked hatchery salmon and steelhead to unmarked natural origin fish in all adult spawner surveys
3. Calculate the average coefficient of variation for all adult natural origin spawner estimates for each population
4. Strive to have adult spawner data with a coefficient of variation (CV) on average of 15% or less
5. Conduct a power analysis for each natural population monitored within an ESU or DPS to determine the power of the data to detect a significant change in abundance
6. Whenever possible, employ regionally standardized methodologies and analysis tools for evaluating population abundance

VSP Productivity

1. Develop at least 12 brood years of accurate spawner information as derived from cohort analysis. Use the geometric mean of recruits per spawner to develop productivity estimates
2. Obtain estimates of juvenile migrants for at least one significant population for each major population group within an ESU or DPS

    a. Achieve juvenile migrant salmon data with a CV on average of 15% or less and steelhead data with a CV on average of 30% or less

VSP Spatial Distribution

1. Determine spatial distribution of populations with the ability to detect a change in distribution of ± 15% with 80% certainty

VSP Diversity

1. Short term: Utilize species distribution information and spawn timing, age distribution, fecundity, and sex ratios to determine status/trend in species diversity of natural populations
2. Long term: Monitoring genetic diversity by developing a molecular genetic (e.g., single nucleotide polymorphism [SNPs]) baseline for each population within each major population group and ESU/DPS

Ideally, data collection will be designed to achieve prescribed levels of accuracy and precision. For accurate management purposes, Robson and Regier (1964) recommended that estimation of abundance should be within 25% of the true abundance. However, an inability to collect the desired sample size and high variability among subjects of data collection may preclude achieving confidence levels to typical scientific standards (e.g., 95%). Lower confidence levels may be used in order to statistically assess the results of the monitoring and evaluation effort (Crawford and Rumsey 2011). Metrics that do not allow collection of data to meet a minimum confidence threshold, are too heavily biased, or require data that cannot be collected reliably, such as those that may be precluded routinely by high water or other environmental conditions, should be avoided.

Collection of field data to assess populations inherently has two sources of variance: process error and observation (measurement) error. Process error is the variation in true population size due to biotic or abiotic processes; that is, the real drivers of population fluctuations that are of importance for management and recovery. Observation error results from variation in the (observation) methodology used to obtain the population sample data. Sources of observation error are many and can include: difficulty in detecting or capturing fish (e.g., bias in capture techniques); difficult field logistics (e.g., private property, remote or dangerous areas), field conditions (e.g., high water or large rivers), variation in observer experience (e.g., variation in observer efficiency during redd surveys); equipment failures (e.g., broken trap); and data recording or entry errors (Ahrestani et al. 2013).

The status of adult spawners is the most important measurement needed for monitoring salmon and steelhead populations. Therefore, the precision and accuracy of adult spawner estimates is particularly important. However, assessment of the time (years) it may take to detect a significant change in abundance in spawners (e.g., 100% increase) has been estimated to be up to 30 years (Crawford and Rumsey 2011). Reduction of observation error may help to reduce the number of years needed, but process error may play as large a role or larger.

Power analyses should be conducted for each population to estimate the sample size (years) needed to detect a desired delta in a population metric and provide the probabilities of Type I and II errors. Reducing observation error, reducing the critical values for Type I and II errors, reducing annual variance by incorporation of other variables, data transformation, and statistical modeling approaches may help reduce the number of years required to detect a trend should a trend exist (Crawford and Rumsey 2011).

The ability to collect data to achieve a desired statistical confidence level is frequently a challenge in ecological monitoring. Data for most metrics, such as adult abundance, are collected on an annual basis. Amassing a large sample may take decades—particularly when attempting to assess a recent management action. Given this, proxy metrics may help inform the efficacy of the management actions

even if the end result cannot be evaluated for a period of time. Furthermore, managers must rely on the best available information to guide management decisions, recognizing that results supported by high levels of statistical confidence may not be available. In light of this, management actions can be viewed as an effort to make a positive difference by applying best management practices guided by monitoring, empirical studies, modelling, and theory. Evaluation of the management actions may also be made in the context of regional performance of other populations.

10.2 Data Management

Data collection, evaluation, and reporting (Crawford and Rumsey 2011) should be performed in a system that adheres to the following criteria:

1. Provides common data dictionaries and metadata in a robust, accessible platform to practitioners from Tacoma Power and the WDFW
2. Enhances accurate communication among partners
3. Interfaces with regional databases
4. Has a schema and infrastructure designed to assess and evaluate the data to ensure transparency and repeatable calculations
5. Facilitates standardized reporting for applications such as annual reports and VSP parameters

Data are collected by WDFW, Tacoma Power, National Marine Fisheries Service, U.S. Fish and Wildlife Service, and contractors. In addition, data are also managed through regional data collection management systems such as the Columbia Basin PIT Tag Information System (PTAGIS), Regional Mark Information System (RMIS), WDFW's FishBooks, Salmon Conservation and Reporting Engine (SCoRE), Data.Wa.gov, and Streamnet.org through the Coordinated Assessment Project. Currently, the Cowlitz data are not stored in a centralized database(s). This has important implications for consistency of data used in analyses among practitioners, security of the data, retaining chain of custody of the data to ensure integrity, accessibility of the data for WDFW and Tacoma Power, and control of data sharing, and risks losing data should personnel or contractors change. Currently, summary data are directed to a spreadsheet solution, "The Big Table," that comprehensively organizes the key data for the populations and hatchery programs. However, the Big Table is a static table of derived or summarized data and does not function as a database that can be queried. Raw (or non-summarized) data are not available through the Big Table solution. Numerous metrics are identified in the Big Table Dataset, but data are not currently available for many of them. These metrics that lack information are the data gaps that baseline and, particularly, directed studies will address.

The lack of a centralized database(s) that has a carefully constructed schema with rigorous data entry rules and auditing steps results in, at best, data collection and distribution systems that are inefficient for staff to use and, at worst, a data system that is inadequate to support the analyses Tacoma Power and WDFW are required to perform, despite the substantial financial and staff-time investments to collect the data.

A more robust and longer-term data storage solution is needed to systematize data entry, support analysis and research, and provide reliable, long-term access to a consistent data schema and storage solution. Furthermore, a database may be developed that integrates spatial data (GIS), links to other regional databases such as PTAGIS and RMIS, provides standardized queries for routine analyses, and

can be used to generate standardized reports (e.g., in R Markdown; https://rmarkdown.rstudio.com/). This approach can be further extended to automate routine analyses and generation of reports.

10.2.1 Data Gaps

There are known data gaps related to the populations in the Cowlitz Basin (Tacoma Power 2020). Identification of the data gaps and prioritization to address data gaps is an ongoing process and the work to date is a component of this Plan. APPENDIX D contains the data gaps that have been identified in the 2020 FHMP (Tacoma Power 2020). Prioritization of baseline or directed studies to address these data gaps should follow the approach outlined in Sections 8.3.1 and 14.

11 Annual Monitoring and Evaluation Implementation Plan

An M&E Implementation Plan will be created annually for review and approval by the Cowlitz Fish Technical Committee. The M&E Implementation Plan is to be included in the AOP. The M&E Implementation Plan should not change substantially year to year; however, implementation of the Plan may require adjustment each year. Therefore, the Implementation Plan should be included in the AOP. It is unlikely that the entire Plan will be implemented in a single year. Therefore, a subset of the most important metrics will be implemented. The M&E Implementation Plan will describe the metrics included and the field methods required to collect the necessary data. The M&E Implementation Plan will identify the metrics and populations for which data will be collected. For each metric and population in the M&E Implementation Plan, the methodology will be identified. The M&E Implementation Plan will be used to: 1) ensure that data for the identified metrics will be collected using approved methodologies; 2) coordinate data collection efforts and avoid duplicative effort and handling of fish and data gaps; and 3) assist staff managers with personnel and task planning.

12 Field Methods

Field methods must follow standardized methodologies approved by the Cowlitz Fisheries Technical Committee's M&E subgroup. Consistent methodologies, data collection, and data storage are critical for subsequent analyses, interpretation, and management decisions. Field methods may be adjusted with approval from the Cowlitz Fish Technical Team's M&E subgroup. Unforeseen conditions or improved technology may force the alteration of a field methodology. To the extent possible, field methods descriptions should include contingency methodologies to ensure that data collection opportunities are not lost if conditions do not allow the primary approach to be implemented.

13 Annual Work Product

The annual work product from the M&E efforts currently includes 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 efforts throughout the basin and how these relate to population recovery and other specific management and ESA requirements and objectives. Populating a data management system, to be developed, should be prioritized as an annual work product preferentially over population of the Big Tables. The annual work product, produced through the APR process, should also include a list of remaining data gaps and key questions that are identified as priorities to address. The preliminary results from the M&E efforts will be disseminated during the Annual Science Conference to inform the APR and future fisheries management, hatchery management, and updates to the Plan. This annual APR process will use the information collected each year and test it against FHMP Decision Rules (the decision rules are currently under development) and fish management targets (Tacoma Power 2020). Additional data needs and the monitoring required to address them will be identified from this annual process, as necessary.

The Big Tables currently serve as the "data warehouse." In many cases, data that populate the Big Tables comes from other regional databases where the data are formally housed (e.g., www.data.wa.gov, RMIS, PTAGIS, WDFW FishBooks). The Big Table dataset identifies the source of the data it stores. While the FHMP Annual Status Update is not available until December, the Big Table dataset is updated continuously, as the data are collected, to ensure that the most current data are available to all managers and interested parties. In future, the services provided by the Big Table approach can more effectively provided by a shared data management system.

14 Directed Studies

Directed studies are designed to address uncertainty or key issues/data gaps that are not addressed by the baseline studies. These studies diagnose problems identified from baseline studies information and are intended to inform future management actions, study designs, and facility or program operations that will improve performance of the topic of interest so that goals of the SA can be achieved. Identification of directed studies must be conducted through the adaptive management process within the APR. The APR process will be used to identify directed study needs, the relative importance of a study topic, and the level of effort assigned to a directed study topic. In all cases, directed studies should be related to improvement of management and recovery of the populations.

Directed studies shall address key uncertainties that will inform management decisions or provide critical information about the status of the population. Directed studies focus on addressing key uncertainties or data gaps in a single or multi-year study but are not intended to be work that is continued in perpetuity. The topics of greatest uncertainty and potential to affect the programs are the following (Tacoma Power 2020):

- Population identification (e.g., stock identification through genetic stock identification or other means)
- Hatchery program performance
- pHOS management strategies
- Issues that will require multiple years of data collection before initial results are available

Directed studies that are currently proposed by the M&E subgroup are provided in Table 16. Full descriptions of directed studies that were prioritized by the M&E subgroup are provided in APPENDIX C, Directed Study Plans.

Table 16. Proposed directed studies topics.

Category	Study	Description
Productivity	Life Cycle Model	Develop model and data needs for One-Stage and Two-Stage Life Cycle Models (IPMs)
Productivity	Smolt-to-Adult Return (SAR)	Document returns of hatchery-origin and natural-origin spring Chinook Salmon by age and additional data needs to estimate SAR, TSAR, productivity, and age composition
Management	Develop methods to improve pHOS control of Steelhead in Mill and Blue creeks	Assess options to improve pHOS control (e.g., weirs, regulation changes) to best control steelhead pHOS in Mill and Blue creeks.
Diversity	Genetic studies: Differentiate natural-origin fall Chinook from spring Chinook	Develop genetic stock identification for these stocks to differentiating natural-origin of Fall vs. Spring Chinook Salmon
Productivity	Juvenile studies/smolt trapping: Evaluate factors that affect survival of out-migrating smolts	Identify/quantify causes of natural mortality of out-migrating juveniles: develop directed studies to evaluate effects of predation, disease, flushing flows, *C. shasta*, etc.
Productivity and Fish Health	Effects of *Ceratonova shasta* on Cowlitz Basin populations	Literature review in preparation for field studies and informing future management actions. See juvenile studies/smolt trapping study noted previously.
Management	Creel survey: study design for evaluation of exploitation	Develop the goals and objectives of creel surveys for Coho, fall Chinook, spring Chinook, summer steelhead, winter steelhead, and Cutthroat. Once goals and objectives are established, creel study(ies) can be developed as directed study(ies).

Category	Study	Description
Hatchery	Hatchery evaluation methods	Develop methods to evaluate strategies for improving survival in the hatchery, after release, and age composition (including precocious maturation). Develop study design and then potential specific directed studies.
Productivity	Assess production of natural-origin fall Chinook Salmon coming from the Lower Cowlitz and Tilton subbasins	Assess understanding of natural origin fall Chinook Salmon production coming from the Lower Cowlitz and Tilton subbasins. Analysis of newly implemented marking strategy to address lower river overshoots.
Diversity	Evaluate stray rates in the Lower Cowlitz River	Estimate stray rates of hatchery-origin fall Chinook Salmon, spring Chinook Salmon, Coho Salmon, and winter steelhead spawning in the Lower Cowlitz River, including strays from the Tilton and Upper Cowlitz subbasins
Management	Evaluate the popularity of the Cowlitz Basin Cutthroat Trout hatchery program	Estimate the popularity of the Cowlitz Basin Cutthroat Trout hatchery program
VSP Parameters	Recovery Phase – Transition: VSP Parameters for the eventual release of spring Chinook Salmon into the Tilton Subbasin	Develop criteria using VSP Parameters for the eventual release of Spring Chinook Salmon into the Tilton Subbasin
Productivity	Spawner to adult productivity	This is a VSP baseline study. Adult productivity by population (Recruits/Spawner) of hatchery-origin and natural-origin fall Chinook Salmon, spring Chinook Salmon, Coho Salmon, and winter steelhead. May use a life cycle model to generate the results.

Topics for directed studies shall be identified within the APR adaptive management process. Proposals for directed studies topics identified through the APR will be evaluated by the Monitoring and Evaluation sub-committee and approved for implementation by the FTC. Evaluation of proposed directed studies can follow a similar procedure as for prioritization of baseline studies (Section 8.3.1). The FTC shall define the process for submitting directed study proposals and the approval process. Directed studies are discrete efforts with a defined time horizon and application of results to the adaptive management process.

The following steps will be used to identify and prioritize directed studies:

1. APR Adaptive Management Process identifies a key uncertainty.
2. Determine if this key uncertainty can be addressed by the current baseline studies or modifications/additions to these studies.

    a. If yes, direct analysis to existing data.
    b. If no, prioritize the proposed directed study in the context of other directed studies following the baseline studies prioritization approach (Section 8.3.1).

3. Through the APR adaptive management process, identify which directed studies shall be performed (prioritize the study topics).
4. Direct practitioners/proponents of a directed study to develop the study design for review by the FTC within the adaptive management process to ensure that the study will sufficiently address the key uncertainty.
5. Once approved, incorporate the directed study in the annual update of the Plan.

a. Include schedule of data collection, preliminary/interim results, and final report.

Directed studies to be conducted in a given year must be included in the Annual Implementation Plan as part of the AOP. Each directed study proposal shall include the following information:

- Title of the directed study
- Introduction and background
  - Provide introductory and background information to inform the management and scientific context of the study.
- Area of focus: population, program, study area
  - Identify the population(s), hatchery programs, and geographic study area, as applicable to the study.
- Objectives, hypotheses, research questions
  - State the Objectives of the Study, the hypotheses that will be tested (as applicable), and the research question(s) that will be addressed.
- Field methodology
  - Describe the field methodologies that will be used. List and cite standard methodologies and describe novel or non-standard methodologies.
- Analytical methodology
  - Describe the analytical approach.
- Provide a description of the anticipated statistical tests, equations, or models that will be used.
  - Characterize the anticipated uncertainty in the analyses as it pertains to interpretation of the results and management decision-making.
- Assumptions
  - Provide a list of assumptions related to the study.
- How will assumptions be tested?
- How will bias in the results be assessed?
  - Explain potential bias in the study and describe how bias can be assessed.
- Anticipated Results
  - Describe the anticipated results and relate results to management decisions.

15 Baseline Studies: Population Monitoring and Evaluation Metrics, Objectives or Hypotheses, Analytical Approaches

15.1 VSP & Population: Abundance of Spawners

15.1.1 Estimate of the Abundance of Spawners

Abundance of spawners is one of the key VSP parameters (VSP-Abundance) and is central for estimating extinction risk and for managing populations. Abundance of spawners affects productivity through compensatory and depensatory mechanisms and may also be related to effective population size. Maintaining a minimum effective population size is critical for retaining genetic variability and conserving populations. Spawner abundance is also one of the components needed for a two-stage life cycle model (i.e., spawner abundance and smolt abundance). Abundance of natural- and hatchery-origin spawners allows managers to evaluate the effects and interactions of the composition and spawners on the spawning grounds.

15.1.2 Applicable Populations and Hatchery Programs

Table 17 summarizes the populations and hatchery programs to which this study applies.

Table 17. Applicable populations and hatchery programs to estimates of Abundance of Spawners.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Lower Cowlitz	Lower Cowlitz Fall Chinook Salmon	Lower Cowlitz	No Program
	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program
	Cispus			No Program
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
	Tilton	Habitat Not Currently Utilized	Tilton	No Program
Coho Salmon	Lower Cowlitz	Lower Cowlitz Coho Salmon	Lower Cowlitz	No Program
	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	Upper Cowlitz Winter Steelhead
Summer Steelhead	Lower Cowlitz	Lower Cowlitz Summer Steelhead	No recognized population	Lower Cowlitz Summer Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat
	Tilton		Tilton	No Program
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Chum Salmon	Lower Cowlitz	Cowlitz Basin Chum Salmon	Lower Cowlitz	No Program

15.1.3 Management Objectives

Management objectives for abundance of spawners are contained in the following links:

- APPENDIX A
- Appendix Table A-3. Population Attributes and Metrics: Coho Salmon
- Appendix Table A-9. Population Attributes and Metrics: Fall Chinook Salmon
- Appendix Table A-16. Population Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-24. Population Attributes and Metrics: Winter-Run Steelhead1
- Appendix Table A-34. Population Attributes and Metrics: Cowlitz Chum Salmon
- Appendix Table A-37. Population Attributes and Metrics: Cowlitz Cutthroat Trout

15.1.4 Data Required

- Tributary weir data and marking
- Redd counts (peak, index reaches, reaches representative of non-surveyed reaches)
- Live and carcass sampling (species, age, origin, and sex of spawners, marks and tags)
- Mark-recapture data (Lower Cowlitz mainstem [Chinook Salmon] and tributaries [Coho Salmon and steelhead])
- Redd-to-spawner expansion factor per species and methods

15.1.5 Field Methods

- Weir Operation and Lower Cowlitz Adult Capture
- WDFW 2023a
- WDFW 2023b
- WDFW 2023f

15.1.6 Objectives or Hypotheses

- Hypothesis 1: spawner abundance ≥ target
- Objective 1: assess if meeting VSP targets

15.1.7 Analytical Methods

- APPENDIX B, Peak Count Expansion of Redds – Lower Cowlitz Spring Chinook and Fall Chinook
- APPENDIX B, Carcass Mark-Recapture – Lower Cowlitz Fall Chinook and Spring Chinook
- APPENDIX B, Composition of Chinook Spawners in the Lower Cowlitz River
- APPENDIX B, VSP-Abundance – Abundance of Lower Cowlitz Coho and Steelhead Spawners
- APPENDIX B, Coho Model
- APPENDIX B, Steelhead Model
- A one-sample t-test may be used to assess if the mean of a sample of annual numbers of fish transported upstream is equal to or greater than the target
- Trend analysis (regression, graphical analysis) of time series to estimate the status and trajectory of the population compared to management objectives

15.1.8 Assumptions and Bias

- Estimates of redds are accurate.
- Expansion factors are realistic and unbiased.

- Sampling of redds and carcasses is unbiased.
- Bias may be investigated by using alternative estimation methods, if available. Systematic deviance in estimates suggests at least one of the estimates is biased. Further investigation would be required to identify the source of the bias.

15.1.9 Anticipated Results

- Spawner abundance is a key VSP metric. This will be one of the most important datasets that managers will use to assess the population and make future management decisions. Results will indicate if a population is meeting minimum abundance targets, achieving, or trending towards variability, and, as applicable, the magnitude of harvest a population could sustain.

15.2 VSP & Population: Smolt Population Estimate

15.2.1 Estimate of the Abundance of Smolts

Abundance of juvenile emigrants (i.e., smolts) is one of the key VSP parameters (VSP-Abundance). Abundance of smolts in a natural population is central for estimating freshwater productivity, freshwater carrying capacity, extinction risk, and for managing populations. Smolt abundance is also one of the components needed for a two-stage life cycle model (i.e., spawner abundance and smolt abundance). Smolt abundance is used to estimate the number of smolts produced per redd or per spawner, and the number of returns per smolt (smolt to adult return [SAR]). These are critical productivity metrics. Smolt estimates were previously done in the Lower Cowlitz River using a stratified-Peterson mark-recapture population estimation method. Currently, smolt numbers are censused and collection efficiency is estimated at the Cowlitz Falls Fish Facility (Upper Cowlitz and Cispus rivers production). The Mayfield Counting House Facility (Tilton River production) provided counts of smolts collected but not annual fish guidance efficiency (FGE) estimates. Abundance of natural- and hatchery-origin spawners allows managers to evaluate the effects and interactions of the composition and spawner numbers on the spawning grounds. This metric is primarily reported in the Cowlitz Falls North Shore Collector Downstream Fish Passage Evaluation Annual Reports (e.g., Four Peaks 2024) for the Upper Cowlitz and Cispus rivers populations. These reports also include monthly adult and juvenile fish counts from the Mayfield Counting House Facility for the Tilton River populations.

15.2.2 Applicable Populations

Table 18 summarizes the populations to which this study applies.

Table 18. Applicable populations to Smolt Population Estimates.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Lower Cowlitz	Lower Cowlitz Fall Chinook Salmon	Lower Cowlitz	No Program
	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program
	Cispus			No Program
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
	Tilton	Habitat Not Currently Utilized	Tilton	No Program

Species	Location	Management Unit	Population	Hatchery Program
Coho Salmon	Lower Cowlitz	Lower Cowlitz Coho Salmon	Lower Cowlitz	Upper Cowlitz Coho Salmon
	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	Upper Cowlitz Winter Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat
	Tilton		Tilton	No Program
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Chum Salmon	Lower Cowlitz	Cowlitz Basin Chum Salmon	Lower Cowlitz	No Program

15.2.3 Management Objectives

Management objectives for abundance of juvenile emigrants are contained in the following links,:

- APPENDIX A
- Appendix Table A-3. Population Attributes and Metrics: Coho Salmon
- Appendix Table A-9. Population Attributes and Metrics: Fall Chinook Salmon
- Appendix Table A-16. Population Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-24. Population Attributes and Metrics: Winter-Run Steelhead1
- Appendix Table A-34. Population Attributes and Metrics: Cowlitz Chum Salmon
- Appendix Table A-37. Population Attributes and Metrics: Cowlitz Cutthroat Trout

15.2.4 Data Required

- Number of smolts captured
- Number of smolts emigrating
- Estimate of FCE (Cowlitz Falls)
- Estimate of FGE (Mayfield)
- Estimate of FPS (See Four Peaks 2024 for details of FCE and FPS estimation.)

15.2.5 Field Methods

- APPENDIX B, Juveniles from Upper Cowlitz
- Cowlitz Falls North Shore Collector Downstream Fish Passage Evaluation Annual Reports (e.g., Four Peaks 2024)

15.2.6 Objectives or Hypotheses

- Objective 1: Estimate smolt abundance for the Tilton River populations and for the Upper Cowlitz and Cispus rivers populations.

15.2.7 Analytical Methods

"Fish Passage Survival" ("FPS") as used in proposed license article 1 and applied to Cowlitz Falls Dam, Riffe Lake, and Mossyrock Dam, means the percentage of smolts entering the upstream end of Scanewa reservoir, and adjusted for natural mortality, that are collected at Cowlitz Falls Dam and Riffe Lake and Mossyrock Dam, that are transported downstream to the stress relief ponds, and subsequently leave the stress relief ponds at Barrier Dam as healthy migrants. (excerpted from Tacoma Power et al. 2000).

"Fish Guidance Efficiency" ("FGE") as used in proposed license article 2 and applied to Mayfield Dam, means the percentage of smolts entering the Mayfield louver system that are guided through the juvenile fish guidance and fish bypass facilities and do not enter the turbines. (excerpted from Tacoma Power et al. 2000).

- APPENDIX B, Juveniles from Upper Cowlitz
    - Juveniles from Upper Cowlitz and Cispus Rivers
    - Juveniles at Mayfield – Tilton River
- Cowlitz Falls North Shore Collector Downstream Fish Passage Evaluation Annual Reports (e.g., Four Peaks 2024)
- Tilton River (Juvenile Collection Facility at Mayfield Dam):
    - Equation 1: SAm = NCm/Em*Sb + NP*Sm

      Where
      SAm = Smolt Abundance
      NCm = Number of Smolts Collected
      Em = Collection Efficiency Estimate
      Sb = Survival through juvenile facility and bypass pipe
      NP = Number of Smolt that passed the facility via turbine passage
      Sm = Turbine Survival Estimate
- Upper Cowlitz/Cispus Rivers (Cowlitz Falls Fish Facility):
    - Equation 2: SAu = NCu/Eu*Ns

      Where
      SAu = Smolt Abundance
      NCu = Number of Smolts Collected
      Eu = Collection Efficiency Estimate
      Ns = Natural Survival

- To avoid bias in release trials, these estimates must be stratified weekly or other agreed-on methodology.
- To avoid bias in release trials, use sufficient sample size to avoid large error in the estimate and to attempt to control for lost tags and mortality not associated with the facilities.
- Trend analysis can be used to assess abundance over time to track population performance related to management and recovery objectives.

15.2.8 Assumptions

- Smolt collection efficiency estimates are accurate and unbiased and represent the overall outmigration.
- Smolt passage survival estimates are accurate and unbiased.

15.2.9 Anticipated Results

Obtain annual estimates of smolt abundance for the Tilton River populations and the Upper Cowlitz and Cispus rivers populations.

15.3 VSP & Population: Adult-to-Adult Replacement

15.3.1 Estimate Adult-to-Adult Replacement Rate

Adult-to-adult replacement estimates the number of adults that return per number of spawners and is one of the key VSP parameters (VSP-Population Growth Rate). Adult-to-adult replacement data are used to estimate population growth rate and are critical for assessing population viability. In addition, adult-to-adult replacement can be used in lieu of SAR when estimates of natural-origin smolts are not available or unreliable. Adult-to-adult replacement can be applied to both natural populations and hatchery programs. For natural populations, natural return rate (NRR) is a critical VSP measure of productivity. For hatchery programs, hatchery return rate (HRR) allows managers to determine if a hatchery program is meeting its expected demographic increase.

15.3.2 Applicable to Populations and Hatchery Programs

Table 19 summarizes the populations and hatchery programs to which this study applies.

Table 19. Applicable populations and hatchery programs to estimates of Adult-to-Adult Replacement.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Lower Cowlitz	Lower Cowlitz Fall Chinook Salmon	Lower Cowlitz	No Program
	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program
	Cispus			No Program
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
	Tilton	Habitat Not Currently Utilized	Tilton	No Program
Coho Salmon	Lower Cowlitz	Lower Cowlitz Coho Salmon	Lower Cowlitz	No Program
	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	Upper Cowlitz Winter Steelhead

Species	Location	Management Unit	Population	Hatchery Program
Summer Steelhead	Lower Cowlitz	Lower Cowlitz Summer Steelhead	No recognized population	Lower Cowlitz Summer Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat
	Tilton		Tilton	No Program
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Chum Salmon	Lower Cowlitz	Cowlitz Basin Chum Salmon	Lower Cowlitz	No Program

15.3.3 Management Objectives

Management objectives for adult-to-adult replacement estimates are contained in the following links:

- APPENDIX A
- Appendix Table A-3. Population Attributes and Metrics: Coho Salmon
- Appendix Table A-9. Population Attributes and Metrics: Fall Chinook Salmon
- Appendix Table A-16. Population Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-24. Population Attributes and Metrics: Winter-Run Steelhead1
- Appendix Table A-34. Population Attributes and Metrics: Cowlitz Chum Salmon
- Appendix Table A-37. Population Attributes and Metrics: Cowlitz Cutthroat Trout

15.3.4 Data Required

This is a derived metric based on data from the following metrics:

- Estimate of population-specific adult return abundance (by age and origin) to the Lower Cowlitz Basin
- Estimate of population-specific adult return abundance (by age and origin) to specific rivers (Lower Cowlitz mainstem and tributaries, Tilton, Upper Cowlitz, Cispus)
- Population-specific spawner Abundance Estimates (for NRR)
- Population-specific number of broodstock spawned in the hatchery (for HRR)

15.3.5 Field Methods

- No field methods – this is a derived metric.

15.3.6 Hypotheses

- Hypothesis 1: Natural Return Rate: NRR ≥ 1
- Hypothesis 2: Hatchery Return Rate: HRR ≥ Target

15.3.7 Analytical Methods

- Equation 1: NRR = NOR/NOS

  Where

  NRR = Natural population Adult-to-Adult Replacement (Natural Replacement Rate)
  NOR = Natural Adult Return Abundance (recruits from NOS)
  NOS = Natural Spawner Abundance (parent generation of the NOR)

- Equation 2: HRR = HOR/HS

  Where

  HRR = Hatchery population Adult-to-Adult Replacement (Hatchery Replacement Rate)
  HOR = Hatchery Adult Return Abundance (recruits from HS)
  HS = Number of broodstock spawned in the hatchery, per population/program (parent generation of the HOR)

15.3.8 Assumptions

- Estimates of spawner abundance are accurate.
- Estimates of adult return abundance are accurate.

15.3.9 Anticipated Results

- NRR ≥ 1 indicates the population is replacing itself, or potentially growing.
- HRR < target indicates program is under-performing compared to expectations.

15.4 VSP & Population: Smolts per Spawner Recruitment

15.4.1 Estimate of Smolts per Spawner Recruitment

Smolts per spawner is one of the key VSP parameters (VSP-Population Growth Rate). Productivity of smolts per spawner in a natural population is central for estimating freshwater productivity, density-depending smolt production (stock-recruit relationship), freshwater carrying capacity, extinction risk, and for managing populations. The smolts per spawner metric can inform evaluation of overall population productivity and help identify if freshwater productivity is the limiting step. Smolts per spawner is also one of the components needed for a two-stage life cycle model.

15.4.2 Applicable Populations

Table 20 summarizes the populations to which this study applies.

Table 20. Applicable populations to estimates of Smolts per Spawner Recruitment.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Lower Cowlitz	Lower Cowlitz Fall Chinook Salmon	Lower Cowlitz	No Program
	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program
	Cispus			No Program
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
	Tilton	Habitat Not Currently Utilized	Tilton	No Program
Coho Salmon	Lower Cowlitz	Lower Cowlitz Coho Salmon	Lower Cowlitz	Upper Cowlitz Coho Salmon
	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead

Species	Location	Management Unit	Population	Hatchery Program
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	Upper Cowlitz Winter Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat
	Tilton		Tilton	No Program
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Chum Salmon	Lower Cowlitz	Cowlitz Basin Chum Salmon	Lower Cowlitz	No Program

15.4.3 Management Objectives

Smolts per spawner recruitment does not currently have management objectives defined. Management objectives are contained in the following links:

- APPENDIX A
- Appendix Table A-3. Population Attributes and Metrics: Coho Salmon
- Appendix Table A-9. Population Attributes and Metrics: Fall Chinook Salmon
- Appendix Table A-16. Population Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-24. Population Attributes and Metrics: Winter-Run Steelhead1
- Appendix Table A-34. Population Attributes and Metrics: Cowlitz Chum Salmon
- Appendix Table A-37. Population Attributes and Metrics: Cowlitz Cutthroat Trout

15.4.4 Data Required

This is a derived metric based on data from the following metrics:

- Smolt abundance estimates
- Natural origin spawner (NOS) and hatchery origin spawner (HOS) abundance estimates

15.4.5 Field Methods

- No field methods; this is a derived metric.

15.4.6 Objectives or Hypotheses

- Objective 1: calculate the smolt per spawner productivity metric.

15.4.7 Analytical Methods

- Equation 1: $SPS = S_n/(NOS + HOS)$

  Where

  SPS = Smolts per spawner
  Sn = Naturally produced smolt abundance
  NOS = Natural-origin spawner abundance
  HOS = Hatchery-origin spawner abundance

15.4.8 Assumptions

- Estimates of smolt abundance are accurate and unbiased and represent the overall outmigration.
- Estimates of natural origin return (NOR) and hatchery origin return (HOR) abundance are accurate and unbiased.

15.4.9 Anticipated Results

The metric will provide estimates of smolt per spawner productivity.

15.5 VSP & Population: Spatial Distribution of Spawning

15.5.1 Estimate the Spatial Distribution of Spawning

Spatial distribution of spawning is a component of VSP-Spatial Structure and VSP-Diversity. Spatial distribution of spawning informs the resiliency of the population and its range. The number of populations or Major Spawning Groups in an ESU or DPS is a component of the recovery criteria. Knowledge of spatial spawning distribution informs habitat protection and enhancement activities, and implementation of monitoring and evaluation activities.

15.5.2 Applicable Populations and Hatchery Programs

Table 21 summarizes the populations and hatchery programs to which this study applies.

Table 21. Applicable populations and hatchery programs to estimates of Spatial Distribution of Spawning.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Lower Cowlitz	Lower Cowlitz Fall Chinook Salmon	Lower Cowlitz	No Program
	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program
	Cispus			No Program
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
	Tilton	Habitat Not Currently Utilized	Tilton	No Program
Coho Salmon	Lower Cowlitz	Lower Cowlitz Coho Salmon	Lower Cowlitz	Upper Cowlitz Coho Salmon
	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	Upper Cowlitz Winter Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat
	Tilton		Tilton	No Program
	Upper Cowlitz		Upper Cowlitz	

Species	Location	Management Unit	Population	Hatchery Program
	Cispus		Cispus	
Chum Salmon	Lower Cowlitz	Cowlitz Basin Chum Salmon	Lower Cowlitz	No Program

15.5.3 Management Objectives

There are currently no defined spatial spawning distribution management objectives within the Cowlitz Basin. However, populations are managed in the Lower Cowlitz mainstem, Lower Cowlitz tributaries, and Upper Cowlitz Basin (Tilton River, Upper Cowlitz and Cispus rivers). Management objectives are contained in the following links:

- APPENDIX A
- Appendix Table A-3. Population Attributes and Metrics: Coho Salmon
- Appendix Table A-9. Population Attributes and Metrics: Fall Chinook Salmon
- Appendix Table A-16. Population Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-24. Population Attributes and Metrics: Winter-Run Steelhead1
- Appendix Table A-34. Population Attributes and Metrics: Cowlitz Chum Salmon
- Appendix Table A-37. Population Attributes and Metrics: Cowlitz Cutthroat Trout

15.5.4 Data Required

- Spawning ground surveys
- GPS locations of redds

15.5.5 Field Methods

- WDFW 2023a
- WDFW 2023b
- WDFW 2023c

15.5.6 Objectives or Hypotheses

- Objective 1: Characterize the spatial distribution of spawning per population.
- Objective 2: Track the spatial distribution of spawning, per population, over time.

15.5.7 Analytical Methods

- GIS plot of spawning locations
- Comparison of spatial distribution of spawning habitat locations and frequency of use over time
- Trend analysis (regression, graphical analysis) of spatial distribution of spawning

15.5.8 Assumptions

- Spawning ground surveys cover all possible areas where fish may spawn.
- Spawning activity detection efficiency is similar across different rivers or reaches and methodologies.

15.5.9 Anticipated Results

Adult spawning location data that allow characterization and trend assessment of spatial spawning distribution to track changes in spatial spawning distribution over time

15.6 VSP & Population: Population Genetics Sampling

15.6.1 Define the Population Genetics Sampling Design

Population genetic studies may be performed on the populations and hatchery programs within the Cowlitz Basin to address the VSP-Diversity parameter. A population genetics study design must be developed to direct sample collection and subsequent analyses. Work with geneticists to establish a study design.

Collection of genetics samples for each population and hatchery program should be performed to archive samples for future analyses. This can typically be performed during other field assessments, such as spawner surveys or during hatchery spawning. Samples must be collected under an established sampling design to ensure future population genetic analyses are robust and are properly interpretable. Work with geneticists to establish a sampling design.

15.6.2 Applicable Populations and Hatchery Programs

Table 22 summarizes the populations and hatchery programs to which this study applies.

Table 22. Applicable populations and hatchery programs for Population Genetics Sampling.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Lower Cowlitz	Lower Cowlitz Fall Chinook Salmon	Lower Cowlitz	No Program
	Tilton	Upper Cowlitz Fall Chinook Salmon	Tilton	Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
Coho Salmon	Lower Cowlitz	Lower Cowlitz Coho Salmon	Lower Cowlitz	No Program
	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	
Chum Salmon	Lower Cowlitz	Cowlitz Basin Chum Salmon	Lower Cowlitz	No Program

15.6.3 Management Objectives

Collect tissue samples for genetic analysis according to a study design for population genetics analyses and create a database (documentation) of all genetic samples collected annually (or as directed by the applicable sampling plan). Work with geneticists to establish a study design (to be determined).

15.6.4 Data Required

- Genetic sampling design (to be determined)

15.6.5 Field Methods

- Field methods are to be determined but should be able to be accomplished under the ongoing Plan sampling methods.

15.6.6 Objectives or Hypotheses

- Objective 1: collect samples for future genetic analyses as directed by an established sampling design.

15.6.7 Analytical Methods

- No analysis.

15.6.8 Assumptions

- Genetic samples provided by the study design are representative of each population.

15.6.9 Anticipated Results

Collection of genetics samples will provide a basis to conduct population genetics analyses.

15.7 VSP & Population: Population Genetics Analyses

15.7.1 Population Genetics Analyses

Population genetic studies may be performed on the populations and hatchery programs within the Cowlitz Basin to address the VSP-Diversity parameter. Work with geneticists to establish a study design. Population genetic studies may be performed on the populations and hatchery programs within the Cowlitz Basin. A population genetics study design must be developed to direct sample collection and subsequent analyses. Work with geneticists to establish a study design.

15.7.2 Applicable Populations and Hatchery Programs

Table 23 summarizes the populations and hatchery programs to which this study applies.

Table 23. Applicable populations and hatchery programs to estimates of Population Genetics Analyses.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Lower Cowlitz	Lower Cowlitz Fall Chinook Salmon	Lower Cowlitz	No Program
	Tilton	Upper Cowlitz Fall Chinook Salmon	Tilton	Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
Coho Salmon	Lower Cowlitz	Lower Cowlitz Coho Salmon	Lower Cowlitz	No Program
	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz		Upper Cowlitz	Upper Cowlitz Winter Steelhead

Species	Location	Management Unit	Population	Hatchery Program
	Cispus	Upper Cowlitz Subbasin Winter Steelhead	Cispus	
Chum Salmon	Lower Cowlitz	Cowlitz Basin Chum Salmon	Lower Cowlitz	No Program

15.7.3 Management Objectives

- There are currently no defined genetic study designs for the Cowlitz Basin.

15.7.4 Data Required

- Genetics samples and biological data according to the study design (to be determined)

15.7.5 Field Methods

- No field methods

15.7.6 Objectives or Hypotheses

- Objective 1: Develop a population genetics study design to address management and recovery needs.

15.7.7 Analytical Methods

- To be developed in a separate study design

15.7.8 Assumptions

- No assumptions

15.7.9 Anticipated Results

Complete a study design that can be implemented to assess the population genetics of the Cowlitz Basin populations and associated hatchery programs.

15.8 VSP & Population: Age at Return

15.8.1 Estimate Age at Return

The age structure of a population is a VSP-Diversity metric and affects productivity, size at return, fecundity, adult return timing, and population resiliency. The age of returning adults is needed to calculate SAR, which is a critical VSP-Population Growth Rate metric. Age structure also affects management of fisheries and harvest. Retaining older age classes (larger fish) in populations and minimizing precocity or returns as jacks are often objectives of hatchery programs and fisheries management.

15.8.2 Applicable Populations and Hatchery Programs

Table 24 summarizes the populations and hatchery programs to which this study applies.

Table 24. Applicable populations and hatchery programs to estimates of Age at Return.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Lower Cowlitz	Lower Cowlitz Fall Chinook Salmon	Lower Cowlitz	No Program
	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program

Species	Location	Management Unit	Population	Hatchery Program
	Cispus			No Program
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
	Tilton	Habitat Not Currently Utilized	Tilton	No Program
Coho Salmon	Lower Cowlitz	Lower Cowlitz Coho Salmon	Lower Cowlitz	No Program
	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	Upper Cowlitz Winter Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat
	Tilton		Tilton	No Program
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Chum Salmon	Lower Cowlitz	Cowlitz Basin Chum Salmon	Lower Cowlitz	No Program

15.8.3 Management Objectives

There are currently no defined age structure management objectives within the Cowlitz Basin. However, the need for age structure data collection and data management is discussed extensively in the FHMP (Tacoma Power 2020). Management objectives are contained in the following links:

- APPENDIX A
- Appendix Table A-3. Population Attributes and Metrics: Coho Salmon
- Appendix Table A-9. Population Attributes and Metrics: Fall Chinook Salmon
- Appendix Table A-16. Population Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-24. Population Attributes and Metrics: Winter-Run Steelhead1
- Appendix Table A-34. Population Attributes and Metrics: Cowlitz Chum Salmon
- Appendix Table A-37. Population Attributes and Metrics: Cowlitz Cutthroat Trout

15.8.4 Data Required

- Natural origin ages derived from scale samples, otolith (if collected), and CWT for adults from Upper Cowlitz Basin populations
- Ages derived from broodstock scale sampling (all broodstock spawned are sampled)
- Hatchery origin ages derived from CWT

15.8.5 Field Methods

- WDFW 2023a
- WDFW 2023b
- WDFW 2023c
- WDFW 2023e
- WDFW 2023f
- APPENDIX B, Barrier Dam Adult Returns
- APPENDIX B, Weir Operation and Lower Cowlitz Adult Capture

15.8.6 Objectives or Hypotheses

- Objective 1: Collect standardized data of adult return ages. Establish data set in a standardized database to facilitate analysis and interpretation of the age data.

15.8.7 Analytical Methods

- Trend analysis (regression, graphical analysis) to characterize the age at return for each population and track changes in the age structure over time

15.8.8 Assumptions

- Sampling of adults or carcasses is representative of the population.
- Sufficient samples sizes are obtained of each age class.
- Ageing methods are accurate and unbiased.

15.8.9 Anticipated Results

- Establish a data set of estimated age at returns for each population and hatchery program to assess current conditions and track shifts in age structure over time.

15.9 VSP & Population: Adult Return Timing

15.9.1 Estimate Adult Return Timing

Adult return timing is a component of VSP-Diversity. Return timing is a heritable trait that may be shifted through natural or artificial selection. Monitoring return timing can identify unexpected shifts in timing due to environmental conditions or artificial selection. In addition, return timing data are used to plan broodstock collection and manage fisheries. Adult return timing assessment will be critical for evaluating the progress on development of an earlier returning winter steelhead hatchery program.

15.9.2 Applicable Populations and Hatchery Programs

Table 25 summarizes the populations and hatchery programs to which this study applies.

Table 25. Applicable populations and hatchery programs to estimates of Adult Return Timing.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Lower Cowlitz	Lower Cowlitz Fall Chinook Salmon	Lower Cowlitz	No Program
	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program
	Cispus			No Program

Species	Location	Management Unit	Population	Hatchery Program
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
	Tilton	Habitat Not Currently Utilized	Tilton	No Program
Coho Salmon	Lower Cowlitz	Lower Cowlitz Coho Salmon	Lower Cowlitz	No Program
	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	Upper Cowlitz Winter Steelhead
Summer Steelhead	Lower Cowlitz	Lower Cowlitz Summer Steelhead	No recognized population	Lower Cowlitz Summer Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat
	Tilton		Tilton	No Program
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Chum Salmon	Lower Cowlitz	Cowlitz Basin Chum Salmon	Lower Cowlitz	No Program

15.9.3 Management Objectives

There are currently no defined adult return timing management objectives. Management objectives are contained in the following links:

- APPENDIX A
- Appendix Table A-3. Population Attributes and Metrics: Coho Salmon
- Appendix Table A-9. Population Attributes and Metrics: Fall Chinook Salmon
- Appendix Table A-16. Population Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-24. Population Attributes and Metrics: Winter-Run Steelhead1
- Appendix Table A-34. Population Attributes and Metrics: Cowlitz Chum Salmon
- Appendix Table A-37. Population Attributes and Metrics: Cowlitz Cutthroat Trout

15.9.4 Data Required

- Adult return timing is a derived metric from adult fish collected at the Barrier Dam and lower Cowlitz weirs. Estimates of timing will use a 5-year average mean (or median).
- Adult return timing is not available for all populations due to data collection limitations.

- Lower Cowlitz weir sampling for Coho Salmon and steelhead provide adult return timing to those tributaries (5-year mean or median).
- Returns to the Barrier Dam fish separator provide return timing for the populations in the Tilton River, and Upper Cowlitz and Cispus rivers basin (5-year mean or median).

15.9.5 Field Methods

- WDFW 2023f
- APPENDIX A, Weir Operation and Lower Cowlitz Adult Capture
- APPENDIX A, Barrier Dam Adult Returns

15.9.6 Objectives or Hypotheses

- Objective 1: Monitor adult return timing

15.9.7 Analytical Methods

- WDFW 2023f
- APPENDIX B, Barrier Dam Adult Returns
- Trend analysis (regression, graphical analysis) to characterize return timing and track shifts in return timing

15.9.8 Assumptions

- Sampling of adult returns at Lower Cowlitz tributary weirs and the Barrier Dam fish separator is representative of the returning population.

15.9.9 Anticipated Results

Collect adult return data that allow trend assessment of return timing.

15.10 VSP & Population: Adult Spawn Timing

15.10.1 Estimate Adult Spawn Timing

Adult spawn timing is a component of VSP-Diversity. Spawn timing is a heritable trait that may be shifted through natural or artificial selection. Monitoring spawn timing can identify unexpected shifts in timing due to environmental conditions or artificial selection. Adult spawn timing assessment will be critical for evaluating the progress on development of an earlier returning winter steelhead hatchery program.

15.10.2 Applicable Populations and Hatchery Programs

Table 26 summarizes the populations and hatchery programs to which this study applies.

Table 26. Applicable populations and hatchery programs to estimate Adult Spawn Timing.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Lower Cowlitz	Lower Cowlitz Fall Chinook Salmon	Lower Cowlitz	No Program
	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program
	Cispus			No Program

Species	Location	Management Unit	Population	Hatchery Program
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
	Tilton	Habitat Not Currently Utilized	Tilton	No Program
Coho Salmon	Lower Cowlitz	Lower Cowlitz Coho Salmon	Lower Cowlitz	No Program
	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	Upper Cowlitz Winter Steelhead
Summer Steelhead	Lower Cowlitz	Lower Cowlitz Summer Steelhead	No recognized population	Lower Cowlitz Summer Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat
	Tilton		Tilton	No Program
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Chum Salmon	Lower Cowlitz	Cowlitz Basin Chum Salmon	Lower Cowlitz	No Program

15.10.3 Management Objectives

There are currently no defined management objectives for adult spawn timing. Management objectives are contained in the following links:

- APPENDIX A
- Appendix Table A-3. Population Attributes and Metrics: Coho Salmon
- Appendix Table A-9. Population Attributes and Metrics: Fall Chinook Salmon
- Appendix Table A-16. Population Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-24. Population Attributes and Metrics: Winter-Run Steelhead1
- Appendix Table A-34. Population Attributes and Metrics: Cowlitz Chum Salmon
- Appendix Table A-37. Population Attributes and Metrics: Cowlitz Cutthroat Trout

15.10.4 Data Required

Spawning ground survey data (dates redds are observed)

15.10.5 Field Methods

- WDFW 2023a
- WDFW 2023b
- WDFW 2023c

15.10.6 Objectives or Hypotheses

- Objective 1: Monitor adult spawn timing.

15.10.7 Analytical Methods

- Trend analysis (regression, graphical analysis) to characterize spawn timing and track shifts in peak spawn timing and temporal distribution of spawn timing

15.10.8 Assumptions

- Spawner survey data are representative of the population.

15.10.9 Anticipated Results

Collect adult spawn data that allow characterization of current conditions and trend assessment of spawn timing to detect shifts over time.

15.11 VSP & Population: Juvenile Migration Timing

15.11.1 Estimate of Smolt Migration Timing

Juvenile (smolt) migration timing is a component of VSP-Diversity. Emigration timing of smolts affects survival and productivity related to stream flows, turbidity, and temperatures, migration distance, entry time to estuaries, and food supply and predator assemblage. Monitoring smolt migration timing can identify unexpected shifts in timing due to environmental conditions or artificial selection. Knowledge of smolt migration timing is important for managing hydroelectric project operations, setting fish release dates for hatchery programs, and assessing the smolt population.

15.11.2 Applicable Populations

Table 27 summarizes the populations to which this study applies.

Table 27. Applicable populations to estimates of Smolt Migration Timing.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Lower Cowlitz	Lower Cowlitz Fall Chinook Salmon	Lower Cowlitz	No Program
	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program
	Cispus			No Program
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
	Tilton	Habitat Not Currently Utilized	Tilton	No Program
Coho Salmon	Lower Cowlitz	Lower Cowlitz Coho Salmon	Lower Cowlitz	Upper Cowlitz Coho Salmon
	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	
	Upper Cowlitz		Upper Cowlitz	

Species	Location	Management Unit	Population	Hatchery Program
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	Upper Cowlitz Winter Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat
	Tilton		Tilton	No Program
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Chum Salmon	Lower Cowlitz	Cowlitz Basin Chum Salmon	Lower Cowlitz	No Program

15.11.3 Management Objectives

There are currently no smolt migration timing management objectives for the Cowlitz Basin. Tacoma Power developed an Instream Flow Monitoring Plan (Tacoma Power 2004) under License Article 15 that included monitoring survival and travel times of natural- and hatchery-origin salmon and steelhead smolts. Management objectives are contained in the following links:

- APPENDIX A
- Appendix Table A-3. Population Attributes and Metrics: Coho Salmon
- Appendix Table A-9. Population Attributes and Metrics: Fall Chinook Salmon
- Appendix Table A-16. Population Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-24. Population Attributes and Metrics: Winter-Run Steelhead1
- Appendix Table A-34. Population Attributes and Metrics: Cowlitz Chum Salmon
- Appendix Table A-37. Population Attributes and Metrics: Cowlitz Cutthroat Trout

15.11.4 Data Required

- Smolt arrival dates at the downstream sampling and/or collection facilities

15.11.5 Field Methods

- APPENDIX B: Juveniles from Upper Cowlitz and Cispus Rivers
- APPENDIX B: Juveniles at Mayfield – Tilton River

15.11.6 Objectives or Hypotheses

- Objective 1: monitor smolt migration timing to characterize the run for each population

15.11.7 Analytical Methods

- Descriptive statistics of smolt migration timing, graphical analyses
- Simple timing of mean or median. Median is preferred because the 50th percentile smolt is captured = middle of run.

- Trend analyses (regression, graphical analyses) to characterize the run for each population and detect changes in smolt emigration timing and temporal distribution of timing.

15.11.8 Assumptions

- Sampling at the downstream collectors is representative of the smolt/juvenile outmigrating population.

15.11.9 Anticipated Results

Establish time series data of smolt emigration timing within and among years to characterize current conditions and detect shift in emigration timing or distribution in the future.

15.12 VSP & Population: Age at Smolt Migration

15.12.1 Estimate Age at Smolt Migration

The age structure of juvenile migrants may affect survival, productivity, and population resiliency (VSP-Diversity metric). Shifts in the age at smolt migration may indicate adaptation to changing environmental conditions. Furthermore, it may be important to match the age structure of hatchery produced smolts to emigrating natural smolts.

15.12.2 Applicable Populations and Hatchery Programs

Table 28 summarizes the populations and hatchery programs to which this study applies.

Table 28. Applicable populations and hatchery programs to estimates of age at return.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Lower Cowlitz	Lower Cowlitz Fall Chinook Salmon	Lower Cowlitz	No Program
	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program
	Cispus			No Program
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
	Tilton	Habitat Not Currently Utilized	Tilton	No Program
Coho Salmon	Lower Cowlitz	Lower Cowlitz Coho Salmon	Lower Cowlitz	Upper Cowlitz Coho Salmon
	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	Upper Cowlitz Winter Steelhead

Species	Location	Management Unit	Population	Hatchery Program
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat
	Tilton		Tilton	No Program
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Chum Salmon	Lower Cowlitz	Cowlitz Basin Chum Salmon	Lower Cowlitz	No Program

15.12.3 Management Objectives

There are currently no defined juvenile age structure management objectives within the Cowlitz Basin. Management objectives are contained in the following links:

- APPENDIX A
- Appendix Table A-3. Population Attributes and Metrics: Coho Salmon
- Appendix Table A-9. Population Attributes and Metrics: Fall Chinook Salmon
- Appendix Table A-16. Population Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-24. Population Attributes and Metrics: Winter-Run Steelhead1
- Appendix Table A-34. Population Attributes and Metrics: Cowlitz Chum Salmon
- Appendix Table A-37. Population Attributes and Metrics: Cowlitz Cutthroat Trout

15.12.4 Data Required

- Natural origin smolt ages derived from scale samples, otolith (if collected) for smolts from Cowlitz Basin populations

15.12.5 Field Methods

- APPENDIX B: Juveniles from Upper Cowlitz and Cispus Rivers
- APPENDIX B: Juveniles at Mayfield – Tilton River

15.12.6 Objectives or Hypotheses

- Objective 1: monitor smolt age to characterize age at migration for each population

15.12.7 Analytical Methods

- Descriptive statistics of age at smolt migration, graphical analyses
- Evaluation of the frequencies of smolt age classes: compare over time
- Trend analyses (regression, graphical analysis) to characterize the run for each population and detect changes in smolt age.

15.12.8 Assumptions

- Sampling at the downstream collectors is representative of the smolt/juvenile outmigrating population.

15.12.9 Anticipated Results

Establish time series data of smolt age at emigration within and among years to characterize current conditions and detect shift in smolt age in the future.

15.13 VSP & Population: Mean Age of Adult Returns

15.13.1 Estimate Mean Age at Return

The mean age at return for adults is a summary statistic of the Age at Return data for each population. This statistic provides a cursory method to assess differences in age at return among populations, hatchery programs, or to perform trend analyses.

15.13.2 Applicable Populations and Hatchery Programs

Table 29 summarizes the populations and hatchery programs to which this study applies.

Table 29. Applicable populations and hatchery programs to estimates of Mean Age at Return.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Lower Cowlitz	Lower Cowlitz Fall Chinook Salmon	Lower Cowlitz	No Program
	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program
	Cispus			No Program
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
	Tilton	Habitat Not Currently Utilized	Tilton	No Program
Coho Salmon	Lower Cowlitz	Lower Cowlitz Coho Salmon	Lower Cowlitz	No Program
	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	Upper Cowlitz Winter Steelhead
Summer Steelhead	Lower Cowlitz	Lower Cowlitz Summer Steelhead	No recognized population	Lower Cowlitz Summer Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat
	Tilton		Tilton	No Program
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Chum Salmon	Lower Cowlitz	Cowlitz Basin Chum Salmon	Lower Cowlitz	No Program

15.13.3 Management Objectives

There are currently no defined, mean age-at-return management objectives. Management objectives are contained in the following links:

- APPENDIX A
- Appendix Table A-3. Population Attributes and Metrics: Coho Salmon
- Appendix Table A-9. Population Attributes and Metrics: Fall Chinook Salmon
- Appendix Table A-16. Population Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-24. Population Attributes and Metrics: Winter-Run Steelhead1
- Appendix Table A-34. Population Attributes and Metrics: Cowlitz Chum Salmon
- Appendix Table A-37. Population Attributes and Metrics: Cowlitz Cutthroat Trout

15.13.4 Data Required

- Derived metric from the VSP & Population: Age at Return metric data

15.13.5 Field Methods

- No field methods – this is a derived metric.

15.13.6 Objectives or Hypotheses

- Objective: Calculate mean age at return statistics for each population.

15.13.7 Analytical Methods

- Mean of annual age at return per population
- Trend analysis (regression, graphical analysis) to characterize the mean age at return for each population and track changes in the mean age at return over time.

15.13.8 Assumptions

- Mean age at return sufficiently characterizes the age structure of the population.
- Sampling of adults or carcasses is representative of the population.
- Sufficient samples sizes are obtained of each age class.
- Ageing methods are accurate and unbiased.

15.13.9 Anticipated Results

The mean age at return provides a summary statistic for each population and hatchery program.

15.14 VSP & Population: Abundance of Adult Returns to Target Populations

15.14.1 Estimate of the Abundance of Returning Adults to Target Rivers

Abundance and composition of returning adults to each target river (VSP-Abundance; Lower Cowlitz River, Upper Cowlitz River and Cispus River, and Tilton River) serves as a baseline from which to estimate rates of harvest in the target river, and pre-spawn mortality. It also provides data on which to base management decisions related to harvest, fish transport upstream of the Barrier Dam, gene flow management (pHOS), and broodstock collection composition and numbers.

15.14.2 Applicable Populations and Hatchery Programs

Table 30 summarizes the populations and hatchery programs to which this study applies.

Table 30. Applicable populations and hatchery programs to estimates of the Abundance of Returning Adults to Target Rivers.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Lower Cowlitz	Lower Cowlitz Fall Chinook Salmon	Lower Cowlitz	No Program
	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program
	Cispus			No Program
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
	Tilton	Habitat Not Currently Utilized	Tilton	No Program
Coho Salmon	Lower Cowlitz	Lower Cowlitz Coho Salmon	Lower Cowlitz	No Program
	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	Upper Cowlitz Winter Steelhead
Summer Steelhead	Lower Cowlitz	Lower Cowlitz Summer Steelhead	No recognized population	Lower Cowlitz Summer Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat
	Tilton		Tilton	No Program
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Chum Salmon	Lower Cowlitz	Cowlitz Basin Chum Salmon	Lower Cowlitz	No Program

15.14.3 Management Objectives

The management objectives are the target numbers of adults to transport upstream annually from the Barrier Dam fish separator. Currently, populations in the Lower Cowlitz River (fall Chinook Salmon, winter-run steelhead, summer-run steelhead, and coho salmon) do not have adult return objectives. Adult abundance objectives are limited to spawner abundance (as opposed to adult returns). Management objectives are contained in the following links:

- APPENDIX A

- Appendix Table A-3. Population Attributes and Metrics: Coho Salmon
- Appendix Table A-9. Population Attributes and Metrics: Fall Chinook Salmon
- Appendix Table A-16. Population Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-24. Population Attributes and Metrics: Winter-Run Steelhead1
- Appendix Table A-34. Population Attributes and Metrics: Cowlitz Chum Salmon
- Appendix Table A-37. Population Attributes and Metrics: Cowlitz Cutthroat Trout

15.14.4 Data Required

- The annual number of adults transported from the Barrier Dam fish separator and released upstream of Mayfield Dam

15.14.5 Field Methods

- APPENDIX B, Barrier Dam Adult Returns
- APPENDIX B, Weir Operation and Lower Cowlitz Adult Capture

15.14.6 Objectives or Hypotheses

- Hypothesis 1: Number of adults transported ≥ Target (Tilton and Upper Cowlitz/Cispus)

15.14.7 Analytical Methods

- Compare the number of adults for each population transported (released) upstream to the population target. May be assessed using 5-year averages to account for annual variability.
- A one-sample t-test may be used to assess if the mean of a sample of annual numbers of fish released upstream is equal to or greater than the release target.
- Trend analysis (regression, graphical analysis) of time series to estimate the status and trajectory of the population compared to management objectives.

15.14.8 Assumptions

- The counts of the numbers of fish released upstream are accurate.
- This assumption may be tested by using a second independent count of the number of fish released to verify if the counts agree. If the counts disagree, the source of the error (i.e., the first count, the second count, or both) will have to be further investigated.
- There is no reason to believe these counts will be biased.

15.14.9 Anticipated Results

Evaluation of this metric will inform managers if the management objectives related to transporting fish upstream of the Barrier Dam are being attained.

15.15 VSP & Population: Abundance at Mouth of Cowlitz River

15.15.1 Estimate of the Abundance of Returning Adults to the Mouth of the Cowlitz River

Abundance and composition of returning adults serves as a baseline from which to estimate rates of harvest in the Cowlitz Basin, pre-spawn mortality, and natural mortality. It also provides data on which to base in-season management decisions related to harvest, fish transport upstream of the Barrier Dam, gene flow management (pHOS), and broodstock collection composition and numbers.

15.15.2 Applicable Populations and Hatchery Programs

Table 31 summarizes the populations and hatchery programs to which this study applies.

Table 31. Applicable populations and hatchery programs to develop estimates of Abundance at the Mouth of the Cowlitz River.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Lower Cowlitz	Lower Cowlitz Fall Chinook Salmon	Lower Cowlitz	No Program
	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program
	Cispus			No Program
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
	Tilton	Habitat Not Currently Utilized	Tilton	No Program
Coho Salmon	Lower Cowlitz	Lower Cowlitz Coho Salmon	Lower Cowlitz	No Program
	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	Upper Cowlitz Winter Steelhead
Summer Steelhead	Lower Cowlitz	Lower Cowlitz Summer Steelhead	No recognized population	Lower Cowlitz Summer Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat
	Tilton		Tilton	No Program
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Chum Salmon	Lower Cowlitz	Cowlitz Basin Chum Salmon	Lower Cowlitz	No Program

15.15.3 Management Objectives

There are currently no defined management objectives for abundance of returns at the mouth of the Cowlitz River. Management objectives are contained in the following links:

- APPENDIX A
- Appendix Table A-3. Population Attributes and Metrics: Coho Salmon
- Appendix Table A-9. Population Attributes and Metrics: Fall Chinook Salmon

- Appendix Table A-16. Population Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-24. Population Attributes and Metrics: Winter-Run Steelhead1
- Appendix Table A-34. Population Attributes and Metrics: Cowlitz Chum Salmon
- Appendix Table A-37. Population Attributes and Metrics: Cowlitz Cutthroat Trout

15.15.4 Data Required

- Spawner abundance estimates per population by origin in the Lower Cowlitz and its tributaries
- Number of broodstock collected per population by origin
- Number of fish harvested in the Lower Cowlitz by population and origin
- Number of returns to the Barrier Dam by population and origin
- Estimates of pre-spawn mortality in the Lower Cowlitz by population and origin

15.15.5 Field Methods

- This is a calculated metric based on other metrics that require field data collection.
- Field methods are subject to change based on operational needs and constraints.

15.15.6 Objectives or Hypotheses

- Objective 1: Estimate the return (abundance) of adult fish (jacks and adults, as appropriate to the species) to the mouth of the Cowlitz River.

15.15.7 Analytical Methods

- Reconstruct run numbers to the mouth of the Cowlitz based on returns to the Barrier Dam with the other sources of fish added to the Barrier Dam return count.
- Equation 1: $R_m = R_b + B + S + H + M$

  Where:

  R_m = Returns to the mouth of the Cowlitz River
  R_b = Returns to the Barrier Dam
  B = Number of Broodstock Collected (not included in R_b)
  S = Estimate of spawner abundance in the Lower Cowlitz and tributaries
  H = Estimate of harvest in the Lower Cowlitz and tributaries
  M = Estimate of pre-spawn mortality number in the Lower Cowlitz and tributaries

- Uncertainty: estimates of spawner abundance have statistical uncertainty. Counts of fish to the Barrier Dam fish separator and numbers of fish collected as broodstock have unknown levels of uncertainty (error in counts may be negligible). Creel census has statistical uncertainty. Harvest estimates have statistical uncertainty. Estimates of pre-spawn mortality have statistical uncertainty.

15.15.8 Assumptions

- This metric methodology assumes that the run size to the mouth of the Cowlitz River can be accurately reconstructed using the available data.
- The assumption may be evaluated if there is an alternative approach to estimating the run size to the mouth of the Cowlitz River.
- The estimate may be biased if the data used to perform the calculation are biased. These data may be evaluated for bias as methods allow.

15.15.9 Anticipated Results

Estimates of abundance of returning adults to mouth of the Cowlitz River will provide initial abundance to the Cowlitz River to inform fisheries management decisions and evaluation, broodstock collection, translocation of fish upstream in the basin, and inform pre-spawn mortality estimation for the Lower Cowlitz populations.

15.16 VSP & Population: Smolt to Adult Return (Survival)

15.16.1 Estimate Smolt to Adult Survival of Natural Populations

SAR is one of the key VSP parameters (VSP-Population Growth Rate). The SAR of a natural population is central for population productivity and assessing ocean survival (stock-recruit relationship), extinction risk, and for managing populations. The SAR can inform evaluation of overall population productivity and help identify if ocean survival is the limiting step. SAR is also one of the components needed for a two-stage life cycle model.

15.16.2 Applicable Populations and Hatchery Programs

Table 32 summarizes the populations and hatchery programs to which this study applies.

Table 32. Applicable populations and hatchery programs to estimates of Smolt to Adult Return (Survival).

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Lower Cowlitz	Lower Cowlitz Fall Chinook Salmon	Lower Cowlitz	No Program
	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program
	Cispus			No Program
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
	Tilton	Habitat Not Currently Utilized	Tilton	No Program
Coho Salmon	Lower Cowlitz	Lower Cowlitz Coho Salmon	Lower Cowlitz	Upper Cowlitz Coho Salmon
	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	Upper Cowlitz Winter Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat
	Tilton		Tilton	No Program
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Chum Salmon	Lower Cowlitz	Cowlitz Basin Chum Salmon	Lower Cowlitz	No Program

15.16.3 Management Objectives

There are currently no defined SAR management objectives. Management objectives are contained in the following links:

- APPENDIX A
- Appendix Table A-3. Population Attributes and Metrics: Coho Salmon
- Appendix Table A-9. Population Attributes and Metrics: Fall Chinook Salmon
- Appendix Table A-16. Population Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-24. Population Attributes and Metrics: Winter-Run Steelhead1
- Appendix Table A-34. Population Attributes and Metrics: Cowlitz Chum Salmon
- Appendix Table A-37. Population Attributes and Metrics: Cowlitz Cutthroat Trout

15.16.4 Data Required

This is a derived metric based on data from the following metrics:

- Natural-origin smolt abundance estimates (population specific)
- Natural-origin adult return estimates (population specific)
- Program hatchery release numbers (counts or estimated as per hatchery program)
- Hatchery-origin adult return estimates per program

15.16.5 Field Methods

- No field methods – this is a derived metric.

15.16.6 Objectives or Hypotheses

- Objective 1: Estimate SAR_N to monitor natural population performance
- Objective 2: Estimate SAR_H to monitor hatchery program performance

15.16.7 Analytical Methods

- Equation 1: $SAR_N = NOR/S_N$

  Where

  SAR_N *= Smolt to adult return (natural-origin)*
  NOR = natural-origin return
  S_N *= natural-origin smolt abundance*

- Equation 2: $SAR_H = HOR/S_H$

  Where

  SAR_H *= Smolt to adult Return (hatchery-origin)*
  HOR = hatchery-origin return
  S_H *= hatchery-origin smolt release abundance*

  To incorporate uncertainty in these calculations, Monte Carlo simulation can be used to incorporate uncertainty estimates of the input variables.

15.16.8 Assumptions

- Natural-origin smolt estimates are accurate and unbiased and represent the overall outmigration.

- NOR adult return estimates are accurate and unbiased.
- Hatchery smolt release abundances are accurate and unbiased.
- HOR adult return estimates are accurate and unbiased.

15.16.9 Anticipated Results

SAR estimates will provide critical information to assess the natural population and hatchery program productivity performance.

15.17 VSP & Population: Pre-Spawn Mortality

15.17.1 Estimates of Pre-Spawn Mortality

Pre-spawn mortality occurs between the time fish enter a river at a defined point (e.g., mouth of river) and spawning. Pre-spawn mortality, considered here separately from mortality as a result of fisheries, can result from a variety of reasons, including predation, pathogens/parasites/disease, fish condition, energetics, injuries, and environmental conditions such as warm water. The common theme is that a percentage of adult fish that return from the ocean do not survive to complete spawning. Estimates of pre-spawn mortality can inform managers of mortality that affects spawner abundance and effective population size. Concerning levels of pre-spawn mortality may require further analysis or research as to the causes and may offer solutions to improve conservation of the population.

15.17.2 Applicable Populations and Hatchery Programs

Table 33 summarizes the populations and hatchery programs to which this study applies.

Table 33. Applicable populations and hatchery programs to estimates of Pre-Spawn Mortality.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Lower Cowlitz	Lower Cowlitz Fall Chinook Salmon	Lower Cowlitz	No Program
	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program
	Cispus			No Program
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
	Tilton	Habitat Not Currently Utilized	Tilton	No Program
Coho Salmon	Lower Cowlitz	Lower Cowlitz Coho Salmon	Lower Cowlitz	No Program
	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	Upper Cowlitz Winter Steelhead
Summer Steelhead	Lower Cowlitz	Lower Cowlitz Summer Steelhead	No recognized population	Lower Cowlitz Summer Steelhead

Species	Location	Management Unit	Population	Hatchery Program
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat
	Tilton		Tilton	No Program
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Chum Salmon	Lower Cowlitz	Cowlitz Basin Chum Salmon	Lower Cowlitz	No Program

15.17.3 Management Objectives

There are currently no defined pre-spawn mortality management targets. Management objectives are contained in the following links:

- APPENDIX A
- Appendix Table A-3. Population Attributes and Metrics: Coho Salmon
- Appendix Table A-9. Population Attributes and Metrics: Fall Chinook Salmon
- Appendix Table A-16. Population Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-24. Population Attributes and Metrics: Winter-Run Steelhead1
- Appendix Table A-34. Population Attributes and Metrics: Cowlitz Chum Salmon
- Appendix Table A-37. Population Attributes and Metrics: Cowlitz Cutthroat Trout

15.17.4 Data Required

Pre-spawn mortality is a derived metric and uses data from the following metrics:

- Estimate of population-specific adult return abundance at the Mouth of the Cowlitz
- Estimate of population-specific adult return abundance to specific rivers (Lower Cowlitz mainstem and tributaries, Tilton, Upper Cowlitz, Cispus)
- Population-specific spawner abundance estimates
- Population-specific broodstock collection numbers (after adult return number was established)
- Population-specific harvest in the Cowlitz Basin (after adult return number was established)

15.17.5 Field Methods

- 15.15 VSP & Population: Abundance at Mouth of Cowlitz River; Page 70
- APPENDIX B, VSP-Abundance – Abundance of Adult Returns to Target River
- APPENDIX B, VSP & Population: Abundance of Spawners

15.17.6 Objectives or Hypotheses

- Objective 1: Estimated pre-spawn mortality
- Objective 2: Track pre-spawn mortality over time

15.17.7 Analytical Methods

- Approach:
  - Qualitative assessment of estimated pre-spawn mortality to identify concerning levels
  - Trend analyses (regression, graphical analysis) to characterize pre-spawn mortality rates and identify concerning trends

- Equation: PSM=S/R

  Where

  S = the abundance of spawners
  R = the return abundance adjusted for broodstock removal and harvest in the Cowlitz Basin that occurred after the number of returns was estimated

15.17.8 Assumptions

- Estimates of returns are accurate and unbiased.
- Estimates of spawners are accurate and unbiased.

15.17.9 Anticipated Results

Pre-spawn mortality that is concerningly high may be cause for further investigation. Tracking pre-spawn mortality over time can help managers identify concerning trends in a population. Pre-spawn mortality estimates may be misleading if the estimates of return or spawner abundance are not unbiased and precise.

15.18 VSP & Population: Stray Rate Within Basin

15.18.1 Estimate of the Stray Rate with the Cowlitz Basin for Each Hatchery Program

Stray rates are a VSP-Diversity metric. Within-basin straying of hatchery fish may have genetic implications if there are genetically distinct populations within the basin. Within-basin straying may also compromise management objectives to return a target number of spawners to specific areas of the basin.

15.18.2 Applicable Populations and Hatchery Programs

Table 34 summarizes the populations and hatchery programs to which this study applies.

Table 34. Applicable populations and hatchery programs to estimates of Stray Rate Within Basin.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Tilton	Upper Cowlitz Fall Chinook Salmon	Upper Cowlitz	Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
Coho Salmon	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus	Upper Cowlitz Subbasin Winter Steelhead	Cispus	Upper Cowlitz Winter Steelhead

15.18.3 Management Objectives

There are currently no defined within-basin stray rate management objectives for the Cowlitz Basin. Management objectives are contained in the following links:

- APPENDIX A
- Appendix Table A-3. Population Attributes and Metrics: Coho Salmon
- Appendix Table A-9. Population Attributes and Metrics: Fall Chinook Salmon
- Appendix Table A-16. Population Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-24. Population Attributes and Metrics: Winter-Run Steelhead1
- Appendix Table A-34. Population Attributes and Metrics: Cowlitz Chum Salmon
- Appendix Table A-37. Population Attributes and Metrics: Cowlitz Cutthroat Trout

15.18.4 Data Required

This is a derived metric based on data from the following sources:

- Spawning Ground Survey origin and abundance estimates
- Lower Cowlitz Tributary Weirs origin and abundance of adults sampled
- Barrier Dam fish separator origin and abundance of adults sampled
- Origin and abundance of broodstock
- Data collected from creel surveys (e.g., CWT, passive integrated transponder [PIT], Floy tags)

15.18.5 Field Methods

- No field methods – this is a derived metric.

15.18.6 Objectives or Hypotheses

- Objective 1: Estimate within-basin stray rates to identify programs that have excessive within-basin straying

15.18.7 Analytical Methods

- Annual estimation of within-basin stray rates.
  - Calculation 1: percentage of the hatchery return that strayed within-basin
  - Calculation 2: percent composition of strays : spawners in the receiving population
- Trend analysis (regression, graphical) of within-basin stray rates

15.18.8 Assumptions

- Estimates of spawner abundance by origin are accurate and unbiased.
- If adults are sampled prior to spawning (e.g., sampled at a weir or via creel), this assumes fish sampled in a location spawned in that location (e.g., in a tributary where they were sampled).

15.18.9 Anticipated Results

Characterize within-basin stray rates for each program. Identify programs, if any, that have concerning levels of in-basin straying.

15.19 VSP & Population: Stray Rate Outside of Basin

15.19.1 Estimate of the Stray Rate Outside of the Cowlitz Basin for Each Hatchery Program

Stray rates are a VSP-Diversity metric. Straying of Cowlitz hatchery fish outside of the Cowlitz Basin may have genetic implications if there are genetically distinct populations receiving strays. Outside of basin straying may also compromise management objectives to return a target number of spawners to specific areas of the Cowlitz Basin.

15.19.2 Applicable Populations and Hatchery Programs

Table 35 summarizes the populations and hatchery programs to which this study applies.

Table 35. Applicable populations and hatchery programs to estimates of Stray Rate Outside of Basin.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Tilton	Upper Cowlitz Fall Chinook Salmon	Upper Cowlitz	Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
Coho Salmon	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus	Upper Cowlitz Subbasin Winter Steelhead	Cispus	Upper Cowlitz Winter Steelhead

15.19.3 Management Objectives

There are currently no defined outside of basin stray rate management objectives for the Cowlitz Basin. Management objectives are contained in the following links:

- APPENDIX A
- Appendix Table A-3. Population Attributes and Metrics: Coho Salmon
- Appendix Table A-9. Population Attributes and Metrics: Fall Chinook Salmon
- Appendix Table A-16. Population Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-24. Population Attributes and Metrics: Winter-Run Steelhead1
- Appendix Table A-34. Population Attributes and Metrics: Cowlitz Chum Salmon
- Appendix Table A-37. Population Attributes and Metrics: Cowlitz Cutthroat Trout

15.19.4 Data Required

- CWT, PIT tag, jaw tag, and Floy tag data of adults detected in other basins from RMIS, PTAGIS, and corporate databases.

15.19.5 Field Methods

- No field methods – this is a derived metric.

15.19.6 Objectives or Hypotheses

- Objective 1: Estimate outside of basin stray rates to identify programs that have excessive outside of basin straying.

15.19.7 Analytical Methods

- Annual estimation of outside of basin stray rates
  - Calculation 1: percentage of the hatchery return that strayed to another basin
  - Calculation 2: percent composition of strays : total spawners in the receiving population
- Trend analysis of outside of basin stray rates

15.19.8 Assumptions

- Estimates of spawner abundance by origin are accurate and unbiased.

15.19.9 Anticipated Results

Characterize outside of basin stray rates for each program. Identify programs, if any, that have concerning levels of outside of basin straying.

15.20 VSP & Population: Stray Rate into Basin

15.20.1 Estimate of the Stray Rate into the Cowlitz Basin by Non-Cowlitz Fish

Stray rates are a VSP-Diversity metric. Straying of hatchery fish into the Cowlitz Basin may have genetic implications if the strays are from a genetically distinct hatchery program or if the number of strays affects pHOS within a Cowlitz population. Strays may also be inadvertently incorporated into broodstock, inflicting a genetic risk to the hatchery program and associated populations.

15.20.2 Applicable Populations and Hatchery Programs

Table 36 summarizes the populations and hatchery programs to which this study applies.

Table 36. Applicable populations and hatchery programs to estimates of Stray Rate into Basin.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Lower Cowlitz	Lower Cowlitz Fall Chinook Salmon	Lower Cowlitz	No Program
	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program
	Cispus			No Program
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
Coho Salmon	Lower Cowlitz	Lower Cowlitz Coho Salmon	Lower Cowlitz	No Program
	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	

Species	Location	Management Unit	Population	Hatchery Program
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	Upper Cowlitz Winter Steelhead

15.20.3 Management Objectives

There are currently no defined stray-rate-into-basin management objectives for the Cowlitz Basin. Management objectives are contained in the following links:

- APPENDIX A
- Appendix Table A-3. Population Attributes and Metrics: Coho Salmon
- Appendix Table A-9. Population Attributes and Metrics: Fall Chinook Salmon
- Appendix Table A-16. Population Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-24. Population Attributes and Metrics: Winter-Run Steelhead1
- Appendix Table A-34. Population Attributes and Metrics: Cowlitz Chum Salmon
- Appendix Table A-37. Population Attributes and Metrics: Cowlitz Cutthroat Trout

15.20.4 Data Required

This is a derived metric based on data from the following metrics:

- Spawning Ground Survey origin and abundance estimates
- Lower Cowlitz Tributary Weirs origin and abundance of adults sampled
- Barrier Dam fish separator origin and abundance of adults sampled
- Origin and abundance of broodstock

15.20.5 Field Methods

- No field methods – this is a derived metric.

15.20.6 Objectives or Hypotheses

- Objective 1: Estimate stray rates into the Cowlitz Basin to natural populations within the Cowlitz
- Objective 2: Estimate stray rates from outside the Cowlitz Basin into the broodstock for Cowlitz hatchery programs

15.20.7 Analytical Methods

- Annual estimation of stray rates from outside the Cowlitz Basin
  - Calculated as percent of strays into the Cowlitz Basin in the receiving population or broodstock
- Trend analysis (regression, graphical analysis) of stray rates into the Cowlitz Basin populations and broodstock

15.20.8 Assumptions

- Estimates of spawner abundance by origin are accurate and unbiased.
- Estimates of broodstock by origin are accurate and unbiased.

15.20.9 Anticipated Results

Characterize stray rates into the Cowlitz Basin for each population and program. Identify populations or programs, if any, that experience concerning levels of strays from outside of the Cowlitz Basin.

16 Hatchery Assessment Metrics, Objectives or Hypotheses, Analytical Approaches

16.1 Hatchery Assessment: Biological Sampling in Hatchery

16.1.1 In-Hatchery Biological Sampling

Track biological attributes in the hatchery including broodstock, spawning, incubation, and rearing.

16.1.2 Applicable Populations and Hatchery Programs

Table 37 summarizes the populations and hatchery programs to which this study applies.

Table 37. Biological Sampling in Hatchery applies to these populations and hatchery programs.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Tilton	Upper Cowlitz Fall Chinook Salmon	Upper Cowlitz	Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
Coho Salmon	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	
Summer Steelhead	Lower Cowlitz	Lower Cowlitz Summer Steelhead	No recognized population	Lower Cowlitz Summer Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat

16.1.3 Management Objectives

Hatchery management objectives for biological attributes in the hatchery are contained in the following links:

- APPENDIX A
- Appendix Table A-4. Hatchery Program Attributes and Metrics: Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon
- Appendix Table A-10. Hatchery Program Attributes and Metrics: Upper Cowlitz Fall Chinook Salmon (Tilton River)
- Appendix Table A-17. Hatchery Program Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-25. Hatchery Program Attributes and Metrics: Lower Cowlitz Winter-Run Steelhead
- Appendix Table A-26. Hatchery Program Attributes and Metrics: Tilton Winter-Run Steelhead

- Appendix Table A-27. Hatchery Program Attributes and Metrics: Upper Cowlitz Subbasin Winter Steelhead (Upper Cowlitz and Cispus)
- Appendix Table A-28. Hatchery Program Attributes and Metrics: Lower Cowlitz Summer-Run Steelhead
- Appendix Table A-38. Hatchery Program Attributes and Metrics: Cowlitz Cutthroat Trout

16.1.4 Data Required

- Broodstock origin, age, sex, length, fecundity
- Size of juveniles at standard sampling times to track growth
- Size at release
- Marking and tagging
  - Type of tag or mark
  - Number marked
  - Quality assurance and quality control results of marking and tagging
- Fish Health Results
- Routine fish health assessments
- Diagnosis and treatment for outbreak
- Mortality associated with fish health issues

16.1.5 Field Methods

- APPENDIX B, In-Hatchery Monitoring and Record Keeping

16.1.6 Objectives or Hypotheses

- Objective 1: Monitor biological attributes of broodstock, spawning, incubation, and rearing during fish culture
- Hypothesis 1: Biological Attribute = Attribute Target

16.1.7 Analytical Methods

- Compare during rearing and at release: fish size to fish size targets.

16.1.8 Assumptions

- Sampling is representative of the population and unbiased.

16.1.9 Anticipated Results

Monitor biological attributes of broodstock, spawning, incubation, and rearing during fish culture, including summary of fish health records.

16.2 Hatchery Assessment: Proportion of Hatchery Origin Spawners

16.2.1 Estimate Proportion of Hatchery Origin Spawners

The pHOS on the spawning grounds is a metric established by the HSRG (2009). pHOS is a critical metric for the management and conservation of natural populations that are subjected to hatchery programs. This strategy is intended to limit gene flow from the hatchery population to the natural population to retain the fitness of the natural population. pHOS is a term in the PNI metric calculation.

16.2.2 Applicable Populations and Hatchery Programs

Table 38 summarizes the populations and hatchery programs to which this study applies.

Table 38. Applicable populations and hatchery programs to estimates of Proportion of Hatchery Origin Spawners.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Lower Cowlitz	Lower Cowlitz Fall Chinook Salmon	Lower Cowlitz	No Program
	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program
	Cispus			No Program
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
Coho Salmon	Lower Cowlitz	Lower Cowlitz Coho Salmon	Lower Cowlitz	No Program
	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	Upper Cowlitz Winter Steelhead

16.2.3 Management Objectives

Hatchery management objectives for pHOS are contained in the links, below:

- APPENDIX A
- Appendix Table A-4. Hatchery Program Attributes and Metrics: Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon
- Appendix Table A-10. Hatchery Program Attributes and Metrics: Upper Cowlitz Fall Chinook Salmon (Tilton River)
- Appendix Table A-17. Hatchery Program Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-25. Hatchery Program Attributes and Metrics: Lower Cowlitz Winter-Run Steelhead
- Appendix Table A-26. Hatchery Program Attributes and Metrics: Tilton Winter-Run Steelhead
- Appendix Table A-27. Hatchery Program Attributes and Metrics: Upper Cowlitz Subbasin Winter Steelhead (Upper Cowlitz and Cispus)

16.2.4 Data Required

This is a derived metric based on data from the following metrics:

- NOS abundance
- HOS abundance

16.2.5 Field Methods

- No field methods – this is a derived metric.

16.2.6 Objectives or Hypotheses

- Hypothesis 1: pHOS ≤ Target

16.2.7 Analytical Methods

- APPENDIX B, pHOS, pNOB, PNI
- Comparison of observed pHOS to target to determine if program is meeting the pHOS target
- Trend analysis (regression, graphical analysis) to track pHOS over time compared to target pHOS

16.2.8 Assumptions

- Estimates of redds are accurate.
- Expansion factors are realistic and unbiased
- Sampling of redds and carcasses is unbiased
- Expansion to numbers of spawners by origin is accurate
- Bias may be investigated by using alternative estimation methods, if available. Systematic deviance in estimates suggests at least one of the estimates is biased. Further investigation would be required to identify the source of the bias.

16.2.9 Anticipated Results

Calculation of pHOS for each population will allow evaluation of the hatchery program compliance with pHOS and PNI targets.

16.3 Hatchery Assessment: Proportions of Natural- and Hatchery-Origin Broodstock

16.3.1 Estimate Proportions of Natural- and Hatchery-Origin Broodstock in Hatchery Programs

The pNOB in a hatchery program is a metric established by the HSRG (2009). pNOB is a critical metric for the management and conservation of natural populations that are subjected to hatchery programs. This strategy is intended to maintain gene flow from the natural population at a greater level than the hatchery population in an integrated hatchery program to retain the fitness of the natural population. pNOB is a term in the PNI metric calculation.

16.3.2 Applicable Populations and Hatchery Programs

Table 39 summarizes the populations and hatchery programs to which this study applies.

Table 39. Applicable populations and hatchery programs to estimates of pNOB.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Tilton	Upper Cowlitz Fall Chinook Salmon	Upper Cowlitz	Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	

Species	Location	Management Unit	Population	Hatchery Program
Coho Salmon	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus	Upper Cowlitz Subbasin Winter Steelhead	Cispus	Upper Cowlitz Winter Steelhead

16.3.3 Management Objectives

Hatchery management objectives for pNOB are contained in the links, below:

- APPENDIX A
- Appendix Table A-4. Hatchery Program Attributes and Metrics: Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon
- Appendix Table A-10. Hatchery Program Attributes and Metrics: Upper Cowlitz Fall Chinook Salmon (Tilton River)
- Appendix Table A-17. Hatchery Program Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-25. Hatchery Program Attributes and Metrics: Lower Cowlitz Winter-Run Steelhead
- Appendix Table A-26. Hatchery Program Attributes and Metrics: Tilton Winter-Run Steelhead
- Appendix Table A-27. Hatchery Program Attributes and Metrics: Upper Cowlitz Subbasin Winter Steelhead (Upper Cowlitz and Cispus)

16.3.4 Data Required

- NOB and HOB for each hatchery program are from Section 16.1 Hatchery Assessment: Biological Sampling in Hatchery.

16.3.5 Field Methods

- No field methods – this is a derived metric.

16.3.6 Objectives or Hypotheses

- Hypothesis 1: pNOB ≥ Target

16.3.7 Analytical Methods

- APPENDIX B, pHOS, pNOB, PNI
- Comparison of observed pNOB to target to determine if program is meeting the pNOB target
- Trend analysis (regression, graphical analysis) to track pNOB over time compared to target pNOB

16.3.8 Assumptions

- Broodstock spawning numbers and origin data are accurate.

16.3.9 Anticipated Results

Calculation of pNOB for each hatchery program will allow evaluation of the hatchery program compliance with pNOB and PNI targets.

16.4 Hatchery Assessment: Proportionate Natural Influence

16.4.1 Estimate Proportionate Natural Influence for each population

PNI in a hatchery program/natural population is a metric established by the HSRG (2009) that estimates the geneflow between natural and integrated hatchery populations. The concept is that PNI > 0.50 indicates that the majority of geneflow is from the natural population. PNI of ≥0.67 is recommended for Primary populations and conservation hatchery programs, ≥0.50 for Contributing populations and maintaining current condition for Stabilizing populations (HSRG 2009). PNI is a critical metric for the management and conservation of natural populations that are supported by hatchery programs.

16.4.2 Applicable Populations and Hatchery Programs

Table 40 summarizes the populations and hatchery programs to which this study applies.

Table 40. Applicable populations and hatchery programs to estimates of Proportionate Natural Influence.

Species	Location	Management Unit	Population (Recovery Designation)	Hatchery Program
Fall Chinook Salmon	Tilton	Upper Cowlitz Fall Chinook Salmon	Upper Cowlitz (Stabilizing)	Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz (Primary)	Upper Cowlitz Spring Chinook[1]
	Cispus		Cispus (Primary)	
Coho Salmon	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton (Stabilizing)	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz (Primary)	
	Cispus		Cispus (Primary)	
Winter Steelhead	Tilton	Tilton River Winter Steelhead	Tilton (Contributing)	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz (Primary)	Upper Cowlitz Winter Steelhead
	Cispus	Upper Cowlitz Subbasin Winter Steelhead	Cispus (Primary)	Upper Cowlitz Winter Steelhead

Note.
1. This program is currently segregated, therefore PNI = 0. However, the spring Chinook Transition Plan calls for development of an integrated program.

16.4.3 Management Objectives

Hatchery management objectives for PNI are contained in the following links:

- APPENDIX A
- Appendix Table A-4. Hatchery Program Attributes and Metrics: Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon
- Appendix Table A-10. Hatchery Program Attributes and Metrics: Upper Cowlitz Fall Chinook Salmon (Tilton River)
- Appendix Table A-17. Hatchery Program Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-25. Hatchery Program Attributes and Metrics: Lower Cowlitz Winter-Run Steelhead
- Appendix Table A-26. Hatchery Program Attributes and Metrics: Tilton Winter-Run Steelhead
- Appendix Table A-27. Hatchery Program Attributes and Metrics: Upper Cowlitz Subbasin Winter Steelhead (Upper Cowlitz and Cispus)

16.4.4 Data Required

This is a derived metric based on data from the following metrics:

- pHOS and pNOB for each hatchery program and natural population

16.4.5 Field Methods

- No field methods – this is a derived metric.

16.4.6 Objectives or Hypotheses

- Hypothesis 1: PNI ≥ Target

16.4.7 Analytical Methods

- APPENDIX B, pHOS, pNOB, PNI
- Comparison of observed PNI to target to determine if program is meeting the PNI target
- Trend analysis (regression, graphical analysis) to track PNI over time compared to target PNI

16.4.8 Assumptions

- pNOB and pHOS estimates are accurate and unbiased.

16.4.9 Anticipated Results

Calculation of PNI for each hatchery program and population will allow evaluation of the hatchery program compliance with PNI targets.

16.5 Hatchery Assessment: Number of Hatchery Smolts Released

16.5.1 Estimate the Number of Hatchery Smolts Released

Document the number of smolts released annually for each hatchery program.

16.5.2 Applicable Populations and Hatchery Programs

Table 41 summarizes the populations and hatchery programs to which this study applies.

Table 41. Number of Hatchery Smolts Released applies to these populations and hatchery programs.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Tilton	Upper Cowlitz Fall Chinook Salmon	Upper Cowlitz	Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
Coho Salmon	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	
Summer Steelhead	Lower Cowlitz	Lower Cowlitz Summer Steelhead	No recognized population	Lower Cowlitz Summer Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat

16.5.3 Management Objectives

Hatchery management objectives for hatchery smolt (juvenile) release numbers are contained in the following links:

- APPENDIX A
- Appendix Table A-4. Hatchery Program Attributes and Metrics: Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon
- Appendix Table A-10. Hatchery Program Attributes and Metrics: Upper Cowlitz Fall Chinook Salmon (Tilton River)
- Appendix Table A-17. Hatchery Program Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-25. Hatchery Program Attributes and Metrics: Lower Cowlitz Winter-Run Steelhead
- Appendix Table A-26. Hatchery Program Attributes and Metrics: Tilton Winter-Run Steelhead
- Appendix Table A-27. Hatchery Program Attributes and Metrics: Upper Cowlitz Subbasin Winter Steelhead (Upper Cowlitz and Cispus)
- Appendix Table A-28. Hatchery Program Attributes and Metrics: Lower Cowlitz Summer-Run Steelhead
- Appendix Table A-38. Hatchery Program Attributes and Metrics: Cowlitz Cutthroat Trout

16.5.4 Data Required

- Estimated number of fish released from hatchery
- For steelhead releases, see Stevens (2023)

16.5.5 Field Methods

- APPENDIX B, In-Hatchery Monitoring and Record Keeping

16.5.6 Objectives or Hypotheses

- Hypothesis 1: Number Released = Target (not to exceed target + 10%)

16.5.7 Analytical Methods

- Steelhead release number estimation: Stevens (2023)
- Comparison of release numbers to target
- Trend analysis (regression, graphical analysis) to characterize release numbers over time

16.5.8 Assumptions

- Release numbers are accurate and unbiased.
- Bias or errors may be detected by comparing results of alternative methods to estimate the number released.

16.5.9 Anticipated Results

Annual estimates of the number of hatchery smolts released by species and program will be documented. Trend analyses will assess hatchery program performance in meeting release targets over time.

16.6 Hatchery Assessment: Precocious Maturation Rate

16.6.1 Estimate Precocious Maturation Rate

Precocious maturation occurs in natural populations, primarily in males, but may be greatly amplified in hatchery programs. Precocity may be expressed through early maturation of males while in freshwater, or by the mini-jacks life history variant. Assessment of precocity ranges from visual classification of physiological state of juveniles using parr to smolt characteristics (i.e., smolt index) to lethal sampling and dissection to examine testes and collect gonadal and somatic weight to calculate gonadal-somatic index (GSI). Mini-jacks may be observed on spawning grounds, by PIT tag detection (if fish are PIT tagged), and in upstream migrant fish traps. Precocity increases the risk of residualism (particularly in steelhead), which could impart risk to a natural population through competition and predation. In addition, precocity reduces the number of adults that return per hatchery smolt released because a percentage of the juveniles express an early maturation life history.

16.6.2 Applicable Populations and Hatchery Programs

Table 42 summarizes the populations and hatchery programs to which this study applies.

Table 42. Precocious Maturation Rate applies to these populations and hatchery programs.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Tilton	Upper Cowlitz Fall Chinook Salmon	Upper Cowlitz	Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
Coho Salmon	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead

Species	Location	Management Unit	Population	Hatchery Program
Winter Steelhead	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	
Summer Steelhead	Lower Cowlitz	Lower Cowlitz Summer Steelhead	No recognized population	Lower Cowlitz Summer Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat

16.6.3 Management Objectives

There are currently no management objectives for precocity rates. Hatchery management objectives are contained in the following links:

- APPENDIX A
- Appendix Table A-4. Hatchery Program Attributes and Metrics: Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon
- Appendix Table A-10. Hatchery Program Attributes and Metrics: Upper Cowlitz Fall Chinook Salmon (Tilton River)
- Appendix Table A-17. Hatchery Program Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-25. Hatchery Program Attributes and Metrics: Lower Cowlitz Winter-Run Steelhead
- Appendix Table A-26. Hatchery Program Attributes and Metrics: Tilton Winter-Run Steelhead
- Appendix Table A-27. Hatchery Program Attributes and Metrics: Upper Cowlitz Subbasin Winter Steelhead (Upper Cowlitz and Cispus)
- Appendix Table A-28. Hatchery Program Attributes and Metrics: Lower Cowlitz Summer-Run Steelhead
- Appendix Table A-38. Hatchery Program Attributes and Metrics: Cowlitz Cutthroat Trout

16.6.4 Data Required

- Program release number
- Number of precocious fish

16.6.5 Field Methods

- Pre-release sampling for precocity using visual observation (smolt index, expressing milt)
- APPENDIX A, In-Hatchery Monitoring and Record Keeping

16.6.6 Objectives or Hypotheses

- Objective 1: Monitor precocity to document baseline rates and identify program that have unexpectedly high level of precocity.

16.6.7 Analytical Methods

- Assess precocity levels in hatchery programs annually
- Trend analysis (regression, graphical analysis) to characterize precocity rates over time

16.6.8 Assumptions

- Methodology to identify precocious fish is accurate and unbiased.

16.6.9 Anticipated Results

Monitoring will provide baseline information and identify programs with unexpectedly high rates of precocity.

16.7 Hatchery Assessment: Survival by Life Stage

16.7.1 Estimate Survival by Life Stage

Hatchery programs track the abundance and survival of cultured fish from egg to release, as well as survival of broodstock from collection to spawning. Identifying life history intervals that do not meet survival expectations can help a hatchery program improve its performance.

16.7.2 Applicable Populations and Hatchery Programs

Table 43 summarizes the populations and hatchery programs to which this study applies.

Table 43. Survival by Life Stage applies to these populations and hatchery programs.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Tilton	Upper Cowlitz Fall Chinook Salmon	Upper Cowlitz	Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
Coho Salmon	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	
Summer Steelhead	Lower Cowlitz	Lower Cowlitz Summer Steelhead	No recognized population	Lower Cowlitz Summer Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat

16.7.3 Management Objectives

Hatchery management objectives for hatchery life stage survival rates are contained in the following links:

- APPENDIX A
- Appendix Table A-4. Hatchery Program Attributes and Metrics: Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon
- Appendix Table A-10. Hatchery Program Attributes and Metrics: Upper Cowlitz Fall Chinook Salmon (Tilton River)

- Appendix Table A-17. Hatchery Program Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-25. Hatchery Program Attributes and Metrics: Lower Cowlitz Winter-Run Steelhead
- Appendix Table A-26. Hatchery Program Attributes and Metrics: Tilton Winter-Run Steelhead
- Appendix Table A-27. Hatchery Program Attributes and Metrics: Upper Cowlitz Subbasin Winter Steelhead (Upper Cowlitz and Cispus)
- Appendix Table A-28. Hatchery Program Attributes and Metrics: Lower Cowlitz Summer-Run Steelhead
- Appendix Table A-38. Hatchery Program Attributes and Metrics: Cowlitz Cutthroat Trout

16.7.4 Data Required

- In-hatchery survival
- Broodstock collection to spawning survival
- Fecundity
- Green to eyed-egg stage survival
- Eyed-egg stage to ponding survival
- Ponding to release survival
- Green egg to release – overall survival

16.7.5 Field Methods

- WDFW 2023e
- APPENDIX B, In-Hatchery Monitoring and Record Keeping

16.7.6 Objectives or Hypotheses

- Hypothesis 1: Life Stage Survival ≥ Target

16.7.7 Analytical Methods

- Compare observed in-hatchery survivals to in-hatchery survival targets
- Trend analysis (regression, graphical) to characterize in-hatchery survival over time

16.7.8 Assumptions

- Assumes in-hatchery abundance estimates are accurate and unbiased.
- Assumes in-hatchery survival estimates are accurate and unbiased.

16.7.9 Anticipated Results

Monitor in-hatchery survival to ensure hatchery programs are operating effectively and to identify periods during fish culture that are not meeting survival expectations.

16.8 Hatchery Assessment: Population Genetics Sampling

16.8.1 Define the Population Genetics Sampling Design

Population genetics studies may be performed on the populations and hatchery programs within the Cowlitz Basin. A population genetics study design must be developed to direct sample collection and subsequent analyses. Work with geneticists to establish a study design.

Collection of genetics samples for each hatchery program should be performed to archive samples for future analyses according to the sampling design developed for the genetics study design. Collection of samples can often be performed during other field assessments, such as during spawner surveys or during hatchery spawning. Samples must be collected under an established sampling design to ensure future population genetic analyses are robust and are properly interpretable. Work with geneticists to establish a sampling design.

See Section 15.6 VSP & Population: Population Genetics Sampling for more information.

16.9 Hatchery Assessment: Population Genetics Analyses

16.9.1 Define the Population Genetics Study Design

Hatchery programs shall be included in the population genetics study design and analyses of the natural populations. See Section 15.6 VSP & Population: Population Genetics Analyses for more information.

16.10 Hatchery Assessment: Demographic Replacement

16.10.1 Estimate of Demographic Replacement

Programs intended to supplement populations may inadvertently fail to achieve demographic replacement of natural-origin fish collected as broodstock. To achieve demographic replacement, hatchery-origin spawners in nature must produce at least an equivalent number of estimated offspring as would have been produced by the natural-origin adults removed for broodstock had they spawned in nature instead of the hatchery.

16.10.2 Applicable Populations

Table 44 summarizes the populations to which this study applies.

Table 44. Applicable populations to Demographic Replacement estimates.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program
	Cispus			
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
Coho Salmon	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	

16.10.3 Management Objectives

Management objectives for demographic replacement are contained in the following links:

- APPENDIX A
- Appendix Table A-4. Hatchery Program Attributes and Metrics: Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon
- Appendix Table A-10. Hatchery Program Attributes and Metrics: Upper Cowlitz Fall Chinook Salmon (Tilton River)
- Appendix Table A-17. Hatchery Program Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-25. Hatchery Program Attributes and Metrics: Lower Cowlitz Winter-Run Steelhead
- Appendix Table A-26. Hatchery Program Attributes and Metrics: Tilton Winter-Run Steelhead
- Appendix Table A-27. Hatchery Program Attributes and Metrics: Upper Cowlitz Subbasin Winter Steelhead (Upper Cowlitz and Cispus)
- Appendix Table A-28. Hatchery Program Attributes and Metrics: Lower Cowlitz Summer-Run Steelhead

16.10.4 Data Required

This is a derived metric based on data from the following metrics:

- N_{HOR}: Estimate of population-specific hatchery-origin adult return abundance to the Lower Cowlitz Basin (for Lower Cowlitz mainstem)
- N_{HOR}: Estimate of population-specific hatchery-origin adult return abundance to specific rivers (Lower Cowlitz Tributaries, Tilton, Upper Cowlitz, Cispus)
- *f*: Population-specific number of hatchery-origin fish removed by harvest in the Cowlitz Basin
- NOB: Population-specific number of natural-origin broodstock collected
- *r*: The estimated relative reproductive success of hatchery-origin fish to natural-origin fish (from studies or literature)

16.10.5 Field Methods

- No field methods – this is a derived metric.

16.10.6 Objectives or Hypotheses

- Objective 1: achieve $d \geq 1$
  - where d = demographic replacement.

16.10.7 Analytical Methods

- APPENDIX B, Demographic Replacement
- Trend analysis (regression, graphical analysis) may be used to assess a program for its demographic replacement values over time.

16.10.8 Assumptions

- N_{HOR}: the estimate of hatchery-origin returns in nature is accurate and unbiased.

- *r* : the estimated relative reproductive success of hatchery-origin fish to natural-origin fish (from studies or literature) is accurate and unbiased.
- *f* : the estimate of the number of hatchery-origin fish removed by mark-selective harvest is accurate and unbiased.
- See sections on adult return (N_{HOR}) estimation and harvest (*f*) for discussion of bias in these estimates. Relative reproductive success bias may be addressed by modeling a range of relative reproductive success results derived from literature.

16.10.9 Anticipated Results

Assessing demographic replacement will identify programs that may be mining natural-origin fish for broodstock. This metric can also identify risk to natural populations related to operation of a hatchery program.

16.11 Hatchery Assessment: Size at Release

16.11.1 Estimate the Size at Release

Monitor size at release of hatchery fish to document that program size at release targets are being met. In addition, size at release may be correlated with post-release survival, residualism, and precocity. Monitoring size at release will allow future investigations of effects on survival, precocity, or residualism should these topics require further analyses.

16.11.2 Applicable Populations and Hatchery Programs

Table 45 summarizes the populations to which the size-at-release study applies.

Table 45. Size at Release applies to these populations and hatchery programs.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Tilton	Upper Cowlitz Fall Chinook Salmon	Upper Cowlitz	Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
Coho Salmon	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	
Summer Steelhead	Lower Cowlitz	Lower Cowlitz Summer Steelhead	No recognized population	Lower Cowlitz Summer Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat

16.11.3 Management Objectives

Hatchery management objectives for size at release of hatchery fish are contained in the following links:

- APPENDIX A
- Appendix Table A-4. Hatchery Program Attributes and Metrics: Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon
- Appendix Table A-10. Hatchery Program Attributes and Metrics: Upper Cowlitz Fall Chinook Salmon (Tilton River)
- Appendix Table A-17. Hatchery Program Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-25. Hatchery Program Attributes and Metrics: Lower Cowlitz Winter-Run Steelhead
- Appendix Table A-26. Hatchery Program Attributes and Metrics: Tilton Winter-Run Steelhead
- Appendix Table A-27. Hatchery Program Attributes and Metrics: Upper Cowlitz Subbasin Winter Steelhead (Upper Cowlitz and Cispus)
- Appendix Table A-28. Hatchery Program Attributes and Metrics: Lower Cowlitz Summer-Run Steelhead
- Appendix Table A-38. Hatchery Program Attributes and Metrics: Cowlitz Cutthroat Trout

16.11.4 Data Required

- Pre-release sampling data: size (fork length, weight)

16.11.5 Field Methods

- APPENDIX B, In-Hatchery Monitoring and Record Keeping

16.11.6 Objectives or Hypotheses

- Hypothesis 1: Size at Release = Release Size Target

16.11.7 Analytical Methods

- Comparison of size at release to target size at release
- Trend analysis (regression, graphical analysis) to characterize size at release over time

16.11.8 Assumptions

- Size-at-release estimate is accurate and unbiased.
- CV is reasonably narrow, avoiding large variance in size at release that may reduce expected performance based on size at release.

16.11.9 Anticipated Results

- Estimates of size at release to assess program performance in meeting size at release management targets. This metric provides important information for other assessment of hatchery program performance such as survival and HRR.

16.12 Hatchery Assessment: Date(s) of Release

16.12.1 Report the Date(s) of Release

Release date or dates may affect survival of hatchery-released fish. Documenting the date(s) of release is important for understanding post-release survival results.

16.12.2 Applicable Populations and Hatchery Programs

Table 46 summarizes the populations to which the dates(s)-of-release study applies.

Table 46. Dates(s) of Release applies to these populations and hatchery programs.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Tilton	Upper Cowlitz Fall Chinook Salmon	Upper Cowlitz	Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
Coho Salmon	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	
Summer Steelhead	Lower Cowlitz	Lower Cowlitz Summer Steelhead	No recognized population	Lower Cowlitz Summer Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat

16.12.3 Management Objectives

Hatchery management objectives for smolt (juvenile) release date or dates are contained in the following links:

- APPENDIX A
- Appendix Table A-4. Hatchery Program Attributes and Metrics: Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon
- Appendix Table A-10. Hatchery Program Attributes and Metrics: Upper Cowlitz Fall Chinook Salmon (Tilton River)
- Appendix Table A-17. Hatchery Program Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-25. Hatchery Program Attributes and Metrics: Lower Cowlitz Winter-Run Steelhead
- Appendix Table A-26. Hatchery Program Attributes and Metrics: Tilton Winter-Run Steelhead
- Appendix Table A-27. Hatchery Program Attributes and Metrics: Upper Cowlitz Subbasin Winter Steelhead (Upper Cowlitz and Cispus)
- Appendix Table A-28. Hatchery Program Attributes and Metrics: Lower Cowlitz Summer-Run Steelhead
- Appendix Table A-38. Hatchery Program Attributes and Metrics: Cowlitz Cutthroat Trout

16.12.4 Data Required

- Release date(s) per program

16.12.5 Field Methods

- APPENDIX B, In-Hatchery Monitoring and Record Keeping

16.12.6 Objectives or Hypotheses

- Hypothesis 1: Release Date(s) = Target Release Dates

16.12.7 Analytical Methods

- Comparison of release date(s) to target release dates
- Trend analysis (regression, graphical analysis) of release dates to characterize release dates over time

16.12.8 Assumptions

- Release dates are recorded accurately.

16.12.9 Anticipated Results

Monitor release dates to ensure hatchery programs conform to management target release dates. This metric provides important information for other assessments of hatchery program performance such as survival and HRR.

16.13 Hatchery Assessment: Growth Conversion

16.13.1 Estimate and Evaluate Growth Conversion

Monitor growth conversion to assess hatchery fish culture growth efficiency.

16.13.2 Applicable Populations and Hatchery Programs

Table 47 summarizes the populations to which the growth conversion study applies.

Table 47. Growth Conversion applies to these populations and hatchery programs.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Tilton	Upper Cowlitz Fall Chinook Salmon	Upper Cowlitz	Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
Coho Salmon	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	
Summer Steelhead	Lower Cowlitz	Lower Cowlitz Summer Steelhead	No recognized population	Lower Cowlitz Summer Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat

16.13.3 Management Objectives

There are currently no defined objectives for growth conversion in the hatcheries. Hatchery management objectives are contained in the following links:

- APPENDIX A
- Appendix Table A-4. Hatchery Program Attributes and Metrics: Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon
- Appendix Table A-10. Hatchery Program Attributes and Metrics: Upper Cowlitz Fall Chinook Salmon (Tilton River)
- Appendix Table A-17. Hatchery Program Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-25. Hatchery Program Attributes and Metrics: Lower Cowlitz Winter-Run Steelhead
- Appendix Table A-26. Hatchery Program Attributes and Metrics: Tilton Winter-Run Steelhead
- Appendix Table A-27. Hatchery Program Attributes and Metrics: Upper Cowlitz Subbasin Winter Steelhead (Upper Cowlitz and Cispus)
- Appendix Table A-28. Hatchery Program Attributes and Metrics: Lower Cowlitz Summer-Run Steelhead
- Appendix Table A-38. Hatchery Program Attributes and Metrics: Cowlitz Cutthroat Trout

16.13.4 Data Required

- Growth conversion for each program as reported by hatchery staff

16.13.5 Field Methods

- APPENDIX B, In-Hatchery Monitoring and Record Keeping

16.13.6 Objectives or Hypotheses

- Hypothesis 1: Observed Growth Conversion ≥ Target Growth Conversion

16.13.7 Analytical Methods

- Comparison of growth conversion targets to observed growth conversion
- Trend analysis (regression, graphical analysis) to characterize growth conversion over time

16.13.8 Assumptions

- Growth conversions are accurate and unbiased.

16.13.9 Anticipated Results

Monitor growth conversion to ensure hatchery programs are operating effectively and to identify programs with growth conversions that are not meeting expectations.

16.14 Hatchery Assessment: Broodstock Collected – Numerical

16.14.1 Number of Broodstock Collected for Each Program

The number of broodstock collected for each program/population is evaluated to determine if the target collection number was achieved and to track the origin, sex, and age of the fish collected. The number of

broodstock collected will allow estimation of pre-spawn mortality in the hatchery and will be used in calculation of demographic replacement.

16.14.2 Applicable Populations and Hatchery Programs

Table 48 summarizes the populations to which the number-of-broodstock-collected study applies.

Table 48. Broodstock Collected – Numerical applies to these populations and hatchery programs.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Tilton	Upper Cowlitz Fall Chinook Salmon	Upper Cowlitz	Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
Coho Salmon	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	
Summer Steelhead	Lower Cowlitz	Lower Cowlitz Summer Steelhead	No recognized population	Lower Cowlitz Summer Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat

16.14.3 Management Objectives

Hatchery management objectives for broodstock collection are contained in the following links:

- APPENDIX A
- Appendix Table A-4. Hatchery Program Attributes and Metrics: Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon
- Appendix Table A-10. Hatchery Program Attributes and Metrics: Upper Cowlitz Fall Chinook Salmon (Tilton River)
- Appendix Table A-17. Hatchery Program Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-25. Hatchery Program Attributes and Metrics: Lower Cowlitz Winter-Run Steelhead
- Appendix Table A-26. Hatchery Program Attributes and Metrics: Tilton Winter-Run Steelhead
- Appendix Table A-27. Hatchery Program Attributes and Metrics: Upper Cowlitz Subbasin Winter Steelhead (Upper Cowlitz and Cispus)
- Appendix Table A-28. Hatchery Program Attributes and Metrics: Lower Cowlitz Summer-Run Steelhead
- Appendix Table A-38. Hatchery Program Attributes and Metrics: Cowlitz Cutthroat Trout

16.14.4 Data Required

- Number of fish retained for broodstock at the Barrier Dam fish separator and other locations such as Lower Cowlitz Tributary weirs

16.14.5 Field Methods

- WDFW 2023e
- WDFW 2023f
- APPENDIX B, Barrier Dam Adult Returns

16.14.6 Objectives or Hypotheses

- Hypothesis 1: Broodstock Collected = Target

16.14.7 Analytical Methods

- Evaluation of the number of broodstock collected against the collection target per program
- Trend analysis to characterize the broodstock collection performance of a program over time

16.14.8 Assumptions

- Broodstock collection numbers are accurate.

16.14.9 Anticipated Results

Assessment of meeting broodstock collection targets for each program. Informs hatchery program performance and demographic replacement assessments.

16.15 Hatchery Assessment: Broodstock Spawned – Numerical

16.15.1 Number of Broodstock Spawned for Each Hatchery Program

The number of broodstock spawned for each program/population is evaluated to determine if the target number of fish was spawned and if programmatic egg take needs were met. The number of broodstock spawned will be used with the number of broodstock collected to estimate pre-spawn mortality in the hatchery. The origin (hatchery or natural) of the broodstock spawned will be used to calculate pNOB (and subsequently PNI) for integrated hatchery programs.

16.15.2 Applicable Populations and Hatchery Programs

Table 49 summarizes the populations to which the number-of-broodstock-spawned study applies.

Table 49. Broodstock Spawned – Numerical applies to these populations and hatchery programs.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Tilton	Upper Cowlitz Fall Chinook Salmon	Upper Cowlitz	Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
Coho Salmon	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead

Species	Location	Management Unit	Population	Hatchery Program
Winter Steelhead	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	
Summer Steelhead	Lower Cowlitz	Lower Cowlitz Summer Steelhead	No recognized population	Lower Cowlitz Summer Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat

16.15.3 Management Objectives

Hatchery management objectives for spawning targets are contained in the following links:

- APPENDIX A
- Appendix Table A-4. Hatchery Program Attributes and Metrics: Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon
- Appendix Table A-10. Hatchery Program Attributes and Metrics: Upper Cowlitz Fall Chinook Salmon (Tilton River)
- Appendix Table A-17. Hatchery Program Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-25. Hatchery Program Attributes and Metrics: Lower Cowlitz Winter-Run Steelhead
- Appendix Table A-26. Hatchery Program Attributes and Metrics: Tilton Winter-Run Steelhead
- Appendix Table A-27. Hatchery Program Attributes and Metrics: Upper Cowlitz Subbasin Winter Steelhead (Upper Cowlitz and Cispus)
- Appendix Table A-28. Hatchery Program Attributes and Metrics: Lower Cowlitz Summer-Run Steelhead
- Appendix Table A-38. Hatchery Program Attributes and Metrics: Cowlitz Cutthroat Trout

16.15.4 Data Required

Number of broodstock spawned by program/population by origin, sex, and age.

16.15.5 Field Methods

- APPENDIX B, In-Hatchery Monitoring and Record Keeping

16.15.6 Objectives or Hypotheses

- Hypothesis 1: Broodstock Spawned = Target

16.15.7 Analytical Methods

- Evaluation of the number of broodstock spawned against the spawn targets per program
- Trend analysis (regression, graphical analysis) to characterize the broodstock spawning numbers of a program over time

16.15.8 Assumptions

- Broodstock spawning numbers and origin data are accurate.

16.15.9 Anticipated Results

Assessment of meeting spawning targets for each program. Informs hatchery performance and demographic replacement assessments and pNOB and PNI calculations.

16.16 Hatchery Assessment: Release Location

16.16.1 Report Release Location(s)

Document fish release locations for each hatchery program. Release locations may affect post-release survival and homing. Release location may also affect risk analysis of hatchery program on natural populations.

16.16.2 Applicable Populations and Hatchery Programs

Table 50 summarizes the populations to which the Release Location study applies.

Table 50. Release Location applies to these populations and hatchery programs.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Tilton	Upper Cowlitz Fall Chinook Salmon	Upper Cowlitz	Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
Coho Salmon	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	
Summer Steelhead	Lower Cowlitz	Lower Cowlitz Summer Steelhead	No recognized population	Lower Cowlitz Summer Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat

16.16.3 Management Objectives

Hatchery management objectives for smolt (juvenile) release locations are contained in the following links:

- APPENDIX A
- Appendix Table A-4. Hatchery Program Attributes and Metrics: Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon
- Appendix Table A-10. Hatchery Program Attributes and Metrics: Upper Cowlitz Fall Chinook Salmon (Tilton River)
- Appendix Table A-17. Hatchery Program Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon

- Appendix Table A-25. Hatchery Program Attributes and Metrics: Lower Cowlitz Winter-Run Steelhead
- Appendix Table A-26. Hatchery Program Attributes and Metrics: Tilton Winter-Run Steelhead
- Appendix Table A-27. Hatchery Program Attributes and Metrics: Upper Cowlitz Subbasin Winter Steelhead (Upper Cowlitz and Cispus)
- Appendix Table A-28. Hatchery Program Attributes and Metrics: Lower Cowlitz Summer-Run Steelhead
- Appendix Table A-38. Hatchery Program Attributes and Metrics: Cowlitz Cutthroat Trout

16.16.4 Data Required

- Release location(s) per program.

16.16.5 Field Methods

- APPENDIX B, In-Hatchery Monitoring and Record Keeping

16.16.6 Objectives or Hypotheses

- Hypothesis 1: Release Location(s) = Target Release Locations

16.16.7 Analytical Methods

- Compare release location(s) to target release locations

16.16.8 Assumptions

- Assumes release locations are reported accurately.

16.16.9 Anticipated Results

- Monitor release location(s) to ensure hatchery programs conform to management target release locations. Release locations may inform hatchery performance assessments such as survival and risk assessment to natural populations.

17 Facility Assessment Metrics, Hypotheses, Analytical Approaches

17.1 Facility Assessment: Fish Collection Efficiency and Fish Guidance Efficiency

17.1.1 Estimate Fish Collection Efficiency at Each Facility

FCE is a critical component for estimating FPS. Continual efforts to monitor, study, and improve FGE at Mayfield and FCE at Cowlitz Falls dams are underway. FCE is estimated by releasing groups of marked fish upstream of the downstream collection facilities and evaluating how many are recaptured in the downstream collectors. Various environmental covariates are also assessed. Directed telemetry studies are used to evaluate fish behavior and test hypotheses concerning collector configurations, dam operation, and life history strategies related to the various species. FPS (see Section 17.2 Facility Assessment: Juvenile Fish Passage Survival) is derived using estimates of smolts arriving at the head of Lake Scanewa and healthy migrants that subsequently exit into the Cowlitz River downstream of Barrier Dam. FCE is also used to estimate smolt abundance at the head of Lake Scanewa, adjusted for natural mortality with transportation mortality deducted.

17.1.2 Applicable Populations and Programs

All hatchery juveniles are released downstream of Mayfield Dam, so only natural-origin juveniles are encountered at Mayfield Dam and Cowlitz Fall Dam (Table 51).

Table 51. Fish Collection Efficiency applies to these populations.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program
	Cispus			
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
	Tilton	Habitat Not Currently Utilized	Tilton	No Program
Coho Salmon	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	
Coastal Cutthroat	Tilton	Cowlitz Basin Coastal Cutthroat Trout	Tilton	No Program
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	

17.1.3 Management Objectives

Management objectives for FCE are to achieve the juvenile FPS objectives and are contained in the following links:

- APPENDIX A
- Appendix Table A-5. Facility Assessment Attributes and Metrics: Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon
- Appendix Table A-11. Facility Assessment Attributes and Metrics: Tilton River Fall Chinook Salmon[1]
- Appendix Table A-18. Facility Assessment Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-29. Facility Assessment Attributes and Metrics: Tilton Winter-Run Steelhead and Upper Cowlitz Subbasin Winter-Run Steelhead (including Cispus)
- Appendix Table A-39. Facility Assessment Attributes and Metrics: Cowlitz Cutthroat Trout

17.1.4 Data Required

- The juvenile fish collection efficiency data for Cowlitz Falls are described in the annual Cowlitz Falls North Shore Collector Downstream Fish Passage Evaluation Reports (e.g., Four Peaks 2024). Monthly Mayfield fish counts are included as an attachment in these reports (no FCE estimates).

17.1.5 Field Methods

- The juvenile fish collection efficiency field methods for Cowlitz Falls are described in the annual Cowlitz Falls North Shore Collector Downstream Fish Passage Evaluation Reports (e.g., Four Peaks 2024). Mayfield fish collection assessment methods are not included in these reports.

17.1.6 Objectives or Hypotheses

- Hypothesis 1: FCE ≥ Target
  - Where Target is the FCE necessary to meet FPS requirements (Tacoma Power et al. 2000; Article 1)
- Hypothesis 2: FGE ≥ Target
  - Where Target is the FGE necessary to meet FPS requirements (Tacoma Power et al. 2000; Article 2)

17.1.7 Analytical Methods

- The juvenile fish collection efficiency analytical methods for Cowlitz Falls are described in the annual Cowlitz Falls North Shore Collector Downstream Fish Passage Evaluation Reports (e.g., Four Peaks 2024). Mayfield fish collection analytical methods are not included in these reports.

17.1.8 Assumptions

- The juvenile fish collection efficiency assumptions for Cowlitz Falls are described in the annual Cowlitz Falls North Shore Collector Downstream Fish Passage Evaluation Reports (e.g., Four Peaks 2024). Mayfield fish collection assumptions are not included in these reports.

17.1.9 Anticipated Results

- Estimates of Fish Collection Efficiency by species (see Tacoma Power et al. 2000).

17.2 Facility Assessment: Juvenile Fish Passage Survival

17.2.1 Estimate Smolt Passage Survival at Each Facility

Juvenile FPS is a key limiting factor for abundance of populations located upstream of hydroelectric projects. At Mayfield Dam and Cowlitz Falls Dam, emigrating juveniles are trapped at the Cowlitz Falls Fish Facility (Upper Cowlitz and Cispus rivers production) and the Juvenile Collection Facility at Mayfield Dam (Tilton River production). However, fish guidance and capture efficiency are not 100% at the downstream collection facilities. FPS at Cowlitz Falls is an estimate "of the percentage of smolts entering the upstream end of Scanewa reservoir, and adjusted for natural mortality, that are collected at Cowlitz Falls Dam and Riffe Lake and Mossyrock Dam, that are transported downstream to the stress relief ponds, and subsequently leave the stress relief ponds at Barrier Dam as healthy migrants" (Tacoma Power et al. 2000). FPS has a performance obligation of 95%, with a minimum of 75%, after the best available technology has been employed (Tacoma Power et al. 2000).

FPS at Mayfield must achieve "a 95% downstream fish passage survival or the National Marine Fisheries Service and U. S. Fish and Wildlife Service, in consultation with the FTC or agencies, determine that passage effectiveness and survival are high enough to support self-sustaining populations of anadromous stocks; that protection of anadromous fish migrating downstream at Mayfield Dam has been maximized by all reasonable and prudent measures," (Tacoma Power et al. 2000).

17.2.2 Applicable Populations and Hatchery Programs

All hatchery juveniles are released from the hatcheries downstream of Mayfield Dam, so only natural-origin juveniles are encountered at Mayfield Dam and Cowlitz Fall Dam (Table 52).

Table 52. Juvenile Fish Passage Survival applies to these populations.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program
	Cispus			
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
	Tilton	Habitat Not Currently Utilized	Tilton	No Program
Coho Salmon	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	
Coastal Cutthroat	Tilton	Cowlitz Basin Coastal Cutthroat Trout	Tilton	No Program
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	

17.2.3 Management Objectives

Management objectives for FPS are contained in the following links:

- APPENDIX A
- Appendix Table A-5. Facility Assessment Attributes and Metrics: Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon
- Appendix Table A-11. Facility Assessment Attributes and Metrics: Tilton River Fall Chinook Salmon[1]
- Appendix Table A-18. Facility Assessment Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-29. Facility Assessment Attributes and Metrics: Tilton Winter-Run Steelhead and Upper Cowlitz Subbasin Winter-Run Steelhead (including Cispus)
- Appendix Table A-39. Facility Assessment Attributes and Metrics: Cowlitz Cutthroat Trout

17.2.4 Data Required

- The juvenile FPS data Cowlitz Falls are described in the annual Cowlitz Falls North Shore Collector Downstream Fish Passage Evaluation Reports (e.g., Four Peaks 2024). Monthly Mayfield fish counts are included as an attachment in these reports (no survival estimates).

17.2.5 Field Methods

- The juvenile FPS field methods Cowlitz Falls are described in the annual Cowlitz Falls North Shore Collector Downstream Fish Passage Evaluation Reports (e.g., Four Peaks 2024). Mayfield FPS assessment methods are not included in these reports.

17.2.6 Objectives or Hypotheses

- Hypothesis 1: FPS ≥ Target-Cowlitz Falls (Tacoma Power et al. 2000; Article 1)
- Hypothesis 2: FPS ≥ Target-Mayfield (Tacoma Power et al. 2000; Article 2)

17.2.7 Analytical Methods

- The juvenile FPS analytical methods Cowlitz Falls are described in the annual Cowlitz Falls North Shore Collector Downstream Fish Passage Evaluation Reports (e.g., Four Peaks 2024). Mayfield FPS analytical methods are not included in these reports.

17.2.8 Assumptions

- The juvenile FPS assumptions for Cowlitz Falls are described in the annual Cowlitz Falls North Shore Collector Downstream Fish Passage Evaluation Reports (e.g., Four Peaks 2024). Mayfield FPS assumptions are not included in these reports.

17.2.9 Anticipated Results

- Estimates of Fish Passage Survival by species at each facility (see Tacoma Power et al. 2000).

17.3 Facility Assessment: Adult Fallback

17.3.1 Estimate Adult Fallback at Each Facility

Adult salmon and steelhead transported upstream of Mayfield Dam or Cowlitz Falls Dam and released may "fallback" downstream through the dams. This is undesirable because it reduces the number of adult fish effectively transported upstream to contribute to spawning or fisheries opportunity. Estimation of fallback provides a corrected number of fish upstream of Mayfield or Cowlitz Falls dams that can contribute to natural spawning or to fisheries opportunity and provides managers information to evaluate factors that contribute to fallback.

17.3.2 Applicable Populations and Hatchery Programs

Both natural-origin and hatchery-origin adults are transported upstream to the Tilton River and Upper Cowlitz and Cispus rivers (Table 53).

Table 53. Adult Fallback applies to these populations and hatchery programs.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program
	Cispus			
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
Coho Salmon	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	
Coastal Cutthroat	Tilton	Cowlitz Basin Coastal Cutthroat Trout	Tilton	Cutthroat
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	

17.3.3 Management Objectives

Management objectives for adult fallback are contained in the following links:

- APPENDIX A
- Appendix Table A-5. Facility Assessment Attributes and Metrics: Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon
- Appendix Table A-11. Facility Assessment Attributes and Metrics: Tilton River Fall Chinook Salmon[1]
- Appendix Table A-18. Facility Assessment Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon

- Appendix Table A-29. Facility Assessment Attributes and Metrics: Tilton Winter-Run Steelhead and Upper Cowlitz Subbasin Winter-Run Steelhead (including Cispus)
- Appendix Table A-39. Facility Assessment Attributes and Metrics: Cowlitz Cutthroat Trout

17.3.4 Data Required

The adult fallback objective is addressed in the annual Cowlitz Falls North Shore Collector Downstream Fish Passage Evaluation Reports (e.g., Four Peaks 2024). Annual counts of adult fallback are provided for Cowlitz Falls.

17.3.5 Field Methods

- Adult salmon, steelhead, and Cutthroat Trout that were released upstream of Mayfield Dam or Cowlitz Falls Dam and are collected in the downstream fish collectors at these locations are documented as fallbacks.

17.3.6 Objectives or Hypotheses

- Objective 1: Use an assumed rate of fallback (e.g., 12%).
- Objective 2: Develop an estimate of fallback.

17.3.7 Analytical Methods

- The fallback rate is currently assumed to be 12% at Mayfield Dam and 12% at Cowlitz Falls Dam (Tacoma Power 2020).

17.3.8 Assumptions

- The current assumption is that adult fallback is 12% at Mayfield Dam and 12% at Cowlitz Falls Dam (Tacoma Power 2020).

17.3.9 Anticipated Results

- Decision on continued use of the assumed 12% fallback rate for each dam or need to develop methods to estimate the fallback rate.

18 Fishery/Harvest Metrics, Hypotheses, Analytical Approaches

18.1 Fishery/Harvest Assessment: Harvest – Numerical

Estimate Number of Fish Harvested for Each Population and Hatchery Program

Harvest and fisheries opportunity for Cowlitz River salmonids include fisheries in the ocean, Columbia River, and within the Cowlitz Basin. Fisheries include commercial, tribal, and recreational fisheries. Commercial fisheries (including tribal) generally rely on the reporting of landings and catch sampling to collect biological data and CWTs. Recreational fisheries generally rely on catch reporting via catch record cards and creel surveys to collect biological data and recover CWTs. Both commercial and recreational fisheries can impact non-target species or origin type (i.e., natural origin) through indirect mortality (e.g., non-retention "catch & release" fisheries or mark-selective fisheries where only hatchery-origin fish can be retained). Indirect mortalities are generally incorporated into estimates of harvest using estimated mortality rates established by fishery managers or calculated from spot creels. Harvest may be reported as an estimate of the number of fish harvested or as a percentage of the run. Both metrics are important because a relatively low number of fish harvested may be a relatively high percentage of a small population.

18.1.1 Applicable Populations and Hatchery Programs

Table 54 summarizes the populations to which the Harvest – Numerical study applies.

Table 54. Harvest – Numerical applies to these populations and hatchery programs.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Lower Cowlitz	Lower Cowlitz Fall Chinook Salmon	Lower Cowlitz	No Program
	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program
	Cispus			No Program
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
	Tilton	Habitat Not Currently Utilized	Tilton	No Program
Coho Salmon	Lower Cowlitz	Lower Cowlitz Coho Salmon	Lower Cowlitz	No Program
	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	
Summer Steelhead	Lower Cowlitz	Lower Cowlitz Summer Steelhead	No recognized population	Lower Cowlitz Summer Steelhead

Species	Location	Management Unit	Population	Hatchery Program
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat
	Tilton		Tilton	No Program
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Chum Salmon	Lower Cowlitz	Cowlitz Basin Chum Salmon	Lower Cowlitz	No Program

18.1.2 Management Objectives

Commercial, tribal, and recreational fisheries management objectives are developed outside of the Plan process and are updated annually by fisheries managers. Fisheries harvest levels are managed annually based in part on projected abundance of stocks. See current recreational, tribal, and commercial harvest rules. Hatchery management objectives are contained in the links, below:

- APPENDIX A
- Appendix Table A-6. Fishery/Harvest Attributes and Metrics: Lower Cowlitz Basin and Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon
- Appendix Table A-12. Fishery/Harvest Attributes and Metrics: Lower Cowlitz Fall Chinook Salmon
- Appendix Table A-13. Fishery/Harvest Attributes and Metrics: Upper Cowlitz Fall Chinook Salmon (Tilton River)
- Appendix Table A-19. Fishery/Harvest Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-30. Fishery/Harvest Attributes and Metrics: Lower Cowlitz Winter Steelhead
- Appendix Table A-31. Fishery/Harvest Attributes and Metrics: Tilton Winter Steelhead
- Appendix Table A-32. Fishery/Harvest Attributes and Metrics: Upper Cowlitz Subbasin Winter Steelhead (Upper Cowlitz and Cispus)
- Appendix Table A-35. Fishery/Harvest Attributes and Metrics: Cowlitz Chum Salmon
- Appendix Table A-40. Fishery/Harvest Attributes and Metrics: Cowlitz Cutthroat Trout

18.1.3 Data Required

- CWT data (RMIS)
- Creel survey (WDFW-Tacoma Power Funded)
- Angler catch record cards (WDFW)
- Landings reports (Pacific States Marine Fisheries Commission)

18.1.4 Field Methods

- WDFW 2023d
- APPENDIX B, Harvest
- APPENDIX B, Spot Creel Surveys
- APPENDIX B, Catch of Natural-Origin Fish in the Cowlitz River Fishery – Catch Card Methodology
- APPENDIX B, Ocean Fisheries
- APPENDIX B, Mainstem Columbia River
- APPENDIX B, Commercial Fisheries

18.1.5 Objectives or Hypotheses

- Objective 1: Report estimated harvest numbers for each natural population and hatchery program. Includes fisheries:
  - Within the Cowlitz Basin
  - Outside of the Cowlitz Basin

18.1.6 Analytical Methods

- WDFW 2023d
- APPENDIX B, Harvest
- APPENDIX B, Spot Creel Surveys
- APPENDIX B, Catch of Natural-Origin Fish in the Cowlitz River Fishery – Catch Card Methodology
- APPENDIX B, Ocean Fisheries
- APPENDIX B, Mainstem Columbia River
- APPENDIX B, Commercial Fisheries
  - Trend analysis (regression, graphical analysis) to characterize harvest numbers over time

18.1.7 Assumptions

- Harvest data are accurate and unbiased.

18.1.8 Anticipated Results

Monitor harvest results to track harvest compared to management targets and identify populations or hatchery programs that can sustain harvest and those that are overharvested.

18.2 Fishery/Harvest Assessment: Harvest – Percentage

18.2.1 Estimate Percentage of the Run Harvested for Each Population and Hatchery Program

See Section 18.1 Fishery/Harvest Assessment: Harvest – Numerical. Harvest may be reported as an estimate of the number of fish harvested, or as a percentage of the run. Both metrics are important because a relatively low number of fish harvested may be a relatively high percentage of a small population.

18.2.2 Applicable Populations and Hatchery Programs

Table 55 summarizes the populations to which the Harvest – Percentage study applies.

Table 55. Harvest – Percentage applies to these populations and hatchery programs.

Species	Location	Management Unit	Population	Hatchery Program
Fall Chinook Salmon	Lower Cowlitz	Lower Cowlitz Fall Chinook Salmon	Lower Cowlitz	No Program
	Upper Cowlitz	Habitat Not Currently Utilized	Upper Cowlitz	No Program
	Cispus			No Program
	Tilton	Upper Cowlitz Fall Chinook Salmon		Upper Cowlitz Fall Chinook

Species	Location	Management Unit	Population	Hatchery Program
Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook Salmon	Upper Cowlitz	Upper Cowlitz Spring Chinook
	Cispus		Cispus	
	Tilton	Habitat Not Currently Utilized	Tilton	No Program
Coho Salmon	Lower Cowlitz	Lower Cowlitz Coho Salmon	Lower Cowlitz	No Program
	Tilton	Upper Cowlitz Basin Coho Salmon	Tilton	Upper Cowlitz Coho Salmon
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead	Lower Cowlitz	Lower Cowlitz Winter Steelhead
	Tilton	Tilton River Winter Steelhead	Tilton	Tilton River Winter Steelhead
	Upper Cowlitz	Upper Cowlitz Subbasin Winter Steelhead	Upper Cowlitz	Upper Cowlitz Winter Steelhead
	Cispus		Cispus	
Summer Steelhead	Lower Cowlitz	Lower Cowlitz Summer Steelhead	No recognized population	Lower Cowlitz Summer Steelhead
Coastal Cutthroat	Lower Cowlitz	Cowlitz Basin Coastal Cutthroat Trout	Lower Cowlitz	Cutthroat
	Tilton		Tilton	No Program
	Upper Cowlitz		Upper Cowlitz	
	Cispus		Cispus	
Chum Salmon	Lower Cowlitz	Cowlitz Basin Chum Salmon	Lower Cowlitz	No Program

18.2.3 Management Objectives

Commercial, tribal, and recreational harvest and fisheries management objectives are developed outside of the Plan process and are reviewed and updated annually by fisheries managers. Fisheries harvest levels are managed annually based in part on projected abundance of stocks. See current recreational, tribal, and commercial harvest rules. Hatchery management objectives are contained in the following links:

- APPENDIX A
- Appendix Table A-6. Fishery/Harvest Attributes and Metrics: Lower Cowlitz Basin and Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon
- Appendix Table A-12. Fishery/Harvest Attributes and Metrics: Lower Cowlitz Fall Chinook Salmon
- Appendix Table A-13. Fishery/Harvest Attributes and Metrics: Upper Cowlitz Fall Chinook Salmon (Tilton River)
- Appendix Table A-19. Fishery/Harvest Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon
- Appendix Table A-30. Fishery/Harvest Attributes and Metrics: Lower Cowlitz Winter Steelhead
- Appendix Table A-31. Fishery/Harvest Attributes and Metrics: Tilton Winter Steelhead
- Appendix Table A-32. Fishery/Harvest Attributes and Metrics: Upper Cowlitz Subbasin Winter Steelhead (Upper Cowlitz and Cispus)
- Appendix Table A-35. Fishery/Harvest Attributes and Metrics: Cowlitz Chum Salmon
- Appendix Table A-40. Fishery/Harvest Attributes and Metrics: Cowlitz Cutthroat Trout

18.2.4 Data Required

- CWT data (RMIS)
- Creel census (WDFW)
- Angler catch cards (WDFW)
- Landings reports (Pacific States Marine Fisheries Commission)

18.2.5 Field Methods

- WDFW 2023d
- APPENDIX B, Harvest
- APPENDIX B, Spot Creel Surveys
- APPENDIX B, Catch of Natural-Origin Fish in the Cowlitz River Fishery – Catch Card Methodology
- APPENDIX B, Ocean Fisheries
- APPENDIX B, Mainstem Columbia River
- APPENDIX B, Commercial Fisheries

18.2.6 Objectives or Hypotheses

- Objective 1: Report estimated harvest percentages for each population
  - Within the Cowlitz Basin
  - Outside of the Cowlitz Basin

18.2.7 Analytical Methods

- WDFW 2023d
- APPENDIX B, Harvest
- APPENDIX B, Spot Creel Surveys
- APPENDIX B, Catch of Natural-Origin Fish in the Cowlitz River Fishery – Catch Card Methodology
- APPENDIX B, Ocean Fisheries
- APPENDIX B, Mainstem Columbia River
- APPENDIX B, Commercial Fisheries
- Trend analysis (regression, graphical analysis) to characterize harvest percentage over time

18.2.8 Assumptions

- Harvest data are accurate and unbiased.

18.2.9 Anticipated Results

Monitor harvest results to track harvest compared to management targets and identify populations or hatchery programs that can sustain harvest and those that are overharvested.

19 References

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APPENDIX A Management and Recovery Objectives

Appendix Table A-1. Population Status: Upper Cowlitz Basin and Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon: Lower Columbia River Coho Salmon Evolutionarily Significant Unit

Metric	ESU/DPS	Population	Status	Reference	Notes
Listing Status	Lower Columbia River Coho Salmon ESU	Lower Cowlitz	Threatened	NMFS 2005 NMFS 2022	Classified as Threatened in 2005
		Upper Cowlitz			
		Cispus			
		Tilton			
Population Type	NA	Lower Cowlitz	Primary	NMFS 2013	No Note
	NA	Upper Cowlitz	Primary		
	NA	Cispus	Primary		
	NA	Tilton	Stabilizing		
Recovery Phase	NA	Lower Cowlitz	Local Adaptation	HSRG 2014 Tacoma Power 2020 Tacoma Power 2021a	No Note
	NA	Upper Cowlitz	Recolonization		
	NA	Cispus			
	NA	Tilton			

Appendix Table A-2. Population Abundance Categories and Ranges for NOR and HOR: Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon

Metric	Level	Value	Reference	Notes
Abundance Category and Range NOR	Low	<1,000	Tacoma Power 2021a	Range of NORs that triggers management targets and actions
	Normal	1,000 to 5,000		
Abundance Category and Range HOR	Low	<2,000		Range of HORs that triggers management targets and actions
	Normal	2,000 to 8,000		

Notes:
HOR: hatchery origin return; NOR: natural origin return

Appendix Table A-3. Population Attributes and Metrics: Coho Salmon

Metric	Life Stage	Level	Cowlitz Basin	Lower Cowlitz	Tilton	Upper Cowlitz	Cispus	Tilton-Upper Cowlitz-Cispus	Upper Cowlitz-Cispus	References	Notes
Abundance of Spawners	Adult	NOS	--	3,700	--	2,000	2,000	--	--	NMFS 2013	ESA recovery targets
Smolt Population Estimate	Smolt	Natural Origin	--	--	--	--	--	--	--	--	Population Estimate from Mayfield and Cowlitz Falls
Adult-to-Adult Replacement	Spawner and Adult	NOR	--	≥1	≥1	≥1	≥1	--	--	Tacoma Power 2020	Test if population is stable or growing
Adult-to-Adult Replacement	Spawner and Adult	HOR	--	>>1	>>1	>>1	>>1	--	--	Tacoma Power 2020	Target hatchery replacement rate should be ≥ 1 and is typically greater than the natural replacement rate.
Smolts per Spawner Recruitment	Smolt and Adult	Natural Origin	--	--	--	--	--	--	--	--	Freshwater productivity rate
Spatial Distribution of Spawning	Adult	HOS	--	--	--	--	--	--	--	--	Compare to NOS spawning spatial distribution
Spatial Distribution of Spawning	Adult	NOS	--	--	--	--	--	--	--	--	Compare to historic spatial spawning data and mapped spawning habitat
Population Genetics Sampling	Smolt and Adult	Natural Origin	--	--	--	--	--	--	--	--	Document collection of genetic samples on an annual basis according to sampling plan
Population Genetics Sampling	Smolt and Adult	Hatchery Origin	--	--	--	--	--	--	--	--	Document collection of genetic samples on an annual basis according to sampling plan
Population Genetics Analyses	Smolt and Adult	Hatchery Origin	--	--	--	--	--	--	--	--	Document number of genetic samples to be analyzed in preparation for genetic analyses

Metric	Life Stage	Level	Cowlitz Basin	Lower Cowlitz	Tilton	Upper Cowlitz	Cispus	Tilton-Upper Cowlitz-Cispus	Upper Cowlitz-Cispus	References	Notes
Population Genetics Analyses	Smolt and Adult	Natural Origin	--	--	--	--	--	--	--	--	Document number of genetic samples to be analyzed in preparation for genetic analyses
Age at Return	Adult	NOR	--	--	--	--	--	--	--	--	Compare to historic age data
Age at Return	Adult	HOR	--	--	--	--	--	--	--	--	Compare to NOR ages
Adult Return Timing	Adult	NOR	--	--	--	--	--	--	--	--	Compare to historic run timing data
Adult Return Timing	Adult	HOR	--	--	--	--	--	--	--	--	Compare to NOR run timing
Adult Spawn Timing	Adult	HOS	--	--	--	--	--	--	--	--	Compare to NOR spawn timing
Adult Spawn Timing	Adult	NOS	--	--	--	--	--	--	--	--	Compare to historic spawn timing data
Juvenile Migration Timing	Juvenile	Natural Origin	--	--	--	--	--	--	--	--	Compare to historic emigration timing data
Age at Smolt Migration	Smolt	NOR	--	--	--	--	--	--	--	--	Compare to historic age data
Mean Age of Adult Returns	Adult	NOR	--	--	--	--	--	--	--	--	Compare to historic mean age data
Mean Age of Adult Returns	Adult	HOR	--	--	--	--	--	--	--	--	Compare to NOR mean ages
Abundance of Adults Returns to Target Populations	Adult	HOR; NOR	--	--	--	--	--	--	--	--	No Note
Abundance at Mouth of Cowlitz River	Adult	HOR	12,751	--	--	--	--	--	--	Tacoma Power 2020	From Big Table: Back-calculated from data collected at upstream locations
Abundance at Mouth of Cowlitz River	Adult	NOR	14,868	--	--	--	--	--	--	Tacoma Power 2020	From Big Table: Back-calculated from data collected at upstream locations

Metric	Life Stage	Level	Cowlitz Basin	Lower Cowlitz	Tilton	Upper Cowlitz	Cispus	Tilton-Upper Cowlitz-Cispus	Upper Cowlitz-Cispus	References	Notes
Smolt-to-Adult Return (Survival)	Adult	Natural Origin	--	--	--	--	--	--	--	--	Natural population productivity from smolt to adult return
Pre-Spawn Mortality	Adult	HOR	--	--	10%	10%	10%	--	--	Tacoma Power 2020	Assumed pre-spawn mortality rate. Test if population differs from assumed rate.
Pre-Spawn Mortality	Adult	NOR	--	--	10%	10%	10%	--	--	Tacoma Power 2020	Assumed pre-spawn mortality rate. Test if population differs from assumed rate.
Stray Rate Within Basin	Adult	HOR	--	NA	<5%	<5%	<5%	--	--	Tacoma Power 2020	Maximum allowable stray rate of hatchery fish within basin
Stray Rate Outside of Basin	Adult	HOR	--	NA	<5%	<5%	<5%	--	--	Tacoma Power 2020	Maximum allowable stray rate of hatchery fish outside of basin
Stray Rate into Basin	Adult	HOR	--	<5%	<5%	<5%	<5%	--	--	Tacoma Power 2020	Document the stray rate of fish into the basin

Notes:
NA indicates the metric is not applicable.
-- indicates the metric has not been established.
HOS: hatchery origin spawner

Appendix Table A-4. Hatchery Program Attributes and Metrics: Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon

Metric	Origin	Life Stage	Level	Values	References	Notes
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Mortality	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Age	Age	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Assessments	Type(s)	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Marking QA/QC Results	Result	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Tagging QA/QC Results	Result	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Results	Result	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Treatments	Description	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Sex	Male or Female	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Origin	Hatchery or Natural	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Number Marked	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Number Tagged	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Tag Type	Tag Type	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Mark Type	Mark Type	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Juvenile Size at Release	FPP	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Juvenile Size at Sampling Time	FPP	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Length	mm	--	No Note
Proportion of Hatchery Origin Spawners	Natural and Hatchery	Adult	pHOS maximum	<0.30	Tacoma Power 2021a	Proportion of Hatchery Origin Spawners

Metric	Origin	Life Stage	Level	Values	References	Notes
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Low NOR; Low HOR	0.10 to 0.50	Tacoma Power 2021a	Proportion of Natural Origin Broodstock
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Normal NOR; Low HOR	0.5	Tacoma Power 2021a	Proportion of Natural Origin Broodstock
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Low NOR; Normal HOR	0.5	Tacoma Power 2021a	Proportion of Natural Origin Broodstock
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Normal NOR; Normal HOR	0.5	Tacoma Power 2021a	Proportion of Natural Origin Broodstock
Proportionate Natural Influence	Natural and Hatchery	Adult	PNI minimum	≥0.67	Tacoma Power 2020	Proportionate Natural Influence. 0.67 is the typical HSRG PNI target for integrated programs
Number Hatchery Smolts Released	Hatchery	Smolt	Smolts	2,200,000	Tacoma Power 2021a	No Note
Precocious Maturation Rate	Hatchery	Juvenile	Hatchery juvenile males	--	--	Determined through GSI via dissection, visual maturation identified via dissection, or external smolt index assessment
Survival by Life Stage	Hatchery	All Life Stages	Parr to Smolt	95%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculated required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Survival by Life Stage	Hatchery	All Life Stages	Fecundity	3,000	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculated required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Survival by Life Stage	Hatchery	All Life Stages	Green Egg to Release	81%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculated required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Survival by Life Stage	Hatchery	All Life Stages	Green Egg to Eyed Egg	95%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculated required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.

Metric	Origin	Life Stage	Level	Values	References	Notes
Survival by Life Stage	Hatchery	All Life Stages	Broodstock Collection to Spawn	≥95%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculated required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Survival by Life Stage	Hatchery	All Life Stages	Fry to Parr	95%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculated required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Survival by Life Stage	Hatchery	All Life Stages	Eyed Egg to Fry	95%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculated required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Population Genetics Sampling	Hatchery	Broodstock and Juvenile	To be determined	--	--	See Section 15.6 VSP & Population: Population Genetics Sampling for more information.
Population Genetics Analyses	Hatchery	Broodstock and Juvenile	To be determined	--	--	See Section 15.6 VSP & Population: Population Genetics Sampling for more information.
Demographic Replacement	Natural and Hatchery	Adult	NOR, HOR	Calculated Annually	Tacoma Power 2021a	Test if the demographic replacement target was met on an annual basis. See Broodstock Mining Rate in the Hatchery Metrics table.
Size at Release	Hatchery	Smolt	Fish per Pound (fpp)	15 to 16	Tacoma Power 2021a	No Note
Date(s) of Release	Hatchery	Smolt	Begin	April	Tacoma Power 2021a	Approximate begin and end months of juvenile releases
Date(s) of Release	Hatchery	Smolt	End	May	Tacoma Power 2021a	Approximate begin and end months of juvenile releases
Growth Conversion	Hatchery	Juvenile	Hatchery juveniles	--	--	Target growth conversion
Broodstock Collected – Numerical	Natural and Hatchery	Adult	Total	~950	Tacoma Power 2021a	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Female	Not Specified	Tacoma Power 2021a	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Male	Not Specified	Tacoma Power 2021a	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates

Metric	Origin	Life Stage	Level	Values	References	Notes
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Jack	Not Specified	Tacoma Power 2021a	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Female	Not Specified	Tacoma Power 2021a	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Male	Not Specified	Tacoma Power 2021a	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Jack	Not Specified	Tacoma Power 2021a	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	Total	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Female	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Male	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Female	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Male	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Jack	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Jack	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Release Location	Hatchery	Smolt	Location	Cowlitz Salmon Hatchery	Tacoma Power 2021a	No Note

Notes:
-- indicates the metric has not been established.
FHMP: Fish Hatchery Management Plan
HSRG: Hatchery Scientific Review Group

Appendix Table A-5. Facility Assessment Attributes and Metrics: Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon

Metric	Management Unit	Origin	Life Stage	Level	Value	References	Notes
Fish Guidance Efficiency (FGE)	Upper Cowlitz Basin Coho Salmon	Natural	Smolt (primarily)	Mayfield Fish Collector	FGE	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	Juvenile FGE is used to estimate FPS. FGE must be high enough to achieve the FPS target.
Fish Collection Efficiency (FCE)	Upper Cowlitz Basin Coho Salmon	Natural	Smolt (primarily)	Cowlitz Falls Fish Collector	FCE	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	Juvenile FGE is used to estimate FPS. FGE must be high enough to achieve the FPS target.
Fish Passage Survival	Upper Cowlitz Basin Coho Salmon	Natural	Smolt (primarily)	Cowlitz Falls Fish Collector	75%/95%	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	95% or at least 75% after best available technology has been employed.
Fish Passage Survival	Upper Cowlitz Basin Coho Salmon	Natural	Smolt (primarily)	Mayfield Fish Collector	95%	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	95% or high enough to support self-sustaining anadromous stocks.
Adult Fallback	Upper Cowlitz Basin Coho Salmon	Natural and Hatchery	Adult	Cowlitz Falls Hydroelectric Project	12%	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	Assumed fallback rate (assumed in lieu of annual estimates)
Adult Fallback	Upper Cowlitz Basin Coho Salmon	Natural and Hatchery	Adult	Mayfield Hydroelectric Project	12%	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	Assumed fallback rate (assumed in lieu of annual estimates)

Appendix Table A-6. Fishery/Harvest Attributes and Metrics: Lower Cowlitz Basin and Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Coho Salmon

Metric	Management Unit	Fishery Location 1	Fishery Location 2	Fishery Type	Hatchery	Natural	References[1]
Harvest – Numerical	Upper Cowlitz Basin Coho Salmon	Ocean	NA	Commercial	--	--	--
Harvest – Numerical	Upper Cowlitz Basin Coho Salmon	Ocean	NA	Tribal	--	--	--
Harvest – Numerical	Upper Cowlitz Basin Coho Salmon	Ocean	NA	Sport	--	--	--
Harvest – Numerical	Upper Cowlitz Basin Coho Salmon	Ocean	NA	Total	--	--	--
Harvest – Numerical	Upper Cowlitz Basin Coho Salmon	Columbia River	NA	Commercial	--	--	--
Harvest – Numerical	Upper Cowlitz Basin Coho Salmon	Columbia River	NA	Tribal	--	--	--
Harvest – Numerical	Upper Cowlitz Basin Coho Salmon	Columbia River	NA	Sport	--	--	--
Harvest – Numerical	Upper Cowlitz Basin Coho Salmon	Columbia River	NA	Total	--	--	--
Harvest – Numerical	Upper Cowlitz Basin Coho Salmon	Cowlitz Basin	Lower Cowlitz River	Commercial	No Fishery	No Fishery	--
Harvest – Numerical	Upper Cowlitz Basin Coho Salmon	Cowlitz Basin	Lower Cowlitz River	Tribal	--	--	--
Harvest – Numerical	Upper Cowlitz Basin Coho Salmon	Cowlitz Basin	Lower Cowlitz River	Sport	--	--	--
Harvest – Numerical	Upper Cowlitz Basin Coho Salmon	Cowlitz Basin	Lower Cowlitz River	Total	--	--	--
Harvest – Numerical	Upper Cowlitz Basin Coho Salmon	Cowlitz Basin	Above Mayfield Dam	Commercial	No Fishery	No Fishery	--
Harvest – Numerical	Upper Cowlitz Basin Coho Salmon	Cowlitz Basin	Above Mayfield Dam	Tribal	No Fishery	No Fishery	--
Harvest – Numerical	Upper Cowlitz Basin Coho Salmon	Cowlitz Basin	Above Mayfield Dam	Sport	--	--	--
Harvest – Numerical	Upper Cowlitz Basin Coho Salmon	Cowlitz Basin	Above Mayfield Dam	Total	--	--	--
Harvest – Percentage	Upper Cowlitz Basin Coho Salmon	Ocean	NA	Commercial	--	--	--
Harvest – Percentage	Upper Cowlitz Basin Coho Salmon	Ocean	NA	Tribal	--	--	--
Harvest – Percentage	Upper Cowlitz Basin Coho Salmon	Ocean	NA	Sport	--	--	--
Harvest – Percentage	Upper Cowlitz Basin Coho Salmon	Ocean	NA	Total	--	--	--
Harvest – Percentage	Upper Cowlitz Basin Coho Salmon	Columbia River	NA	Commercial	--	--	--
Harvest – Percentage	Upper Cowlitz Basin Coho Salmon	Columbia River	NA	Tribal	--	--	--
Harvest – Percentage	Upper Cowlitz Basin Coho Salmon	Columbia River	NA	Sport	--	--	--
Harvest – Percentage	Upper Cowlitz Basin Coho Salmon	Columbia River	NA	Total	--	--	--
Harvest – Percentage	Upper Cowlitz Basin Coho Salmon	Cowlitz Basin	Lower Cowlitz River	Commercial	No Fishery	No Fishery	--
Harvest – Percentage	Upper Cowlitz Basin Coho Salmon	Cowlitz Basin	Lower Cowlitz River	Tribal	--	--	--
Harvest – Percentage	Upper Cowlitz Basin Coho Salmon	Cowlitz Basin	Lower Cowlitz River	Sport	--	--	--
Harvest – Percentage	Upper Cowlitz Basin Coho Salmon	Cowlitz Basin	Lower Cowlitz River	Total	--	--	--
Harvest – Percentage	Upper Cowlitz Basin Coho Salmon	Cowlitz Basin	Above Mayfield Dam	Commercial	No Fishery	No Fishery	--
Harvest – Percentage	Upper Cowlitz Basin Coho Salmon	Cowlitz Basin	Above Mayfield Dam	Tribal	No Fishery	No Fishery	--
Harvest – Percentage	Upper Cowlitz Basin Coho Salmon	Cowlitz Basin	Above Mayfield Dam	Sport	--	--	--

Metric	Management Unit	Fishery Location 1	Fishery Location 2	Fishery Type	Hatchery	Natural	References[1]
Harvest – Percentage	Upper Cowlitz Basin Coho Salmon	Cowlitz Basin	Above Mayfield Dam	Total	--	--	--

Notes:
1. Fisheries harvest levels are managed annually based in part on projected abundance of stocks. See current recreational, tribal, and commercial harvest rules.
NA indicates the metric is not applicable.
-- indicates the metric has not been established.

Appendix Table A-7. Population Status: Lower Cowlitz Basin and Upper Cowlitz Basin (Upper Cowlitz, Cispus, and Tilton rivers) Fall Chinook Salmon

Metric	ESU/DPS	Population	Status	Reference	Notes
Listing Status	Lower Columbia River Chinook Salmon ESU	Lower Cowlitz	Threatened	NMFS 1999a NMFS 2005 NMFS 2022	Classified as Threatened in 1999, re-classified as Threatened in 2005.
		Upper Cowlitz			
		Cispus			
		Tilton			
Population Type	NA	Lower Cowlitz	Contributing	NMFS 2013	Upper Cowlitz Population includes the Upper Cowlitz, Cispus, and Tilton, combined.
	NA	Upper Cowlitz	Stabilizing		
	NA	Cispus	Stabilizing		
	NA	Tilton	Stabilizing		
Recovery Phase	NA	Lower Cowlitz	Local Adaptation	HSRG 2014 Tacoma Power 2020	No Note
	NA	Upper Cowlitz			
	NA	Cispus			
	NA	Tilton			

Appendix Table A-8. Population Abundance Categories and Ranges for Lower Cowlitz Basin and Tilton River Fall Chinook Salmon

Metric	Level	Value	Reference	Notes
Abundance Category and Range NOR (Lower Cowlitz)	Low	≤1,500	Tacoma Power 2021b	Low NOR = 500 redds by second flight (1,500 fish)
	Normal	--		
Abundance Category and Range NOR (Tilton)	Low	<1,000	Tacoma Power 2021b	Range of NORs that triggers management targets and actions
	Normal	1,001 to 2,000		
Abundance Category and Range HOR (Tilton)	Low	<1,000		Range of HORs that triggers management targets and actions
	Normal	1,000 to 3,000		

Appendix Table A-9. Population Attributes and Metrics: Fall Chinook Salmon

Metric	Life Stage	Level	Cowlitz Basin	Lower Cowlitz	Tilton	Upper Cowlitz	Cispus	Tilton-Upper Cowlitz-Cispus	Upper Cowlitz-Cispus	References	Notes
Abundance of Spawners	Adult	Natural and Hatchery	NA	3,000	--	--	--	NA	NA	NMFS 2013	ESA recovery target[1]
Smolt Population Estimate	Smolt	Natural	--	--	--	--	--	--	--	--	Population estimate from Mayfield and Cowlitz Falls
Adult-to-Adult Replacement	Spawner and Adult	Natural	--	≥1	≥1	≥1	≥1	--	--	Tacoma Power 2020	Test if population is stable or growing
Adult-to-Adult Replacement	Spawner and Adult	Natural	--	>>1	>>1	--	--	--	--	Tacoma Power 2020	Target hatchery replacement rate should be ≥ 1 and is typically greater than the natural replacement rate.
Smolts per Spawner Recruitment	Smolt and Adult	Natural	--	--	--	--	--	--	--	--	Freshwater productivity rate
Spatial Distribution of Spawning	Adult	Natural and Hatchery	--	--	--	--	--	--	--	--	Compare to historic spatial spawning data and mapped spawning habitat
Spatial Distribution of Spawning	Adult	Natural and Hatchery	--	--	--	--	--	--	--	--	Compare to NOS spawning spatial distribution
Population Genetics Sampling	Smolt and Adult	Natural	--	--	--	--	--	--	--	--	Document collection of genetic samples on an annual basis according to sampling plan
Population Genetics Sampling	Smolt and Adult	Natural	--	--	--	--	--	--	--	--	Document collection of genetic samples on an annual basis according to sampling plan
Population Genetics Analyses	Smolt and Adult	Natural	--	--	--	--	--	--	--	--	Document number of genetic samples to be analyzed in preparation for genetic analyses

Metric	Life Stage	Level	Cowlitz Basin	Lower Cowlitz	Tilton	Upper Cowlitz	Cispus	Tilton-Upper Cowlitz-Cispus	Upper Cowlitz-Cispus	References	Notes
Population Genetics Analyses	Smolt and Adult	Natural	--	--	--	--	--	--	--	--	Document number of genetic samples to be analyzed in preparation for genetic analyses
Age at Return	Adult	Natural and Hatchery	--	--	--	--	--	--	--	--	Compare to historic age data
Age at Return	Adult	Natural and Hatchery	--	--	--	--	--	--	--	--	Compare to NOR ages
Adult Return Timing	Adult	Natural and Hatchery	--	--	--	--	--	--	--	--	Compare to historic run timing data
Adult Return Timing	Adult	Natural and Hatchery	--	--	--	--	--	--	--	--	Compare to NOR run timing
Adult Spawn Timing	Adult	Natural and Hatchery	--	--	--	--	--	--	--	--	Compare to historic spawn timing data
Adult Spawn Timing	Adult	Natural and Hatchery	--	--	--	--	--	--	--	--	Compare to NOR spawn timing
Juvenile Migration Timing	Juvenile	Natural	--	--	--	--	--	--	--	--	Compare to historic emigration timing data
Age at Smolt Migration	Smolt	Natural	--	--	--	--	--	--	--	--	Compare to historic age data
Mean Age of Adult Returns	Adult	Natural and Hatchery	--	--	--	--	--	--	--	--	Compare to NOR mean ages
Mean Age of Adult Returns	Adult	Natural and Hatchery	--	--	--	--	--	--	--	--	Compare to historic mean age data

Metric	Life Stage	Level	Cowlitz Basin	Lower Cowlitz	Tilton	Upper Cowlitz	Cispus	Tilton-Upper Cowlitz-Cispus	Upper Cowlitz-Cispus	References	Notes
Abundance of Adults Returns to Target Populations	Adult	Natural and Hatchery	--	--	--	--	--	--	--	--	No Note
Abundance at Mouth of Cowlitz River	Adult	Natural and Hatchery	7,606	--	--	--	--	--	--	--	From Big Table: Back-calculated from data collected at upstream locations
Abundance at Mouth of Cowlitz River	Adult	Natural and Hatchery	9,017	--	--	--	--	--	--	--	From Big Table: Back-calculated from data collected at upstream locations
Smolt-to-Adult Return (Survival)	Adult	Natural	--	--	--	--	--	--	--	--	Natural population productivity from smolt to adult return
Pre-Spawn Mortality	Adult	Natural and Hatchery	--	--	0%	10%	10%	--	--	Tacoma Power 2020	Assumed pre-spawn mortality rate. Test if population differs from assumed rate.
Pre-Spawn Mortality	Adult	Natural and Hatchery	--	--	0%	10%	10%	--	--	Tacoma Power 2020	Assumed pre-spawn mortality rate. Test if population differs from assumed rate.
Stray Rate Within Basin	Adult	Natural and Hatchery	--	<5%	<5%	<5%	<5%	--	--	Tacoma Power 2020	Maximum allowable stray rate of hatchery fish within basin
Stray Rate Outside of Basin	Adult	Natural and Hatchery	--	<5%	<5%	<5%	<5%	--	--	Tacoma Power 2020	Maximum allowable stray rate of hatchery fish outside of basin
Stray Rate into Basin	Adult	Natural and Hatchery	--	<5%	<5%	<5%	<5%	--	--	Tacoma Power 2020	Document the stray rate of fish into the basin

Notes:
1. Suggested recovery targets for stabilizing the population were established as 1,000 in the Cispus River, 1,000 in the Upper Cowlitz River, and 1,000 in the Tilton River (Fall Chinook Big Table, Tacoma Power 2020).
NA indicates the metric is not applicable.
-- indicates the metric has not been established.

Appendix Table A-10. Hatchery Program Attributes and Metrics: Upper Cowlitz Fall Chinook Salmon (Tilton River)

Metric	Origin	Life Stage	Level	Values	References	Notes
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Origin	Hatchery or Natural	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Sex	Male or Female	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Mortality	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Treatments	Description	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Results	Result	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Assessments	Type(s)	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Tagging QA/QC Results	Result	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Number Tagged	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Juvenile Size at Release	FPP	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Marking QA/QC Results	Result	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Length	mm	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Age	Age	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Juvenile Size at Sampling Time	FPP	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Number Marked	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Tag Type	Tag Type	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Mark Type	Mark Type	--	No Note
Proportion of Hatchery Origin Spawners	Natural and Hatchery	Adult	pHOS maximum	<0.30	Tacoma Power 2021b	Proportion of Hatchery Origin Spawners

Metric	Origin	Life Stage	Level	Values	References	Notes
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Normal NOR; Low HOR	0.30 to 0.50	Tacoma Power 2021b	Proportion of Natural Origin Broodstock
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Low NOR; Low HOR	Maximize	Tacoma Power 2021b	Proportion of Natural Origin Broodstock; at Low NOR, Low HOR maximize pNOB to the extent possible while meeting seeding goals
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Normal NOR; Normal HOR	0.30 to 0.50	Tacoma Power 2021b	Proportion of Natural Origin Broodstock
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Low NOR; Normal HOR	≤0.30	Tacoma Power 2021b	Proportion of Natural Origin Broodstock
Proportionate Natural Influence	Natural and Hatchery	Adult	PNI minimum	≥0.67	Tacoma Power 2020	Proportionate Natural Influence. 0.67 is the typical HSRG PNI target for integrated programs
Number Hatchery Smolts Released	Hatchery	Smolt	Sub-yearlings	3,500,000	Tacoma Power 2021b	No Note
Precocious Maturation Rate	Hatchery	Juvenile	Hatchery juvenile males	--	--	Determined through GSI via dissection, visual maturation identified via dissection, or external smolt index assessment
Survival by Life Stage	Hatchery	All Life Stages	Parr to Smolt	95%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Survival by Life Stage	Hatchery	All Life Stages	Fecundity	4,500	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Survival by Life Stage	Hatchery	All Life Stages	Green Egg to Release	81%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Survival by Life Stage	Hatchery	All Life Stages	Green Egg to Eyed Egg	95%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.

Metric	Origin	Life Stage	Level	Values	References	Notes
Survival by Life Stage	Hatchery	All Life Stages	Broodstock Collection to Spawn	≥95%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Survival by Life Stage	Hatchery	All Life Stages	Eyed Egg to Fry	95%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Survival by Life Stage	Hatchery	All Life Stages	Fry to Parr	95%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Population Genetics Sampling	Hatchery	Broodstock and Juvenile	To be determined	--	--	See Section 15.6 VSP & Population: Population Genetics Sampling for more information.
Population Genetics Analyses	Hatchery	Broodstock and Juvenile	To be determined	--	--	See Section 15.6 VSP & Population: Population Genetics Sampling for more information.
Demographic Replacement	Natural and Hatchery	Adult	NOR, HOR	Calculated Annually	Tacoma Power 2021b	Test if the demographic replacement target was met on an annual basis. See Broodstock Mining Rate in the Hatchery Metrics table.
Size at Release	Hatchery	Smolt	Fish per Pound (fpp)	80	Tacoma Power 2021b	Sub-yearling program
Date(s) of Release	Hatchery	Smolt	End	June	Tacoma Power 2021b	Approximate begin and end months of juvenile releases
Date(s) of Release	Hatchery	Smolt	Begin	May	Tacoma Power 2021b	Approximate begin and end months of juvenile releases
Growth Conversion	Hatchery	Juvenile	Hatchery juveniles	--	--	Target growth conversion
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Female	Not Specified	Tacoma Power 2021b	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Male	Not Specified	Tacoma Power 2021b	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Jack	Not Specified	Tacoma Power 2021b	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates

Metric	Origin	Life Stage	Level	Values	References	Notes
Broodstock Collected – Numerical	Natural and Hatchery	Adult	Total	~1,577 HOR + ~676 NOR	Tacoma Power 2021b	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Female	Not Specified	Tacoma Power 2021b	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Jack	Not Specified	Tacoma Power 2021b	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Male	Not Specified	Tacoma Power 2021b	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Male	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	Total	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Female	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Jack	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Female	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Male	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Jack	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Origin	Hatchery or Natural	--	No Note

Notes:
NA indicates the metric is not applicable.
-- indicates the metric has not been established.

Appendix Table A-11. Facility Assessment Attributes and Metrics: Tilton River Fall Chinook Salmon[1]

Metric	Management Unit	Origin	Life Stage	Level	Value	References	Notes
Fish Guidance Efficiency (FGE)	Upper Cowlitz Fall Chinook Salmon	Natural	Smolt (primarily)	Mayfield Fish Collector	FGE	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	Juvenile FGE is a component of FPS. FGE must be high enough to achieve the FPS target.
Fish Collection Efficiency (FCE)	Upper Cowlitz Fall Chinook Salmon	Natural	Smolt (primarily)	Cowlitz Falls Fish Collector	FCE	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	Juvenile FCE is a component of FPS. FCE must be high enough to achieve the FPS target. Fall Chinook are only managed in the Tilton River (above Mayfield Dam); therefore, they are unlikely to be encountered at Cowlitz Falls.
Fish Passage Survival	Upper Cowlitz Fall Chinook Salmon	Natural	Smolt (primarily)	Mayfield Fish Collector	95%	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	95% or high enough to support self-sustaining anadromous stocks. Fall Chinook are only managed in the Tilton River (above Mayfield Dam); therefore, they are unlikely to be encountered at Cowlitz Falls.
Fish Passage Survival	Upper Cowlitz Fall Chinook Salmon	Natural	Smolt (primarily)	Cowlitz Falls Fish Collector	75%/95%	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	95% or until best available technology has been employed to achieve 75% survival. Fall Chinook are only managed in the Tilton River (above Mayfield Dam); therefore, they are unlikely to be encountered at Cowlitz Falls.
Adult Fallback	Upper Cowlitz Fall Chinook Salmon	Natural and Hatchery	Adult	Cowlitz Falls Hydroelectric Project	12%	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	Assumed fallback rate (assumed in lieu of annual estimates) fall Chinook are only managed in the Tilton River; therefore, they are unlikely to be encountered at Cowlitz Falls.
Adult Fallback	Upper Cowlitz Fall Chinook Salmon	Natural and Hatchery	Adult	Mayfield Hydroelectric Project	12%	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	Assumed fallback rate (assumed in lieu of annual estimates)

Notes:
1. Fall Chinook are only managed in the Tilton River (above Mayfield Dam); therefore, they are unlikely to be encountered at Cowlitz Falls, but all metrics are provided in this table.

Appendix Table A-12. Fishery/Harvest Attributes and Metrics: Lower Cowlitz Fall Chinook Salmon

Metric	Management Unit	Fishery Location 1	Fishery Location 2	Fishery Type	Hatchery	Natural	References[1]
Harvest – Numerical	Lower Cowlitz Fall Chinook Salmon	Ocean	NA	Commercial	--	--	--
Harvest – Numerical	Lower Cowlitz Fall Chinook Salmon	Ocean	NA	Tribal	--	--	--
Harvest – Numerical	Lower Cowlitz Fall Chinook Salmon	Ocean	NA	Sport	--	--	--
Harvest – Numerical	Lower Cowlitz Fall Chinook Salmon	Ocean	NA	Total	--	--	--
Harvest – Numerical	Lower Cowlitz Fall Chinook Salmon	Columbia River	NA	Commercial	--	--	--
Harvest – Numerical	Lower Cowlitz Fall Chinook Salmon	Columbia River	NA	Tribal	--	--	--
Harvest – Numerical	Lower Cowlitz Fall Chinook Salmon	Columbia River	NA	Sport	--	--	--
Harvest – Numerical	Lower Cowlitz Fall Chinook Salmon	Columbia River	NA	Total	--	--	--
Harvest – Numerical	Lower Cowlitz Fall Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Commercial	No Fishery	No Fishery	--
Harvest – Numerical	Lower Cowlitz Fall Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Tribal	--	--	--
Harvest – Numerical	Lower Cowlitz Fall Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Sport	--	--	--
Harvest – Numerical	Lower Cowlitz Fall Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Total	--	--	--
Harvest – Numerical	Lower Cowlitz Fall Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Commercial	No Fishery	No Fishery	--
Harvest – Numerical	Lower Cowlitz Fall Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Tribal	No Fishery	No Fishery	--
Harvest – Numerical	Lower Cowlitz Fall Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Sport	NA	NA	--
Harvest – Numerical	Lower Cowlitz Fall Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Total	NA	NA	--
Harvest – Percentage	Lower Cowlitz Fall Chinook Salmon	Ocean	NA	Commercial	--	--	--
Harvest – Percentage	Lower Cowlitz Fall Chinook Salmon	Ocean	NA	Tribal	--	--	--
Harvest – Percentage	Lower Cowlitz Fall Chinook Salmon	Ocean	NA	Sport	--	--	--
Harvest – Percentage	Lower Cowlitz Fall Chinook Salmon	Ocean	NA	Total	--	--	--
Harvest – Percentage	Lower Cowlitz Fall Chinook Salmon	Columbia River	NA	Commercial	--	--	--
Harvest – Percentage	Lower Cowlitz Fall Chinook Salmon	Columbia River	NA	Tribal	--	--	--
Harvest – Percentage	Lower Cowlitz Fall Chinook Salmon	Columbia River	NA	Sport	--	--	--
Harvest – Percentage	Lower Cowlitz Fall Chinook Salmon	Columbia River	NA	Total	--	--	--
Harvest – Percentage	Lower Cowlitz Fall Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Commercial	No Fishery	No Fishery	--
Harvest – Percentage	Lower Cowlitz Fall Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Tribal	--	--	--
Harvest – Percentage	Lower Cowlitz Fall Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Sport	--	--	--
Harvest – Percentage	Lower Cowlitz Fall Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Total	--	--	--
Harvest – Percentage	Lower Cowlitz Fall Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Commercial	No Fishery	No Fishery	--
Harvest – Percentage	Lower Cowlitz Fall Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Tribal	No Fishery	No Fishery	--
Harvest – Percentage	Lower Cowlitz Fall Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Sport	NA	NA	--

Metric	Management Unit	Fishery Location 1	Fishery Location 2	Fishery Type	Hatchery	Natural	References[1]
Harvest – Percentage	Lower Cowlitz Fall Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Total	NA	NA	--

Notes:
1. Fisheries harvest levels are managed annually based in part on projected abundance of stocks. See current recreational, tribal, and commercial harvest rules.
NA indicates the metric is not applicable.
-- indicates the metric has not been established.

Appendix Table A-13. Fishery/Harvest Attributes and Metrics: Upper Cowlitz Fall Chinook Salmon (Tilton River)

Metric	Management Unit	Fishery Location 1	Fishery Location 2	Fishery Type	Hatchery	Natural	References[1]
Harvest – Numerical	Upper Cowlitz Fall Chinook Salmon	Ocean	NA	Commercial	--	--	--
Harvest – Numerical	Upper Cowlitz Fall Chinook Salmon	Ocean	NA	Tribal	--	--	--
Harvest – Numerical	Upper Cowlitz Fall Chinook Salmon	Ocean	NA	Sport	--	--	--
Harvest – Numerical	Upper Cowlitz Fall Chinook Salmon	Ocean	NA	Total	--	--	--
Harvest – Numerical	Upper Cowlitz Fall Chinook Salmon	Columbia River	NA	Commercial	--	--	--
Harvest – Numerical	Upper Cowlitz Fall Chinook Salmon	Columbia River	NA	Tribal	--	--	--
Harvest – Numerical	Upper Cowlitz Fall Chinook Salmon	Columbia River	NA	Sport	--	--	--
Harvest – Numerical	Upper Cowlitz Fall Chinook Salmon	Columbia River	NA	Total	--	--	--
Harvest – Numerical	Upper Cowlitz Fall Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Commercial	No Fishery	No Fishery	--
Harvest – Numerical	Upper Cowlitz Fall Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Tribal	--	--	--
Harvest – Numerical	Upper Cowlitz Fall Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Sport	--	--	--
Harvest – Numerical	Upper Cowlitz Fall Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Total	--	--	--
Harvest – Numerical	Upper Cowlitz Fall Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Commercial	No Fishery	No Fishery	--
Harvest – Numerical	Upper Cowlitz Fall Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Tribal	No Fishery	No Fishery	--
Harvest – Numerical	Upper Cowlitz Fall Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Sport	--	--	--
Harvest – Numerical	Upper Cowlitz Fall Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Total	--	--	--
Harvest – Percentage	Upper Cowlitz Fall Chinook Salmon	Ocean	NA	Commercial	--	--	--
Harvest – Percentage	Upper Cowlitz Fall Chinook Salmon	Ocean	NA	Tribal	--	--	--
Harvest – Percentage	Upper Cowlitz Fall Chinook Salmon	Ocean	NA	Sport	--	--	--
Harvest – Percentage	Upper Cowlitz Fall Chinook Salmon	Ocean	NA	Total	--	--	--
Harvest – Percentage	Upper Cowlitz Fall Chinook Salmon	Columbia River	NA	Commercial	--	--	--
Harvest – Percentage	Upper Cowlitz Fall Chinook Salmon	Columbia River	NA	Tribal	--	--	--
Harvest – Percentage	Upper Cowlitz Fall Chinook Salmon	Columbia River	NA	Sport	--	--	--
Harvest – Percentage	Upper Cowlitz Fall Chinook Salmon	Columbia River	NA	Total	--	--	--
Harvest – Percentage	Upper Cowlitz Fall Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Commercial	No Fishery	No Fishery	--
Harvest – Percentage	Upper Cowlitz Fall Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Tribal	--	--	--
Harvest – Percentage	Upper Cowlitz Fall Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Sport	--	--	--
Harvest – Percentage	Upper Cowlitz Fall Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Total	--	--	--
Harvest – Percentage	Upper Cowlitz Fall Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Commercial	No Fishery	No Fishery	--
Harvest – Percentage	Upper Cowlitz Fall Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Tribal	No Fishery	No Fishery	--
Harvest – Percentage	Upper Cowlitz Fall Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Sport	--	--	--

Metric	Management Unit	Fishery Location 1	Fishery Location 2	Fishery Type	Hatchery	Natural	References[1]
Harvest – Percentage	Upper Cowlitz Fall Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Total	--	--	--

Notes:
1. Fisheries harvest levels are managed annually based in part on projected abundance of stocks. See current recreational, tribal, and commercial harvest rules.
NA indicates the metric is not applicable.
-- indicates the metric has not been established.

Appendix Table A-14. Population Status: Upper Cowlitz Spring Chinook Salmon

Metric	ESU/DPS	Population	Status	Reference	Notes
Listing Status	Lower Columbia River Chinook Salmon ESU	Lower Cowlitz	NA	NMFS 1999a NMFS 2005 NMFS 2022	Classified as Threatened in 1999, re-classified as Threatened in 2005.
		Upper Cowlitz	Threatened		
		Cispus			
		Tilton			
Population Type	NA	Lower Cowlitz	NA	NMFS 2013	No Note
	NA	Upper Cowlitz	Primary		
	NA	Cispus	Primary		
	NA	Tilton	Stabilizing		
Recovery Phase	NA	Lower Cowlitz	NA	HSRG 2014 Tacoma Power 2020 Tacoma Power 2021c	Tilton River is not currently managed for Spring Chinook
	NA	Upper Cowlitz	Recolonization		
	NA	Cispus			
	NA	Tilton	NA		

Appendix Table A-15. Population Abundance Categories and Ranges for NOR and HOR: Upper Cowlitz Spring Chinook Salmon

Metric	Level	Value	Reference	Notes
Abundance Category and Range NOR	Low	<200	Tacoma Power 2021c	Range of NORs that triggers management targets and actions
	Normal	≥201		
Abundance Category and Range HOR	Low	<1,500		Range of HORs that triggers management targets and actions
	Normal	≥1,501		

Appendix Table A-16. Population Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon

Metric	Life Stage	Level	Cowlitz Basin	Lower Cowlitz	Tilton	Upper Cowlitz	Cispus	Tilton-Upper Cowlitz-Cispus	Upper Cowlitz-Cispus	References	Notes
Abundance of Spawners	Adult	Natural and Hatchery	NA	NA	100	1,800	1,800	--	--	NMFS 2013	ESA recovery targets
Smolt Population Estimate	Smolt	Natural	--	NA	--	--	--	--	--	--	Population estimate from Mayfield and Cowlitz Falls
Adult-to-Adult Replacement	Spawner and Adult	Natural	NA	>>1	>>1	>>1	>>1	--	--	Tacoma Power 2020	Target hatchery replacement rate should be ≥ 1 and is typically greater than the natural replacement rate.
Adult-to-Adult Replacement	Spawner and Adult	Natural	NA	≥1	≥1	≥1	≥1	--	--	Tacoma Power 2020	Test if population is stable or growing
Smolts per Spawner Recruitment	Smolt and Adult	Natural	--	NA	--	--	--	--	--	--	Freshwater productivity rate
Spatial Distribution of Spawning	Adult	Natural and Hatchery	--	NA	--	--	--	--	--	--	Compare to historic spatial spawning data and mapped spawning habitat
Spatial Distribution of Spawning	Adult	Natural and Hatchery	--	NA	--	--	--	--	--	--	Compare to NOS spawning spatial distribution
Population Genetics Sampling	Smolt and Adult	Natural	--	--	--	--	--	--	--	--	Document collection of genetic samples on an annual basis according to sampling plan
Population Genetics Sampling	Smolt and Adult	Natural	--	--	--	--	--	--	--	--	Document collection of genetic samples on an annual basis according to sampling plan
Population Genetics Analyses	Smolt and Adult	Natural	--	--	--	--	--	--	--	--	Document number of genetic samples to be analyzed in preparation for genetic analyses

Metric	Life Stage	Level	Cowlitz Basin	Lower Cowlitz	Tilton	Upper Cowlitz	Cispus	Tilton-Upper Cowlitz-Cispus	Upper Cowlitz-Cispus	References	Notes
Population Genetics Analyses	Smolt and Adult	Natural	--	--	--	--	--	--	--	--	Document number of genetic samples to be analyzed in preparation for genetic analyses
Age at Return	Adult	Natural and Hatchery	--	NA	--	--	--	--	--	--	Compare to NOR ages
Age at Return	Adult	Natural and Hatchery	--	NA	--	--	--	--	--	--	Compare to historic age data
Adult Return Timing	Adult	Natural and Hatchery	--	NA	--	--	--	--	--	--	Compare to historic run timing data
Adult Return Timing	Adult	Natural and Hatchery	--	NA	--	--	--	--	--	--	Compare to NOR run timing
Adult Spawn Timing	Adult	Natural and Hatchery	--	NA	--	--	--	--	--	--	Compare to NOR spawn timing
Adult Spawn Timing	Adult	Natural and Hatchery	--	NA	--	--	--	--	--	--	Compare to historic spawn timing data
Juvenile Migration Timing	Juvenile	Natural	--	NA	--	--	--	--	--	--	Compare to historic emigration timing data
Age at Smolt Migration	Smolt	Natural	--	NA	--	--	--	--	--	--	Compare to historic age data
Mean Age of Adult Returns	Adult	Natural and Hatchery	--	NA	--	--	--	--	--	--	Compare to historic mean age data
Mean Age of Adult Returns	Adult	Natural and Hatchery	--	NA	--	--	--	--	--	--	Compare to NOR mean ages

Metric	Life Stage	Level	Cowlitz Basin	Lower Cowlitz	Tilton	Upper Cowlitz	Cispus	Tilton-Upper Cowlitz-Cispus	Upper Cowlitz-Cispus	References	Notes
Abundance of Adults Returns to Target Populations	Adult	Natural and Hatchery	--	NA	--	--	--	--	--	--	No Note
Abundance at Mouth of Cowlitz River	Adult	Natural and Hatchery	8,691	NA	--	--	--	--	--	Tacoma Power 2020	From Big Table: Back-calculated from data collected at upstream locations
Abundance at Mouth of Cowlitz River	Adult	Natural and Hatchery	1,522	NA	--	--	--	--	--	Tacoma Power 2020	From Big Table: Back-calculated from data collected at upstream locations
Smolt-to-Adult Return (Survival)	Adult	Natural	--	NA	--	--	--	--	--	--	Natural population productivity from smolt to adult return
Pre-Spawn Mortality	Adult	Natural and Hatchery	--	NA	10%	10%	10%	--	--	Tacoma Power 2020	Assumed pre-spawn mortality rate. Test if population differs from assumed rate.
Pre-Spawn Mortality	Adult	Natural and Hatchery	--	NA	10%	10%	10%	--	--	Tacoma Power 2021	Assumed pre-spawn mortality rate. Test if population differs from assumed rate.
Stray Rate Within Basin	Adult	Natural and Hatchery	NA	NA	<5%	<5%	<5%	--	--	Tacoma Power 2020	Maximum allowable stray rate of hatchery fish within basin
Stray Rate Outside of Basin	Adult	Natural and Hatchery	NA	NA	<5%	<5%	<5%	--	--	Tacoma Power 2020	Maximum allowable stray rate of hatchery fish outside of basin
Stray Rate into Basin	Adult	Natural and Hatchery	NA	<5%	<5%	<5%	<5%	--	--	Tacoma Power 2020	Document the stray rate of fish into the basin

Notes:
NA indicates the metric is not applicable.
-- indicates the metric has not been established.

Appendix Table A-17. Hatchery Program Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon

Metric	Origin	Life Stage	Level	Values	References	Notes
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Assessments	Type(s)	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Juvenile Size at Sampling Time	FPP	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Origin	Hatchery or Natural	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Age	Age	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Length	mm	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Juvenile Size at Release	FPP	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Mark Type	Mark Type	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Treatments	Description	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Sex	Male or Female	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Mortality	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Tag Type	Tag Type	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Tagging QA/QC Results	Result	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Marking QA/QC Results	Result	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Number Tagged	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Number Marked	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Results	Result	--	No Note
Proportion of Hatchery Origin Spawners	Natural and Hatchery	Adult	pHOS maximum	NA	Tacoma Power 2021c	Proportion of Hatchery Origin Spawners

Metric	Origin	Life Stage	Level	Values	References	Notes
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Low NOR; Normal HOR	0	Tacoma Power 2021c	Proportion of Natural Origin Broodstock
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Normal NOR; Normal HOR	0	Tacoma Power 2021c	Proportion of Natural Origin Broodstock
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Low NOR; Low HOR	0	Tacoma Power 2021c	Proportion of Natural Origin Broodstock
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Normal NOR; Low HOR	0	Tacoma Power 2021c	Proportion of Natural Origin Broodstock
Proportionate Natural Influence	Natural and Hatchery	Adult	PNI minimum	0	Tacoma Power 2020	No Note
Number Hatchery Smolts Released	Hatchery	Smolt	Smolts and Sub-Yearlings	1,738,000	Tacoma Power 2021c	The yearling program will be maximized based on facility space and water availability. Subyearlings will be used to make up the difference to achieve the 1.8 million program goal.
Precocious Maturation Rate	Hatchery	Juvenile	Hatchery juvenile males	--	--	Determined through GSI via dissection, visual maturation identified via dissection, or external smolt index assessment
Survival by Life Stage	Hatchery	All Life Stages	Parr to Smolt	95%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Survival by Life Stage	Hatchery	All Life Stages	Fecundity	3,750	Tacoma Power 2021c	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Survival by Life Stage	Hatchery	All Life Stages	Green Egg to Release	81%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Survival by Life Stage	Hatchery	All Life Stages	Green Egg to Eyed Egg	95%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.

Metric	Origin	Life Stage	Level	Values	References	Notes
Survival by Life Stage	Hatchery	All Life Stages	Fry to Parr	95%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Survival by Life Stage	Hatchery	All Life Stages	Eyed Egg to Fry	95%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Survival by Life Stage	Hatchery	All Life Stages	Broodstock Collection to Spawn	≥95%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Population Genetics Sampling	Hatchery	Broodstock and Juvenile	To be determined	--	--	See Section 15.6 VSP & Population: Population Genetics Sampling for more information.
Population Genetics Analyses	Hatchery	Broodstock and Juvenile	To be determined	--	--	See Section 15.6 VSP & Population: Population Genetics Sampling for more information.
Demographic Replacement	Natural and Hatchery	Adult	NOR, HOR	Calculated Annually	Tacoma Power 2021c	Test if the demographic replacement target was met on an annual basis. See Broodstock Mining Rate in the Hatchery Metrics table.
Size at Release	Hatchery	Smolt	Fish per Pound (fpp)	5 to12: Yearling	Tacoma Power 2021c	No Note
Size at Release	Hatchery	Smolt	Fish per Pound (fpp)	16 to 20: Sub-yearling	Tacoma Power 2021c	No Note
Date(s) of Release	Hatchery	Smolt	Begin	March	Tacoma Power 2021c	Approximate begin and end months of juvenile releases
Growth Conversion	Hatchery	Juvenile	Hatchery juveniles	--	--	Target growth conversion
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Female	Not Specified	Tacoma Power 2021c	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Male	Not Specified	Tacoma Power 2021c	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Male	Not Specified	Tacoma Power 2021c	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates

Metric	Origin	Life Stage	Level	Values	References	Notes
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Jack	Not Specified	Tacoma Power 2021c	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Jack	Not Specified	Tacoma Power 2021c	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Female	Not Specified	Tacoma Power 2021c	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	Total	~1,352	Tacoma Power 2021c	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Jack	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Female	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Male	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Male	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Female	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	Total	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Jack	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Release Location	Hatchery	Smolt	Locations	Cowlitz Salmon Hatchery	Tacoma Power 2021c	No Note

Notes:
NA indicates the metric is not applicable.
-- indicates the metric has not been established.

Appendix Table A-18. Facility Assessment Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon

Metric	Management Unit	Origin	Life Stage	Level	Value	References	Notes
Fish Guidance Efficiency (FGE)	Upper Cowlitz Spring Chinook Salmon	Natural	Smolt (primarily)	Mayfield Fish Collector	FGE	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	Juvenile FGE is used to estimate FPS. FGE must be high enough to achieve the FPS target. Spring Chinook are only managed in the Upper Cowlitz/Cispus; therefore, they are unlikely to be encountered at Mayfield
Fish Collection Efficiency (FCE)	Upper Cowlitz Spring Chinook Salmon	Natural	Smolt (primarily)	Cowlitz Falls Fish Collector	FCE	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	Juvenile FCE is used to estimate FPS. FCE must be high enough to achieve the FPS target.
Fish Passage Survival	Upper Cowlitz Spring Chinook Salmon	Natural	Smolt (primarily)	Cowlitz Falls Fish Collector	75%/95%	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	95% or at least 75% after best available technology has been employed.
Fish Passage Survival	Upper Cowlitz Spring Chinook Salmon	Natural	Smolt (primarily)	Mayfield Fish Collector	95%	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	95% or high enough to support self-sustaining anadromous stocks
Adult Fallback	Upper Cowlitz Spring Chinook Salmon	Natural and Hatchery	Adult	Cowlitz Falls Hydroelectric Project	12%	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	Assumed fallback rate (assumed in lieu of annual estimates)
Adult Fallback	Upper Cowlitz Spring Chinook Salmon	Natural and Hatchery	Adult	Mayfield Hydroelectric Project	12%	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	Assumed fallback rate (assumed in lieu of annual estimates) Spring Chinook are only managed in the Upper Cowlitz/Cispus; therefore, they are unlikely to be encountered at Mayfield.

Appendix Table A-19. Fishery/Harvest Attributes and Metrics: Upper Cowlitz Spring Chinook Salmon

Metric	Management Unit	Fishery Location 1	Fishery Location 2	Fishery Type	Hatchery	Natural	References[1]
Harvest – Numerical	Upper Cowlitz Spring Chinook Salmon	Ocean	NA	Commercial	--	--	--
Harvest – Numerical	Upper Cowlitz Spring Chinook Salmon	Ocean	NA	Tribal	--	--	--
Harvest – Numerical	Upper Cowlitz Spring Chinook Salmon	Ocean	NA	Sport	--	--	--
Harvest – Numerical	Upper Cowlitz Spring Chinook Salmon	Ocean	NA	Total	--	--	--
Harvest – Numerical	Upper Cowlitz Spring Chinook Salmon	Columbia River	NA	Commercial	--	--	--
Harvest – Numerical	Upper Cowlitz Spring Chinook Salmon	Columbia River	NA	Tribal	--	--	--
Harvest – Numerical	Upper Cowlitz Spring Chinook Salmon	Columbia River	NA	Sport	--	--	--
Harvest – Numerical	Upper Cowlitz Spring Chinook Salmon	Columbia River	NA	Total	--	--	--
Harvest – Numerical	Upper Cowlitz Spring Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Commercial	No Fishery	No Fishery	--
Harvest – Numerical	Upper Cowlitz Spring Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Tribal	No Fishery	No Fishery	--
Harvest – Numerical	Upper Cowlitz Spring Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Sport	--	--	--
Harvest – Numerical	Upper Cowlitz Spring Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Total	--	--	--
Harvest – Numerical	Upper Cowlitz Spring Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Commercial	No Fishery	No Fishery	--
Harvest – Numerical	Upper Cowlitz Spring Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Tribal	No Fishery	No Fishery	--
Harvest – Numerical	Upper Cowlitz Spring Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Sport	--	--	--
Harvest – Numerical	Upper Cowlitz Spring Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Total	--	--	--
Harvest – Percentage	Upper Cowlitz Spring Chinook Salmon	Ocean	NA	Commercial	--	--	--
Harvest – Percentage	Upper Cowlitz Spring Chinook Salmon	Ocean	NA	Tribal	--	--	--

Metric	Management Unit	Fishery Location 1	Fishery Location 2	Fishery Type	Hatchery	Natural	References[1]
Harvest – Percentage	Upper Cowlitz Spring Chinook Salmon	Ocean	NA	Sport	--	--	--
Harvest – Percentage	Upper Cowlitz Spring Chinook Salmon	Ocean	NA	Total	--	--	--
Harvest – Percentage	Upper Cowlitz Spring Chinook Salmon	Columbia River	NA	Commercial	--	--	--
Harvest – Percentage	Upper Cowlitz Spring Chinook Salmon	Columbia River	NA	Tribal	--	--	--
Harvest – Percentage	Upper Cowlitz Spring Chinook Salmon	Columbia River	NA	Sport	--	--	--
Harvest – Percentage	Upper Cowlitz Spring Chinook Salmon	Columbia River	NA	Total	--	--	--
Harvest – Percentage	Upper Cowlitz Spring Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Commercial	No Fishery	No Fishery	--
Harvest – Percentage	Upper Cowlitz Spring Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Tribal	No Fishery	No Fishery	--
Harvest – Percentage	Upper Cowlitz Spring Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Sport	--	--	--
Harvest – Percentage	Upper Cowlitz Spring Chinook Salmon	Cowlitz Basin	Lower Cowlitz River	Total	--	--	--
Harvest – Percentage	Upper Cowlitz Spring Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Commercial	No Fishery	No Fishery	--
Harvest – Percentage	Upper Cowlitz Spring Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Tribal	No Fishery	No Fishery	--
Harvest – Percentage	Upper Cowlitz Spring Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Sport	--	--	--
Harvest – Percentage	Upper Cowlitz Spring Chinook Salmon	Cowlitz Basin	Above Mayfield Dam	Total	--	--	--

Notes:
1. Fisheries harvest levels are managed annually based in part on projected abundance of stocks. See current recreational, tribal, and commercial harvest rules.
NA indicates the metric is not applicable.
-- indicates the metric has not been established.

Appendix Table A-20. Population Status: Lower Cowlitz Winter-Run Steelhead, Tilton Winter-Run Steelhead, and Upper Cowlitz Subbasin Winter-Run Steelhead (including Cispus)

Metric	ESU/DPS	Population	Status	Reference	Notes
Listing Status	Lower Columbia River Steelhead DPS	Lower Cowlitz	Threatened	NMFS 1998 NMFS 2006 NMFS 2022	Classified as Threatened in 1998, re-classified as Threatened in 2006
		Upper Cowlitz			
		Cispus			
		Tilton			
Population Type	NA	Lower Cowlitz	Contributing	NMFS 2013	No Note
	NA	Upper Cowlitz	Primary		
	NA	Cispus			
	NA	Tilton	Contributing		
Recovery Phase	NA	Lower Cowlitz	Local Adaptation	HSRG 2014 Tacoma Power 2020 Tacoma Power 2021d	No Note
	NA	Upper Cowlitz	Recolonization		
	NA	Cispus			
	NA	Tilton			

Appendix Table A-21. Population Abundance Categories and Ranges for NOR and HOR: Lower Cowlitz Winter-Run Steelhead

Metric	Level	Value	Reference	Notes
Abundance Category and Range NOR	Low	≤400	Tacoma Power 2021d	Range of NORs that triggers management targets and actions
	Normal	401 to 800		
Abundance Category and Range HOR	Low	≤1,200		Range of HORs that triggers management targets and actions
	Normal	1,201 to 5,000		

Appendix Table A-22. Population Abundance Categories and Ranges for NOR and HOR: Tilton Winter-Run Steelhead

Metric	Level	Value	Reference	Notes
Abundance Category and Range NOR	Low	≤100	Tacoma Power 2021d	Range of NORs that triggers management targets and actions
	Normal	101 to 500		
Abundance Category and Range HOR	Low	≤100		Range of HORs that triggers management targets and actions
	Normal	101 to 500		

Appendix Table A-23. Population Abundance Categories and Ranges for NOR and HOR: Upper Cowlitz Subbasin Winter-Run Steelhead (including Cispus)

Metric	Level	Value	Reference	Notes
Abundance Category and Range NOR	Low	≤300	Tacoma Power 2021d	Range of NORs that triggers management targets and actions
	Normal	301 to 800		
Abundance Category and Range HOR	Low	≤200		Range of HORs that triggers management targets and actions
	Normal	201 to 1,000		

Appendix Table A-24. Population Attributes and Metrics: Winter-Run Steelhead[1]

Metric	Life Stage	Level	Cowlitz Basin	Lower Cowlitz	Tilton	Upper Cowlitz	Cispus	Tilton-Upper Cowlitz-Cispus	Upper Cowlitz-Cispus	References	Notes
Abundance of Spawners	Adult	Natural and Hatchery	--	400	200	500	500	--	--	NMFS 2013	ESA recovery targets
Smolt Population Estimate	Smolt	Natural	--	--	--	--	--	--	--	--	Population estimate from Mayfield and Cowlitz Falls
Adult-to-Adult Replacement	Spawner and Adult	Natural	--	--	≥1	≥1	≥1	--	--	Tacoma Power 2020	Test if population is stable or growing
Adult-to-Adult Replacement	Spawner and Adult	Natural	--	--	15.2	15.2	15.2	--	--	Tacoma Power 2020	Target hatchery replacement rate should be ≥ 1 and is typically greater than the natural replacement rate.
Smolts per Spawner Recruitment	Smolt and Adult	Natural	--	--	--	--	--	--	--	--	Freshwater productivity rate
Spatial Distribution of Spawning	Adult	Natural and Hatchery	--	--	--	--	--	--	--	--	Compare to historic spatial spawning data and mapped spawning habitat
Spatial Distribution of Spawning	Adult	Natural and Hatchery	--	--	--	--	--	--	--	--	Compare to NOS spawning spatial distribution
Population Genetics Sampling	Smolt and Adult	Natural	--	--	--	--	--	--	--	--	Document collection of genetic samples on an annual basis according to sampling plan
Population Genetics Sampling	Smolt and Adult	Natural	--	--	--	--	--	--	--	--	Document collection of genetic samples on an annual basis according to sampling plan
Population Genetics Analyses	Smolt and Adult	Natural	--	--	--	--	--	--	--	--	Document number of genetic samples to be analyzed in preparation for genetic analyses

Metric	Life Stage	Level	Cowlitz Basin	Lower Cowlitz	Tilton	Upper Cowlitz	Cispus	Tilton-Upper Cowlitz-Cispus	Upper Cowlitz-Cispus	References	Notes
Population Genetics Analyses	Smolt and Adult	Natural	--	--	--	--	--	--	--	--	Document number of genetic samples to be analyzed in preparation for genetic analyses
Age at Return	Adult	Natural and Hatchery	--	--	--	--	--	--	--	--	Compare to NOR ages
Age at Return	Adult	Natural and Hatchery	--	--	--	--	--	--	--	--	Compare to historic age data
Adult Return Timing	Adult	Natural and Hatchery	--	--	--	--	--	--	--	--	Compare to NOR run timing
Adult Return Timing	Adult	Natural and Hatchery	--	--	--	--	--	--	--	--	Compare to historic run timing data
Adult Spawn Timing	Adult	Natural and Hatchery	--	--	--	--	--	--	--	--	Compare to historic spawn timing data
Adult Spawn Timing	Adult	Natural and Hatchery	--	--	--	--	--	--	--	--	Compare to NOR spawn timing
Juvenile Migration Timing	Juvenile	Natural	--	--	--	--	--	--	--	--	Compare to historic emigration timing data
Age at Smolt Migration	Smolt	Natural	--	--	--	--	--	--	--	--	Compare to historic age data
Mean Age of Adult Returns	Adult	Natural and Hatchery	--	--	--	--	--	--	--	--	Compare to NOR mean ages
Mean Age of Adult Returns	Adult	Natural and Hatchery	--	--	--	--	--	--	--	--	Compare to historic mean age data

Metric	Life Stage	Level	Cowlitz Basin	Lower Cowlitz	Tilton	Upper Cowlitz	Cispus	Tilton-Upper Cowlitz-Cispus	Upper Cowlitz-Cispus	References	Notes
Abundance of Adults Returns to Target Populations	Adult	Natural and Hatchery	--	--	--	--	--	--	--	--	No Notes
Abundance at Mouth of Cowlitz River	Adult	Natural and Hatchery	11,296	--	--	--	--	--	--	Tacoma Power 2020	From Big Table: Back-calculated from data collected at upstream locations
Abundance at Mouth of Cowlitz River	Adult	Natural and Hatchery	1,926	--	--	--	--	--	--	Tacoma Power 2020	From Big Table: Back-calculated from data collected at upstream locations
Smolt-to-Adult Return (Survival)	Adult	Natural	--	>4%	>5%	>3.5%	>3.5%	--	--	Tacoma Power 2020	Natural population productivity from smolt to adult return
Pre-Spawn Mortality	Adult	Natural and Hatchery	--	--	10%	10%	10%	--	--	Tacoma Power 2021	Assumed pre-spawn mortality rate. Test if population differs from assumed rate.
Pre-Spawn Mortality	Adult	Natural and Hatchery	--	--	10%	10%	10%	--	--	Tacoma Power 2020	Assumed pre-spawn mortality rate. Test if population differs from assumed rate.
Stray Rate Within Basin	Adult	Natural and Hatchery	--	<5%	<5%	<5%	<5%	--	--	Tacoma Power 2020	Maximum allowable stray rate of hatchery fish within basin
Stray Rate Outside of Basin	Adult	Natural and Hatchery	--	<5%	<5%	<5%	<5%	--	--	Tacoma Power 2020	Maximum allowable stray rate of hatchery fish outside of basin
Stray Rate into Basin	Adult	Natural and Hatchery	--	<5%	<5%	<5%	<5%	--	--	Tacoma Power 2020	Document the stray rate of fish into the basin

Notes:
1. There is no summer-run steelhead population in the Cowlitz Basin. The segregated summer-run steelhead hatchery program provides a recreational fishery.
-- indicates the metric has not been established.

Appendix Table A-25. Hatchery Program Attributes and Metrics: Lower Cowlitz Winter-Run Steelhead

Metric	Origin	Life Stage	Level	Values	References	Notes
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Juvenile Size at Sampling Time	FPP	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Assessments	Type(s)	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Tag Type	Tag Type	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Mortality	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Number Tagged	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Tagging QA/QC Results	Result	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Number Marked	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Mark Type	Mark Type	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Results	Result	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Length	mm	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Sex	Male or Female	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Marking QA/QC Results	Result	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Origin	Hatchery or Natural	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Treatments	Description	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Age	Age	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Juvenile Size at Release	FPP	--	No Note
Proportion of Hatchery Origin Spawners	Natural and Hatchery	Adult	pHOS maximum	<0.10	Tacoma Power 2021d	Proportion of Hatchery Origin Spawners

Metric	Origin	Life Stage	Level	Values	References	Notes
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Low NOR; Normal HOR	0	Tacoma Power 2021d	Proportion of Natural Origin Broodstock
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Normal NOR; Normal HOR	0	Tacoma Power 2021d	Proportion of Natural Origin Broodstock
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Low NOR; Low HOR	0	Tacoma Power 2021d	Proportion of Natural Origin Broodstock
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Normal NOR; Low HOR	0	Tacoma Power 2021d	Proportion of Natural Origin Broodstock
Proportionate Natural Influence	Natural and Hatchery	Adult	PNI minimum	0	Tacoma Power 2020	Proportionate Natural Influence does not apply to segregated programs
Number Hatchery Smolts Released	Hatchery	Smolt	Smolts	308,500	Tacoma Power 2021d	No Note
Precocious Maturation Rate	Hatchery	Juvenile	Hatchery juvenile males	--	--	Determined through GSI via dissection, visual maturation identified via dissection, or external smolt index assessment
Survival by Life Stage	Hatchery	All Life Stages	Broodstock Collection to Spawn	>90%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Survival by Life Stage	Hatchery	All Life Stages	Parr to Smolt	95%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Survival by Life Stage	Hatchery	All Life Stages	Fry to Parr	95%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Survival by Life Stage	Hatchery	All Life Stages	Green Egg to Eyed Egg	95%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.

Metric	Origin	Life Stage	Level	Values	References	Notes
Survival by Life Stage	Hatchery	All Life Stages	Green Egg to Release	81%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Survival by Life Stage	Hatchery	All Life Stages	Fecundity	5,500	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Survival by Life Stage	Hatchery	All Life Stages	Eyed Egg to Fry	95%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. Baseline survival targets from the 2020 FHMP.
Population Genetics Sampling	Hatchery	Broodstock and Juvenile	To be determined	--	--	See Section 15.6 VSP & Population: Population Genetics Sampling for more information.
Population Genetics Analyses	Hatchery	Broodstock and Juvenile	To be determined	--	--	See Section 15.6 VSP & Population: Population Genetics Sampling for more information.
Demographic Replacement	Natural and Hatchery	Adult	NOR, HOR	Calculated Annually	Tacoma Power 2021d	Test if the demographic replacement target was met on an annual basis. See Broodstock Mining Rate in the Hatchery Metrics table.
Size at Release	Hatchery	Smolt	Fish per Pound (fpp)	5 to 7	Tacoma Power 2021d	Yearling
Date(s) of Release	Hatchery	Smolt	End	May	Tacoma Power 2021d	Approximate begin and end months of juvenile releases
Date(s) of Release	Hatchery	Smolt	Begin	April	Tacoma Power 2021d	Approximate begin and end months of juvenile releases
Growth Conversion	Hatchery	Juvenile	Hatchery juveniles	--	--	Target growth conversion
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Female	Not Specified	Tacoma Power 2021d	No Note
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Male	Not Specified	Tacoma Power 2021d	No Note
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Jack	Not Specified	Tacoma Power 2021d	No Note

Metric	Origin	Life Stage	Level	Values	References	Notes
Broodstock Collected – Numerical	Natural and Hatchery	Adult	Total	~166	Tacoma Power 2021d	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Jack	Not Specified	Tacoma Power 2021d	No Note
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Male	Not Specified	Tacoma Power 2021d	No Note
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Female	Not Specified	Tacoma Power 2021d	No Note
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Male	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Female	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Male	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Jack	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Female	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	Total	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Jack	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Release Location	Hatchery	Smolt	Locations	Cowlitz Trout Hatchery	Tacoma Power 2021d	No Note

Notes:
-- indicates the metric has not been established.

Appendix Table A-26. Hatchery Program Attributes and Metrics: Tilton Winter-Run Steelhead

Metric	Origin	Life Stage	Level	Values	References	Notes
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Assessments	Type(s)	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Length	mm	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Juvenile Size at Sampling Time	FPP	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Juvenile Size at Release	FPP	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Age	Age	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Mark Type	Mark Type	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Number Marked	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Results	Result	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Tagging QA/QC Results	Result	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Marking QA/QC Results	Result	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Treatments	Description	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Number Tagged	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Tag Type	Tag Type	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Sex	Male or Female	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Mortality	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Origin	Hatchery or Natural	--	No Note
Proportion of Hatchery Origin Spawners	Natural and Hatchery	Adult	pHOS maximum	<0.30	Tacoma Power 2021d	Proportion of Hatchery Origin Spawners

Metric	Origin	Life Stage	Level	Values	References	Notes
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Low NOR; Normal HOR	0.5	Tacoma Power 2021d	Proportion of Natural Origin Broodstock
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Normal NOR; Normal HOR	0.5	Tacoma Power 2021d	Proportion of Natural Origin Broodstock
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Normal NOR; Low HOR	0.5	Tacoma Power 2021d	Proportion of Natural Origin Broodstock
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Low NOR; Low HOR	0.5	Tacoma Power 2021d	Proportion of Natural Origin Broodstock
Proportionate Natural Influence	Natural and Hatchery	Adult	PNI minimum	≥0.67	Tacoma Power 2020	Proportionate Natural Influence. 0.67 is the typical HSRG PNI target for integrated programs
Number Hatchery Smolts Released	Hatchery	Smolt	Smolts	100,000	Tacoma Power 2021d	No Note
Precocious Maturation Rate	Hatchery	Juvenile	Hatchery juvenile males	--	--	Determined through GSI via dissection, visual maturation identified via dissection, or external smolt index assessment
Survival by Life Stage	Hatchery	All Life Stages	Green Egg to Release	81%	Tacoma Power 2020	No Note
Survival by Life Stage	Hatchery	All Life Stages	Eyed Egg to Fry	95%	Tacoma Power 2020	No Note
Survival by Life Stage	Hatchery	All Life Stages	Broodstock Collection to Spawn	>90%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. However, there are no baseline targets for specific life history stage survivals in the hatchery set
Survival by Life Stage	Hatchery	All Life Stages	Fry to Parr	95%	Tacoma Power 2020	No Note
Survival by Life Stage	Hatchery	All Life Stages	Green Egg to Eyed Egg	95%	Tacoma Power 2020	No Note
Survival by Life Stage	Hatchery	All Life Stages	Parr to Smolt	95%	Tacoma Power 2020	No Note
Survival by Life Stage	Hatchery	All Life Stages	Fecundity	5,500	Tacoma Power 2020	Assumed fecundity

Metric	Origin	Life Stage	Level	Values	References	Notes
Population Genetics Sampling	Hatchery	Broodstock and Juvenile	To be determined	--	--	See Section 15.6 VSP & Population: Population Genetics Sampling for more information.
Population Genetics Analyses	Hatchery	Broodstock and Juvenile	To be determined	--	--	See Section 15.6 VSP & Population: Population Genetics Sampling for more information.
Demographic Replacement	Natural and Hatchery	Adult	NOR, HOR	Calculated Annually	Tacoma Power 2021d	Test if the demographic replacement target was met on an annual basis. See Broodstock Mining Rate in the Hatchery Metrics table.
Size at Release	Hatchery	Smolt	Fish per Pound (fpp)	5 to 7	Tacoma Power 2021d	No Note
Date(s) of Release	Hatchery	Smolt	Begin	April	Tacoma Power 2021d	Approximate begin and end months of juvenile releases
Date(s) of Release	Hatchery	Smolt	End	May	Tacoma Power 2021d	Approximate begin and end months of juvenile releases
Growth Conversion	Hatchery	Juvenile	Hatchery juveniles	--	--	Target growth conversion
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Male	Not Specified	Tacoma Power 2021d	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Female	Not Specified	Tacoma Power 2021d	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	Total	~53	Tacoma Power 2021d	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Female	Not Specified	Tacoma Power 2021d	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Jack	Not Specified	Tacoma Power 2021d	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Male	Not Specified	Tacoma Power 2021d	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Jack	Not Specified	Tacoma Power 2021d	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates

Metric	Origin	Life Stage	Level	Values	References	Notes
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Jack	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	Total	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Female	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Male	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Jack	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Male	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Female	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Release Location	Hatchery	Smolt	Locations	Cowlitz Trout Hatchery	Tacoma Power 2021d	No Note

Notes:
-- indicates the metric has not been established.

Appendix Table A-27. Hatchery Program Attributes and Metrics: Upper Cowlitz Subbasin Winter Steelhead (Upper Cowlitz and Cispus)

Metric	Origin	Life Stage	Level	Values	References	Notes
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Assessments	Type(s)	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Length	mm	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Juvenile Size at Sampling Time	FPP	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Juvenile Size at Release	FPP	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Age	Age	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Mark Type	Mark Type	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Number Marked	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Results	Result	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Tagging QA/QC Results	Result	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Marking QA/QC Results	Result	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Treatments	Description	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Number Tagged	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Tag Type	Tag Type	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Sex	Male or Female	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Mortality	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Origin	Hatchery or Natural	--	No Note
Proportion of Hatchery Origin Spawners	Natural and Hatchery	Adult	pHOS maximum	<0.30	Tacoma Power 2021d	Proportion of Hatchery Origin Spawners

Metric	Origin	Life Stage	Level	Values	References	Notes
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Low NOR; Normal HOR	0.5	Tacoma Power 2021d	Proportion of Natural Origin Broodstock
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Normal NOR; Normal HOR	0.5	Tacoma Power 2021d	Proportion of Natural Origin Broodstock
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Normal NOR; Low HOR	0.5	Tacoma Power 2021d	Proportion of Natural Origin Broodstock
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Low NOR; Low HOR	0.5	Tacoma Power 2021d	Proportion of Natural Origin Broodstock
Proportionate Natural Influence	Natural and Hatchery	Adult	PNI minimum	≥0.67	Tacoma Power 2020	Proportionate Natural Influence. 0.67 is the typical HSRG PNI target for integrated programs
Number Hatchery Smolts Released	Hatchery	Smolt	Smolts	100,000	Tacoma Power 2021d	No Note
Precocious Maturation Rate	Hatchery	Juvenile	Hatchery juvenile males	--	--	Determined through GSI via dissection, visual maturation identified via dissection, or external smolt index assessment
Survival by Life Stage	Hatchery	All Life Stages	Green Egg to Release	81%	Tacoma Power 2020	No Note
Survival by Life Stage	Hatchery	All Life Stages	Eyed Egg to Fry	95%	Tacoma Power 2020	No Note
Survival by Life Stage	Hatchery	All Life Stages	Broodstock Collection to Spawn	>90%	Tacoma Power 2020	Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year. However, there are no baseline targets for specific life history stage survivals in the hatchery set
Survival by Life Stage	Hatchery	All Life Stages	Fry to Parr	95%	Tacoma Power 2020	No Note
Survival by Life Stage	Hatchery	All Life Stages	Green Egg to Eyed Egg	95%	Tacoma Power 2020	No Note
Survival by Life Stage	Hatchery	All Life Stages	Parr to Smolt	95%	Tacoma Power 2020	No Note
Survival by Life Stage	Hatchery	All Life Stages	Fecundity	5,500	Tacoma Power 2020	Assumed fecundity

Metric	Origin	Life Stage	Level	Values	References	Notes
Population Genetics Sampling	Hatchery	Broodstock and Juvenile	To be determined	--	--	See Section 15.6 VSP & Population: Population Genetics Sampling for more information.
Population Genetics Analyses	Hatchery	Broodstock and Juvenile	To be determined	--	--	See Section 15.6 VSP & Population: Population Genetics Sampling for more information.
Demographic Replacement	Natural and Hatchery	Adult	NOR, HOR	Calculated Annually	Tacoma Power 2021d	Test if the demographic replacement target was met on an annual basis. See Broodstock Mining Rate in the Hatchery Metrics table.
Size at Release	Hatchery	Smolt	Fish per Pound (fpp)	5 to 7	Tacoma Power 2021d	No Note
Date(s) of Release	Hatchery	Smolt	Begin	April	Tacoma Power 2021d	Approximate begin and end months of juvenile releases
Date(s) of Release	Hatchery	Smolt	End	May	Tacoma Power 2021d	Approximate begin and end months of juvenile releases
Growth Conversion	Hatchery	Juvenile	Hatchery juveniles	--	--	Target growth conversion
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Male	Not Specified	Tacoma Power 2021d	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Female	Not Specified	Tacoma Power 2021d	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	Total	~53	Tacoma Power 2021d	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Female	Not Specified	Tacoma Power 2021d	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Jack	Not Specified	Tacoma Power 2021d	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Male	Not Specified	Tacoma Power 2021d	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Jack	Not Specified	Tacoma Power 2021d	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates

Metric	Origin	Life Stage	Level	Values	References	Notes
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Jack	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	Total	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Female	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Male	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Jack	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Male	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Female	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Release Location	Hatchery	Smolt	Locations	Cowlitz Trout Hatchery	Tacoma Power 2021d	No Note

Notes:
-- indicates the metric has not been established.

Appendix Table A-28. Hatchery Program Attributes and Metrics: Lower Cowlitz Summer-Run Steelhead

Metric	Origin	Life Stage	Level	Values	References	Notes
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Juvenile Size at Sampling Time	FPP	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Assessments	Type(s)	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Marking QA/QC Results	Result	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Number Tagged	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Tag Type	Tag Type	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Treatments	Description	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Origin	Hatchery or Natural	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Number Marked	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Length	mm	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Sex	Male or Female	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Age	Age	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Results	Result	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Mark Type	Mark Type	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Juvenile Size at Release	FPP	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Mortality	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Tagging QA/QC Results	Result	--	No Note
Proportion of Hatchery Origin Spawners	Natural and Hatchery	Adult	pHOS maximum	--	Tacoma Power 2020	Proportion of Hatchery Origin Spawners

Metric	Origin	Life Stage	Level	Values	References	Notes
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	pNOB Minimum	0	Tacoma Power 2020	No Note
Proportionate Natural Influence	Natural and Hatchery	Adult	PNI minimum	0	Tacoma Power 2020	No Note
Number Hatchery Smolts Released	Hatchery	Smolt	Smolts	650,000	Tacoma Power 2021d	No Note
Precocious Maturation Rate	Hatchery	Juvenile	Hatchery juvenile males	--	--	Determined through GSI via dissection, visual maturation identified via dissection, or external smolt index assessment
Survival by Life Stage	Hatchery	All Life Stages	Fry to Parr	95%	Tacoma Power 2020	No Note
Survival by Life Stage	Hatchery	All Life Stages	Eyed Egg to Fry	95%	Tacoma Power 2020	No Note
Survival by Life Stage	Hatchery	All Life Stages	Broodstock Collection to Spawn	>90%	Tacoma Power 2020	5-year means are used to calculate required broodstock for upcoming the year. However, there are no baseline targets for specific life history stage survivals in the hatchery setting.
Survival by Life Stage	Hatchery	All Life Stages	Green Egg to Eyed Egg	95%	Tacoma Power 2020	No Note
Survival by Life Stage	Hatchery	All Life Stages	Parr to Smolt	95%	Tacoma Power 2020	No Note
Survival by Life Stage	Hatchery	All Life Stages	Green Egg to Release	81%	Tacoma Power 2020	No Note
Survival by Life Stage	Hatchery	All Life Stages	Fecundity	5,500	Tacoma Power 2020	No Note
Population Genetics Sampling	Hatchery	Broodstock and Juvenile	To be determined	--	--	See Section 15.6 VSP & Population: Population Genetics Sampling for more information.
Population Genetics Analyses	Hatchery	Broodstock and Juvenile	To be determined	--	--	See Section 15.6 VSP & Population: Population Genetics Sampling for more information.
Demographic Replacement	Natural and Hatchery	Adult	NA	NA	Tacoma Power 2020	The summer steelhead program is segregated and does not mine natural origin fish for broodstock
Size at Release	Hatchery	Smolt	Fish per Pound (fpp)	5 to 7	Tacoma Power 2020	No Note
Date(s) of Release	Hatchery	Smolt	End	May	Tacoma Power 2021d	Approximate begin and end months of juvenile releases
Date(s) of Release	Hatchery	Smolt	Begin	April	Tacoma Power 2021d	Approximate begin and end months of juvenile releases

Metric	Origin	Life Stage	Level	Values	References	Notes
Growth Conversion	Hatchery	Juvenile	Hatchery juveniles	--	--	Target growth conversion
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Male	Not Specified	Tacoma Power 2020	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Jack	Not Specified	Tacoma Power 2020	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Male	Not Specified	Tacoma Power 2020	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Female	Not Specified	Tacoma Power 2020	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Female	Not Specified	Tacoma Power 2020	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	Total	Collection Target Is Calculated Annually	Tacoma Power 2020	No Note
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Jack	Not Specified	Tacoma Power 2020	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Male	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Female	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	Total	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Jack	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Jack	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates

Metric	Origin	Life Stage	Level	Values	References	Notes
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Male	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Female	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Release Location	Hatchery	Smolt	Locations	Cowlitz Trout Hatchery	Tacoma Power 2021d	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Juvenile Size at Sampling Time	FPP	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Assessments	Type(s)	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Marking QA/QC Results	Result	--	No Note

Notes:
NA indicates the metric is not applicable.
-- indicates the metric has not been established.

Appendix Table A-29. Facility Assessment Attributes and Metrics: Tilton Winter-Run Steelhead and Upper Cowlitz Subbasin Winter-Run Steelhead (including Cispus)

Metric	Management Unit	Origin	Life Stage	Level	Value	References	Notes
Fish Guidance Efficiency (FGE)	Tilton River Winter Steelhead	Natural	Smolt (primarily)	Mayfield Fish Collector	FGE	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	Juvenile FGE is used to estimate FPS. FGE must be high enough to achieve the FPS target.
Fish Collection Efficiency (FCE)	Upper Cowlitz Subbasin Winter Steelhead	Natural	Smolt (primarily)	Cowlitz Falls Fish Collector	FCE	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	Juvenile FGE is used to estimate FPS. FGE must be high enough to achieve the FPS target.
Fish Passage Survival	Tilton River Winter Steelhead	Natural	Smolt (primarily)	Mayfield Fish Collector	95%	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	95% or high enough to support self-sustaining anadromous stocks
Fish Passage Survival	Upper Cowlitz Subbasin Winter Steelhead	Natural	Smolt (primarily)	Cowlitz Falls Fish Collector	75%/95%	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	95% or at least 75% after best available technology has been employed.
Adult Fallback	Tilton River Winter Steelhead	Natural and Hatchery	Adult	Mayfield Hydroelectric Project	12%	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	Assumed fallback rate (in lieu of annual estimates)
Adult Fallback	Upper Cowlitz Subbasin Winter Steelhead	Natural and Hatchery	Adult	Cowlitz Falls Hydroelectric Project	12%	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	Assumed fallback rate (in lieu of annual estimates)

Appendix Table A-30. Fishery/Harvest Attributes and Metrics: Lower Cowlitz Winter Steelhead

Metric	Management Unit	Fishery Location 1	Fishery Location 2	Fishery Type	Hatchery	Natural	References[1]
Harvest – Numerical	Lower Cowlitz Winter Steelhead	Ocean	NA	Commercial	--	--	--
Harvest – Numerical	Lower Cowlitz Winter Steelhead	Ocean	NA	Tribal	--	--	--
Harvest – Numerical	Lower Cowlitz Winter Steelhead	Ocean	NA	Sport	--	--	--
Harvest – Numerical	Lower Cowlitz Winter Steelhead	Ocean	NA	Total	--	--	--
Harvest – Numerical	Lower Cowlitz Winter Steelhead	Columbia River	NA	Commercial	--	--	--
Harvest – Numerical	Lower Cowlitz Winter Steelhead	Columbia River	NA	Tribal	--	--	--
Harvest – Numerical	Lower Cowlitz Winter Steelhead	Columbia River	NA	Sport	--	--	--
Harvest – Numerical	Lower Cowlitz Winter Steelhead	Columbia River	NA	Total	--	--	--
Harvest – Numerical	Lower Cowlitz Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Commercial	No Fishery	No Fishery	--
Harvest – Numerical	Lower Cowlitz Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Tribal	No Fishery	No Fishery	--
Harvest – Numerical	Lower Cowlitz Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Sport	--	--	--
Harvest – Numerical	Lower Cowlitz Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Total	--	--	--
Harvest – Numerical	Lower Cowlitz Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Commercial	No Fishery	No Fishery	--
Harvest – Numerical	Lower Cowlitz Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Tribal	No Fishery	No Fishery	--
Harvest – Numerical	Lower Cowlitz Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Sport	No Fishery	No Fishery	--
Harvest – Numerical	Lower Cowlitz Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Total	No Fishery	No Fishery	--
Harvest – Percentage	Lower Cowlitz Winter Steelhead	Ocean	NA	Commercial	--	--	--
Harvest – Percentage	Lower Cowlitz Winter Steelhead	Ocean	NA	Tribal	--	--	--
Harvest – Percentage	Lower Cowlitz Winter Steelhead	Ocean	NA	Sport	--	--	--
Harvest – Percentage	Lower Cowlitz Winter Steelhead	Ocean	NA	Total	0%	0%	--
Harvest – Percentage	Lower Cowlitz Winter Steelhead	Columbia River	NA	Commercial	--	--	--
Harvest – Percentage	Lower Cowlitz Winter Steelhead	Columbia River	NA	Tribal	--	--	--
Harvest – Percentage	Lower Cowlitz Winter Steelhead	Columbia River	NA	Sport	0%	0%	--
Harvest – Percentage	Lower Cowlitz Winter Steelhead	Columbia River	NA	Total	--	--	--
Harvest – Percentage	Lower Cowlitz Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Commercial	No Fishery	No Fishery	--
Harvest – Percentage	Lower Cowlitz Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Tribal	No Fishery	No Fishery	--
Harvest – Percentage	Lower Cowlitz Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Sport	--	--	--
Harvest – Percentage	Lower Cowlitz Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Total	71%	2%	--
Harvest – Percentage	Lower Cowlitz Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Commercial	No Fishery	No Fishery	--
Harvest – Percentage	Lower Cowlitz Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Tribal	No Fishery	No Fishery	--
Harvest – Percentage	Lower Cowlitz Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Sport	No Fishery	No Fishery	--

Metric	Management Unit	Fishery Location 1	Fishery Location 2	Fishery Type	Hatchery	Natural	References[1]
Harvest – Percentage	Lower Cowlitz Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Total	No Fishery	No Fishery	--

Notes:
1. Fisheries harvest levels are managed annually based in part on projected abundance of stocks. See current recreational, tribal, and commercial harvest rules.
NA indicates the metric is not applicable.
-- indicates the metric has not been established.

Appendix Table A-31. Fishery/Harvest Attributes and Metrics: Tilton Winter Steelhead

Metric	Management Unit	Fishery Location 1	Fishery Location 2	Fishery Type	Hatchery	Natural	References[1]
Harvest – Numerical	Tilton River Winter Steelhead	Ocean	NA	Commercial	--	--	--
Harvest – Numerical	Tilton River Winter Steelhead	Ocean	NA	Tribal	--	--	--
Harvest – Numerical	Tilton River Winter Steelhead	Ocean	NA	Sport	--	--	--
Harvest – Numerical	Tilton River Winter Steelhead	Ocean	NA	Total	--	--	--
Harvest – Numerical	Tilton River Winter Steelhead	Columbia River	NA	Commercial	--	--	--
Harvest – Numerical	Tilton River Winter Steelhead	Columbia River	NA	Tribal	--	--	--
Harvest – Numerical	Tilton River Winter Steelhead	Columbia River	NA	Sport	--	--	--
Harvest – Numerical	Tilton River Winter Steelhead	Columbia River	NA	Total	--	--	--
Harvest – Numerical	Tilton River Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Commercial	No Fishery	No Fishery	--
Harvest – Numerical	Tilton River Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Tribal	No Fishery	No Fishery	--
Harvest – Numerical	Tilton River Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Sport	--	--	--
Harvest – Numerical	Tilton River Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Total	--	--	--
Harvest – Numerical	Tilton River Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Commercial	No Fishery	No Fishery	--
Harvest – Numerical	Tilton River Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Tribal	No Fishery	No Fishery	--
Harvest – Numerical	Tilton River Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Sport	--	--	--
Harvest – Numerical	Tilton River Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Total	--	--	--
Harvest – Percentage	Tilton River Winter Steelhead	Ocean	NA	Commercial	--	--	--
Harvest – Percentage	Tilton River Winter Steelhead	Ocean	NA	Tribal	--	--	--
Harvest – Percentage	Tilton River Winter Steelhead	Ocean	NA	Sport	--	--	--
Harvest – Percentage	Tilton River Winter Steelhead	Ocean	NA	Total	0%	0%	--
Harvest – Percentage	Tilton River Winter Steelhead	Columbia River	NA	Commercial	--	--	--
Harvest – Percentage	Tilton River Winter Steelhead	Columbia River	NA	Tribal	--	--	--
Harvest – Percentage	Tilton River Winter Steelhead	Columbia River	NA	Sport	0%	0%	--
Harvest – Percentage	Tilton River Winter Steelhead	Columbia River	NA	Total	--	--	--
Harvest – Percentage	Tilton River Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Commercial	No Fishery	No Fishery	--
Harvest – Percentage	Tilton River Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Tribal	No Fishery	No Fishery	--
Harvest – Percentage	Tilton River Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Sport	--	--	--
Harvest – Percentage	Tilton River Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Total	71%	2%	--
Harvest – Percentage	Tilton River Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Commercial	No Fishery	No Fishery	--
Harvest – Percentage	Tilton River Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Tribal	No Fishery	No Fishery	--
Harvest – Percentage	Tilton River Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Sport	--	--	--

Metric	Management Unit	Fishery Location 1	Fishery Location 2	Fishery Type	Hatchery	Natural	References[1]
Harvest – Percentage	Tilton River Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Total	1%	2%	--

Notes:
1. Fisheries harvest levels are managed annually based in part on projected abundance of stocks. See current recreational, tribal, and commercial harvest rules.
NA indicates the metric is not applicable.
-- indicates the metric has not been established.

Appendix Table A-32. Fishery/Harvest Attributes and Metrics: Upper Cowlitz Subbasin Winter Steelhead (Upper Cowlitz and Cispus)

Metric	Management Unit	Fishery Location 1	Fishery Location 2	Fishery Type	Hatchery	Natural	References[1]
Harvest – Numerical	Upper Cowlitz Subbasin Winter Steelhead	Ocean	NA	Commercial	--	--	--
Harvest – Numerical	Upper Cowlitz Subbasin Winter Steelhead	Ocean	NA	Tribal	--	--	--
Harvest – Numerical	Upper Cowlitz Subbasin Winter Steelhead	Ocean	NA	Sport	--	--	--
Harvest – Numerical	Upper Cowlitz Subbasin Winter Steelhead	Ocean	NA	Total	--	--	--
Harvest – Numerical	Upper Cowlitz Subbasin Winter Steelhead	Columbia River	NA	Commercial	--	--	--
Harvest – Numerical	Upper Cowlitz Subbasin Winter Steelhead	Columbia River	NA	Tribal	--	--	--
Harvest – Numerical	Upper Cowlitz Subbasin Winter Steelhead	Columbia River	NA	Sport	--	--	--
Harvest – Numerical	Upper Cowlitz Subbasin Winter Steelhead	Columbia River	NA	Total	--	--	--
Harvest – Numerical	Upper Cowlitz Subbasin Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Commercial	No Fishery	No Fishery	--
Harvest – Numerical	Upper Cowlitz Subbasin Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Tribal	No Fishery	No Fishery	--
Harvest – Numerical	Upper Cowlitz Subbasin Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Sport	--	--	--
Harvest – Numerical	Upper Cowlitz Subbasin Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Total	--	--	--
Harvest – Numerical	Upper Cowlitz Subbasin Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Commercial	No Fishery	No Fishery	--
Harvest – Numerical	Upper Cowlitz Subbasin Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Tribal	No Fishery	No Fishery	--
Harvest – Numerical	Upper Cowlitz Subbasin Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Sport	--	--	--
Harvest – Numerical	Upper Cowlitz Subbasin Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Total	--	--	--
Harvest – Percentage	Upper Cowlitz Subbasin Winter Steelhead	Ocean	NA	Commercial	--	--	--
Harvest – Percentage	Upper Cowlitz Subbasin Winter Steelhead	Ocean	NA	Tribal	--	--	--

Metric	Management Unit	Fishery Location 1	Fishery Location 2	Fishery Type	Hatchery	Natural	References[1]
Harvest – Percentage	Upper Cowlitz Subbasin Winter Steelhead	Ocean	NA	Sport	--	--	--
Harvest – Percentage	Upper Cowlitz Subbasin Winter Steelhead	Ocean	NA	Total	0%	0%	--
Harvest – Percentage	Upper Cowlitz Subbasin Winter Steelhead	Columbia River	NA	Commercial	--	--	--
Harvest – Percentage	Upper Cowlitz Subbasin Winter Steelhead	Columbia River	NA	Tribal	--	--	--
Harvest – Percentage	Upper Cowlitz Subbasin Winter Steelhead	Columbia River	NA	Sport	0%	0%	--
Harvest – Percentage	Upper Cowlitz Subbasin Winter Steelhead	Columbia River	NA	Total	--	--	--
Harvest – Percentage	Upper Cowlitz Subbasin Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Commercial	No Fishery	No Fishery	--
Harvest – Percentage	Upper Cowlitz Subbasin Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Tribal	No Fishery	No Fishery	--
Harvest – Percentage	Upper Cowlitz Subbasin Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Sport	--	--	--
Harvest – Percentage	Upper Cowlitz Subbasin Winter Steelhead	Cowlitz Basin	Lower Cowlitz River	Total	71%	2%	--
Harvest – Percentage	Upper Cowlitz Subbasin Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Commercial	No Fishery	No Fishery	--
Harvest – Percentage	Upper Cowlitz Subbasin Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Tribal	No Fishery	No Fishery	--
Harvest – Percentage	Upper Cowlitz Subbasin Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Sport	--	--	--
Harvest – Percentage	Upper Cowlitz Subbasin Winter Steelhead	Cowlitz Basin	Above Mayfield Dam	Total	1%	2%	--

Notes:
1. Fisheries harvest levels are managed annually based in part on projected abundance of stocks. See current recreational, tribal, and commercial harvest rules.
NA indicates the metric is not applicable.
-- indicates the metric has not been established.

Appendix Table A-33. Population Status: Cowlitz Chum Salmon

Metric	ESU/DPS	Population	Status	Reference	Notes
Listing Status	Columbia River Chum Salmon ESU	Lower Cowlitz	Threatened	NMFS 1999b NMFS 2005 NMFS 2022	Classified as Threatened in 2005, re-classified as Threatened in 2005
		Upper Cowlitz	NA		
		Cispus			
		Tilton			
Population Type	NA	Lower Cowlitz	Contributing	NMFS 2013	Summer and fall run Chum listed by NMFS as separate populations.
	NA	Upper Cowlitz	NA		
	NA	Cispus			
	NA	Tilton			
Recovery Phase	NA	Lower Cowlitz	--	HSRG 2014 Tacoma Power 2020	Chum Salmon are currently restricted to downstream of Mayfield Dam.
	NA	Upper Cowlitz	NA		
	NA	Cispus			
	NA	Tilton			

Notes:
NA: not applicable

Appendix Table A-34. Population Attributes and Metrics: Cowlitz Chum Salmon

Metric	Life Stage	Level	Cowlitz Basin	Lower Cowlitz	Tilton	Upper Cowlitz	Cispus	Tilton-Upper Cowlitz-Cispus	Upper Cowlitz-Cispus	References	Notes
Abundance of Spawners	Adult	NOS – Summer	--	900	NA	NA	NA	NA	NA	NMFS 2013	ESA recovery targets. Target is 1,800 for combined summer and fall populations
Abundance of Spawners	Adult	NOS – Fall	--	900	NA	NA	NA	NA	NA	NMFS 2013	ESA recovery targets. Target is 1,800 for combined summer and fall populations
Smolt Population Estimate	Smolt	Natural Origin	NA	--	NA	NA	NA	NA	NA	--	Population estimate from Mayfield and Cowlitz Falls
Adult-to-Adult Replacement	Spawner and Adult	NOR	--	≥1	NA	NA	NA	NA	NA	Tacoma Power 2020	Test if population is stable or growing
Adult-to-Adult Replacement	Spawner and Adult	HOR	NA	NA	NA	NA	NA	NA	NA	Tacoma Power 2020	Target hatchery replacement rate should be ≥ 1 and is typically greater than the natural replacement rate.
Smolts per Spawner Recruitment	Smolt and Adult	Natural Origin	NA	--	NA	NA	NA	NA	NA	--	Freshwater productivity rate
Spatial Distribution of Spawning	Adult	HOS	NA	NA	NA	NA	NA	NA	NA	--	No Notes
Spatial Distribution of Spawning	Adult	NOS	--	--	NA	NA	NA	NA	NA	--	Compare to historic spatial spawning data and mapped spawning habitat
Population Genetics Sampling	Smolt and Adult	Hatchery Origin	NA	NA	NA	NA	NA	NA	NA	--	No Notes
Population Genetics Sampling	Smolt and Adult	Natural Origin	--	--	NA	NA	NA	NA	NA	--	Document collection of genetic samples on an annual basis according to sampling plan

Metric	Life Stage	Level	Cowlitz Basin	Lower Cowlitz	Tilton	Upper Cowlitz	Cispus	Tilton-Upper Cowlitz-Cispus	Upper Cowlitz-Cispus	References	Notes
Population Genetics Analyses	Smolt and Adult	Natural Origin	--	--	NA	NA	NA	NA	NA	--	Document number of genetic samples to be analyzed in preparation for genetic analyses
Population Genetics Analyses	Smolt and Adult	Hatchery Origin	NA	NA	NA	NA	NA	NA	NA	--	No Notes
Age at Return	Adult	HOR	NA	NA	NA	NA	NA	NA	NA	--	No Notes
Age at Return	Adult	NOR	--	--	NA	NA	NA	NA	NA	--	Compare to historic age data
Adult Return Timing	Adult	NOR – Fall	--	Mid Oct – Dec	NA	NA	NA	NA	NA	Tacoma Power 2020	Compare to historic run timing data
Adult Return Timing	Adult	NOR – Summer	--	Late Jul – ?	NA	NA	NA	NA	NA	Tacoma Power 2020	Compare to historic run timing data
Adult Return Timing	Adult	HOR	NA	NA	NA	NA	NA	NA	NA	--	No Notes
Adult Spawn Timing	Adult	HOS	NA	NA	NA	NA	NA	NA	NA	--	No Notes
Adult Spawn Timing	Adult	NOS	--	--	NA	NA	NA	NA	NA	--	Compare to historic spawn timing data
Juvenile Migration Timing	Juvenile	Natural Origin	--	Mar – May	NA	NA	NA	NA	NA	Tacoma Power 2020	Compare to historic emigration timing data
Age at Smolt Migration	Smolt	NOR	--	--	NA	NA	NA	NA	NA	--	Compare to historic age data
Mean Age of Adult Returns	Adult	NOR	--	--	NA	NA	NA	NA	NA	--	Compare to historic mean age data
Mean Age of Adult Returns	Adult	HOR	NA	NA	NA	NA	NA	NA	NA	--	No Notes

Metric	Life Stage	Level	Cowlitz Basin	Lower Cowlitz	Tilton	Upper Cowlitz	Cispus	Tilton-Upper Cowlitz-Cispus	Upper Cowlitz-Cispus	References	Notes
Abundance of Adults Returns to Target Populations	Adult	NOR	--	--	NA	NA	NA	NA	NA	--	No Notes
Abundance at Mouth of Cowlitz River	Adult	HOR	NA	NA	NA	NA	NA	NA	NA	Tacoma Power 2020	Back-calculated from data collected at upstream locations
Abundance at Mouth of Cowlitz River	Adult	NOR	--	--	NA	NA	NA	NA	NA	Tacoma Power 2020	No Notes
Smolt-to-Adult Return (Survival)	Adult	Natural Origin	NA	--	NA	NA	NA	NA	NA	--	Natural population productivity from smolt to adult return
Pre-Spawn Mortality	Adult	NOR	--	--	NA	NA	NA	NA	NA	--	Assumed pre-spawn mortality rate. Test if population differs from assumed rate.
Pre-Spawn Mortality	Adult	HOR	NA	NA	NA	NA	NA	NA	NA	--	No Notes
Stray Rate Within Basin	Adult	HOR	NA	NA	NA	NA	NA	NA	NA	Tacoma Power 2020	No Notes
Stray Rate Outside of Basin	Adult	HOR	NA	NA	NA	NA	NA	NA	NA	Tacoma Power 2020	No Notes
Stray Rate into Basin	Adult	HOR	--	<5%[1]	NA	NA	NA	NA	NA	Tacoma Power 2020	Document the stray rate of fish into the basin. pHOS target is <0.10

Notes:
1. Although there is no hatchery program for Chum Salmon in the Cowlitz Basin, strays from programs outside the Basin may enter it. The pHOS target is <0.10 for hatchery spawners in the Cowlitz Basin.
NA indicates the metric is not applicable.
-- indicates the metric has not been established.

Appendix Table A-35. Fishery/Harvest Attributes and Metrics: Cowlitz Chum Salmon

Metric	Management Unit	Fishery Location 1	Fishery Location 2	Fishery Type	Hatchery	Natural	References[1]
Harvest – Numerical	Cowlitz Basin Chum Salmon	Ocean	NA	Commercial	NA	--	--
Harvest – Numerical	Cowlitz Basin Chum Salmon	Ocean	NA	Tribal	NA	--	--
Harvest – Numerical	Cowlitz Basin Chum Salmon	Ocean	NA	Sport	NA	--	--
Harvest – Numerical	Cowlitz Basin Chum Salmon	Ocean	NA	Total	NA	--	--
Harvest – Numerical	Cowlitz Basin Chum Salmon	Columbia River	NA	Commercial	NA	--	--
Harvest – Numerical	Cowlitz Basin Chum Salmon	Columbia River	NA	Tribal	NA	--	--
Harvest – Numerical	Cowlitz Basin Chum Salmon	Columbia River	NA	Sport	NA	--	--
Harvest – Numerical	Cowlitz Basin Chum Salmon	Columbia River	NA	Total	NA	--	--
Harvest – Numerical	Cowlitz Basin Chum Salmon	Cowlitz Basin	Lower Cowlitz River	Commercial	No Fishery	No Fishery	--
Harvest – Numerical	Cowlitz Basin Chum Salmon	Cowlitz Basin	Lower Cowlitz River	Tribal	No Fishery	No Fishery	--
Harvest – Numerical	Cowlitz Basin Chum Salmon	Cowlitz Basin	Lower Cowlitz River	Sport	NA	--	--
Harvest – Numerical	Cowlitz Basin Chum Salmon	Cowlitz Basin	Lower Cowlitz River	Total	NA	--	--
Harvest – Numerical	Cowlitz Basin Chum Salmon	Cowlitz Basin	Above Mayfield Dam	Commercial	No Fishery	No Fishery	--
Harvest – Numerical	Cowlitz Basin Chum Salmon	Cowlitz Basin	Above Mayfield Dam	Tribal	No Fishery	No Fishery	--
Harvest – Numerical	Cowlitz Basin Chum Salmon	Cowlitz Basin	Above Mayfield Dam	Sport	NA	--	--
Harvest – Numerical	Cowlitz Basin Chum Salmon	Cowlitz Basin	Above Mayfield Dam	Total	NA	--	--
Harvest – Percentage	Cowlitz Basin Chum Salmon	Ocean	NA	Commercial	NA	≤5%	Tacoma Power 2020
Harvest – Percentage	Cowlitz Basin Chum Salmon	Ocean	NA	Tribal	NA	≤5%	Tacoma Power 2020
Harvest – Percentage	Cowlitz Basin Chum Salmon	Ocean	NA	Sport	NA	≤5%	Tacoma Power 2020
Harvest – Percentage	Cowlitz Basin Chum Salmon	Ocean	NA	Total	NA	≤5%	Tacoma Power 2020
Harvest – Percentage	Cowlitz Basin Chum Salmon	Columbia River	NA	Commercial	NA	≤5%	Tacoma Power 2020
Harvest – Percentage	Cowlitz Basin Chum Salmon	Columbia River	NA	Tribal	NA	≤5%	Tacoma Power 2020
Harvest – Percentage	Cowlitz Basin Chum Salmon	Columbia River	NA	Sport	NA	≤5%	Tacoma Power 2020
Harvest – Percentage	Cowlitz Basin Chum Salmon	Columbia River	NA	Total	NA	≤5%	Tacoma Power 2020
Harvest – Percentage	Cowlitz Basin Chum Salmon	Cowlitz Basin	Lower Cowlitz River	Commercial	No Fishery	No Fishery	--
Harvest – Percentage	Cowlitz Basin Chum Salmon	Cowlitz Basin	Lower Cowlitz River	Tribal	No Fishery	No Fishery	--

Metric	Management Unit	Fishery Location 1	Fishery Location 2	Fishery Type	Hatchery	Natural	References[1]
Harvest – Percentage	Cowlitz Basin Chum Salmon	Cowlitz Basin	Lower Cowlitz River	Sport	NA	≤5%	Tacoma Power 2020
Harvest – Percentage	Cowlitz Basin Chum Salmon	Cowlitz Basin	Lower Cowlitz River	Total	NA	≤5%	Tacoma Power 2020
Harvest – Percentage	Cowlitz Basin Chum Salmon	Cowlitz Basin	Above Mayfield Dam	Commercial	No Fishery	No Fishery	--
Harvest – Percentage	Cowlitz Basin Chum Salmon	Cowlitz Basin	Above Mayfield Dam	Tribal	No Fishery	No Fishery	--
Harvest – Percentage	Cowlitz Basin Chum Salmon	Cowlitz Basin	Above Mayfield Dam	Sport	NA	≤5%	Tacoma Power 2020
Harvest – Percentage	Cowlitz Basin Chum Salmon	Cowlitz Basin	Above Mayfield Dam	Total	NA	≤5%	Tacoma Power 2020

Notes:
1. Fisheries harvest levels are managed annually based in part on projected abundance of stocks. See current recreational, tribal, and commercial harvest rules.
NA indicates the metric is not applicable.
-- indicates the metric has not been established.

Appendix Table A-36. Population Status: Cowlitz Cutthroat Trout: Southwestern Washington/Lower Columbia River Coastal Cutthroat Trout Distinct Population Segment

Metric	ESU/DPS	Population	Status	Reference	Notes
Listing Status	Southwestern Washington/Lower Columbia River Coastal Cutthroat Trout DPS	Lower Cowlitz	Not ESA Listed	Tacoma Power 2020	Coastal Cutthroat Trout are a federal species of concern and the Cowlitz Basin population was classified as Depressed by WDFW.
		Upper Cowlitz			
		Cispus			
		Tilton			
Population Type	NA	Lower Cowlitz	NA	NA	No Note
	NA	Upper Cowlitz			
	NA	Cispus			
	NA	Tilton			
Recovery Phase	NA	Lower Cowlitz	NA	NA	No Note
	NA	Upper Cowlitz			
	NA	Cispus			
	NA	Tilton			

Notes:
NA: not applicable

Appendix Table A-37. Population Attributes and Metrics: Cowlitz Cutthroat Trout

Metric	Life Stage	Level	Cowlitz Basin	Lower Cowlitz	Tilton	Upper Cowlitz	Cispus	Tilton-Upper Cowlitz-Cispus	Upper Cowlitz-Cispus	References	Notes
Abundance of Spawners	Adult	NOS	NA	NA	NA	NA	NA	NA	NA	NMFS 2013	Not ESA listed. No ESA recovery targets.
Smolt Population Estimate	Smolt	Natural Origin	--	Not Estimable	--	--	--	--	--	Tacoma Power 2020	Population estimate from Mayfield and Cowlitz Falls. Not estimable at this time
Adult-to-Adult Replacement	Spawner and Adult	NOR	--	≥1	≥1	≥1	≥1	--	--	Tacoma Power 2020	Test if population is stable or growing
Adult-to-Adult Replacement	Spawner and Adult	HOR	--	--	NA	NA	NA	NA	NA	Tacoma Power 2020	Target hatchery replacement rate should be ≥ 1 and is typically greater than the natural replacement rate.
Smolts per Spawner Recruitment	Smolt and Adult	Natural Origin	--	Not Estimable	--	--	--	--	--	--	Freshwater productivity rate. Not estimable at this time.
Spatial Distribution of Spawning	Adult	HOS	--	--	NA	NA	NA	NA	NA	Tacoma Power 2020	Compare to NOS spawning spatial distribution.
Spatial Distribution of Spawning	Adult	NOS	--	--	--	--	--	--	--	Tacoma Power 2020	Compare to historic spatial spawning data and mapped spawning habitat.
Population Genetics Sampling	Smolt and Adult	Hatchery Origin	--	--	NA	NA	NA	NA	NA	--	Document collection of genetic samples on an annual basis according to sampling plan.
Population Genetics Sampling	Smolt and Adult	Natural Origin	--	--	--	--	--	--	--	--	Document collection of genetic samples on an annual basis according to sampling plan.
Population Genetics Analyses	Smolt and Adult	Hatchery Origin	--	--	NA	NA	NA	NA	NA	--	Document number of genetic samples to be analyzed in preparation for genetic analyses.
Population Genetics Analyses	Smolt and Adult	Natural Origin	--	--	--	--	--	--	--	--	Document number of genetic samples to be analyzed in preparation for genetic analyses.

Metric	Life Stage	Level	Cowlitz Basin	Lower Cowlitz	Tilton	Upper Cowlitz	Cispus	Tilton-Upper Cowlitz-Cispus	Upper Cowlitz-Cispus	References	Notes
Age at Return	Adult	NOR	--	--	--	--	--	--	--	--	Compare to historic age data.
Age at Return	Adult	HOR	--	--	NA	NA	NA	NA	NA	--	Compare to NOR ages.
Adult Return Timing	Adult	HOR	--	Jul - Oct	NA	NA	NA	NA	NA	Tacoma Power 2020	Compare to NOR run timing.
Adult Return Timing	Adult	NOR	--	Jul - Oct	NA	NA	NA	--	--	--	Compare to historic run timing data.
Adult Spawn Timing	Adult	NOS	--	Jan – mid-Apr	--	--	--	--	--	Tacoma Power 2020	Compare to historic spawn timing data.
Adult Spawn Timing	Adult	HOS	--	Nov – Feb	NA	NA	NA	NA	NA	Tacoma Power 2020	Compare to NOR spawn timing.
Juvenile Migration Timing	Juvenile	Natural Origin	--	Mar – May	Mar – May	Mar – May	Mar – May	Mar – May	Mar – May	Tacoma Power 2020	Compare to historic emigration timing data.
Age at Smolt Migration	Smolt	NOR	--	--	--	--	--	--	--	--	Compare to historic age data.
Mean Age of Adult Returns	Adult	NOR	--	--	--	--	--	--	--	--	Compare to historic mean age data.
Mean Age of Adult Returns	Adult	HOR	--	--	NA	NA	NA	NA	NA	--	Compare to NOR mean ages.
Abundance of Adults Returns to Target Populations	Adult	HOR; NOR	--	--	--	--	--	--	--	--	No Note
Abundance at Mouth of Cowlitz River	Adult	NOR	--	--	--	--	--	--	--	Tacoma Power 2020	No Note
Abundance at Mouth of Cowlitz River	Adult	HOR	--	5,000	NA	NA	NA	NA	NA	Tacoma Power 2020	Back-calculated from data collected at upstream locations. Contribution from upstream of Mayfield Dam is not known.

Metric	Life Stage	Level	Cowlitz Basin	Lower Cowlitz	Tilton	Upper Cowlitz	Cispus	Tilton-Upper Cowlitz-Cispus	Upper Cowlitz-Cispus	References	Notes
Smolt-to-Adult Return (Survival)	Adult	Natural Origin	--	Not Estimable	--	--	--	--	--	--	Natural population productivity from smolt to adult return. Not estimable at this time.
Pre-Spawn Mortality	Adult	HOR	--	--	NA	NA	NA	NA	NA	--	Assumed pre-spawn mortality rate. Test if population differs from assumed rate.
Pre-Spawn Mortality	Adult	NOR	--	--	--	--	--	--	--	--	Assumed pre-spawn mortality rate. Test if population differs from assumed rate.
Stray Rate Within Basin	Adult	HOR	--	--	NA	NA	NA	NA	NA	Tacoma Power 2020	Maximum allowable stray rate of hatchery fish within basin
Stray Rate Outside of Basin	Adult	HOR	--	--	NA	NA	NA	NA	NA	Tacoma Power 2020	Maximum allowable stray rate of hatchery fish outside of basin
Stray Rate into Basin	Adult	HOR	--	--	NA	NA	NA	NA	NA	Tacoma Power 2020	Document the stray rate of fish into the basin.

Notes:
NA indicates the metric is not applicable.
-- indicates the metric has not been established.

Appendix Table A-38. Hatchery Program Attributes and Metrics: Cowlitz Cutthroat Trout

Metric	Origin	Life Stage	Level	Values	References	Notes
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Number Tagged	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Mark Type	Mark Type	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Origin	Hatchery or Natural	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Number Marked	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Results	Result	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Tagging QA/QC Results	Result	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Treatments	Description	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Mortality	Count	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Juvenile Size at Release	FPP	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Juvenile Size at Sampling Time	FPP	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Marking QA/QC Results	Result	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Length	mm	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Sex	Male or Female	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Fish Health Assessments	Type(s)	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Tag Type	Tag Type	--	No Note
Biological Sampling in Hatchery	Natural and Hatchery	Adult	Broodstock Age	Age	--	No Note
Proportion of Hatchery Origin Spawners	Natural and Hatchery	Adult	pHOS maximum	--	--	Proportion of Hatchery Origin Spawners

Metric	Origin	Life Stage	Level	Values	References	Notes
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Low NOR; Low HOR	0	Tacoma Power 2020	No Note
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Normal NOR; Low HOR	0	Tacoma Power 2020	No Note
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Normal NOR; Normal HOR	0	Tacoma Power 2020	Proportion of Natural Origin Broodstock
Proportions of Hatchery- and Natural-Origin Broodstock	Natural and Hatchery	Adult	Low NOR; Normal HOR	0	Tacoma Power 2020	No Note
Proportionate Natural Influence	Natural and Hatchery	Adult	PNI minimum	0	Tacoma Power 2020	Segregated Program
Number Hatchery Smolts Released	Hatchery	Smolt	Smolts	100,500	Tacoma Power 2020	90,500 released from Cowlitz Trout Hatchery; 10,000 released by Friends of the Cowlitz
Precocious Maturation Rate	Hatchery	Juvenile	Hatchery juvenile males	--	--	Determined through GSI via dissection, visual maturation identified via dissection, or external smolt index assessment
Survival by Life Stage	Hatchery	All Life Stages	Broodstock Collection to Spawn	≥95%	Tacoma Power 2020	Assumed survival targets based on other anadromous programs. Report by origin (hatchery and natural) if tracked that way in the hatchery. 5-year means are used to calculate required broodstock for upcoming the year.
Survival by Life Stage	Hatchery	All Life Stages	Fry to Parr	95%	Tacoma Power 2020	No Note
Survival by Life Stage	Hatchery	All Life Stages	Green Egg to Eyed Egg	95%	Tacoma Power 2020	No Note
Survival by Life Stage	Hatchery	All Life Stages	Green Egg to Release	81%	Tacoma Power 2020	No Note
Survival by Life Stage	Hatchery	All Life Stages	Parr to Smolt	95%	Tacoma Power 2020	No Note
Survival by Life Stage	Hatchery	All Life Stages	Eyed Egg to Fry	95%	Tacoma Power 2020	No Note
Survival by Life Stage	Hatchery	All Life Stages	Fecundity	--	--	No Note

Metric	Origin	Life Stage	Level	Values	References	Notes
Population Genetics Sampling	Hatchery	Broodstock and Juvenile	To be determined	--	--	See Section 15.6 VSP & Population: Population Genetics Sampling for more information.
Population Genetics Analyses	Hatchery	Broodstock and Juvenile	To be determined	--	--	See Section 15.6 VSP & Population: Population Genetics Sampling for more information.
Demographic Replacement	Natural and Hatchery	Adult	NA	NA	Tacoma Power 2020	The Cutthroat program is segregated and does not mine natural origin fish for broodstock.
Size at Release	Hatchery	Smolt	Fish per Pound (fpp)	5	Tacoma Power 2020	90 g. The 5 FPP was estimated from the 90 g size.
Date(s) of Release	Hatchery	Smolt	End	--	--	Approximate begin and end months of juvenile releases
Date(s) of Release	Hatchery	Smolt	Begin	--	--	Approximate begin and end months of juvenile releases
Growth Conversion	Hatchery	Juvenile	Hatchery juveniles	--	--	Target growth conversion
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Female	--	--	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Male	--	--	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	HOR Jack	--	--	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Jack	--	--	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Male	--	--	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Collected – Numerical	Natural and Hatchery	Adult	NOR Female	--	--	Target broodstock collection numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates

Metric	Origin	Life Stage	Level	Values	References	Notes
Broodstock Collected – Numerical	Natural and Hatchery	Adult	Total	--	--	No Note
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	Total	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Female	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Male	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Jack	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	NOR Jack	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Female	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Broodstock Spawned – Numerical	Natural and Hatchery	Adult	HOR Male	--	--	Target broodstock spawned numbers – numbers to be adjusted each year depending on program size, fish size and fecundity, in-hatchery fertilization, eye-up, and survival rates
Release Location	Hatchery	Smolt	Locations	Cowlitz Trout Hatchery and Friends of Cowlitz	Tacoma Power 2020	No Note

Notes:
NA indicates the metric is not applicable.
-- indicates the metric has not been established.

Appendix Table A-39. Facility Assessment Attributes and Metrics: Cowlitz Cutthroat Trout

Metric	Management Unit	Origin	Life Stage	Level	Value	References	Notes
Fish Guidance Efficiency (FGE)	Cowlitz Basin Coastal Cutthroat Trout	Natural	Smolt (primarily)	Mayfield Fish Collector	FGE	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	Juvenile FGE is used to estimate FPS. FGE must be high enough to achieve the FPS target.
Fish Collection Efficiency (FCE)	Cowlitz Basin Coastal Cutthroat Trout	Natural	Smolt (primarily)	Cowlitz Falls Fish Collector	FCE	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	Juvenile FCE is used to estimate FPS. FCE must be high enough to achieve the FPS target.
Fish Passage Survival	Cowlitz Basin Coastal Cutthroat Trout	Natural	Smolt (primarily)	Mayfield Fish Collector	95%	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	95% or high enough to support self-sustaining anadromous stocks
Fish Passage Survival	Cowlitz Basin Coastal Cutthroat Trout	Natural	Smolt (primarily)	Cowlitz Falls Fish Collector	75%/95%	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	95% or at least 75% after best available technology has been employed
Adult Fallback	Cowlitz Basin Coastal Cutthroat Trout	Natural and Hatchery	Adult	Cowlitz Falls Hydroelectric Project	12%	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	Assumed fallback rate (assumed in lieu of annual estimates)
Adult Fallback	Cowlitz Basin Coastal Cutthroat Trout	Natural and Hatchery	Adult	Mayfield Hydroelectric Project	12%	Tacoma Power 2004; Tacoma Power 2020; Tacoma Power et al. 2000	Assumed fallback rate (assumed in lieu of annual estimates)

Notes:
NA indicates the metric is not applicable.
-- indicates the metric has not been established.

Appendix Table A-40. Fishery/Harvest Attributes and Metrics: Cowlitz Cutthroat Trout

Metric	Management Unit	Fishery Location 1	Fishery Location 2	Fishery Type	Hatchery	Natural	References[1]
Harvest – Numerical	Cowlitz Basin Coastal Cutthroat Trout	Ocean	NA	Commercial	No Fishery	No Fishery	--
Harvest – Numerical	Cowlitz Basin Coastal Cutthroat Trout	Ocean	NA	Tribal	No Fishery	No Fishery	--
Harvest – Numerical	Cowlitz Basin Coastal Cutthroat Trout	Ocean	NA	Sport	No Fishery	No Fishery	--
Harvest – Numerical	Cowlitz Basin Coastal Cutthroat Trout	Ocean	NA	Total	No Fishery	No Fishery	--
Harvest – Numerical	Cowlitz Basin Coastal Cutthroat Trout	Columbia River	NA	Commercial	No Fishery	No Fishery	--
Harvest – Numerical	Cowlitz Basin Coastal Cutthroat Trout	Columbia River	NA	Tribal	No Fishery	No Fishery	--
Harvest – Numerical	Cowlitz Basin Coastal Cutthroat Trout	Columbia River	NA	Sport	--	0	--
Harvest – Numerical	Cowlitz Basin Coastal Cutthroat Trout	Columbia River	NA	Total	--	0	--
Harvest – Numerical	Cowlitz Basin Coastal Cutthroat Trout	Cowlitz Basin	Lower Cowlitz River	Commercial	No Fishery	No Fishery	--
Harvest – Numerical	Cowlitz Basin Coastal Cutthroat Trout	Cowlitz Basin	Lower Cowlitz River	Tribal	No Fishery	No Fishery	--
Harvest – Numerical	Cowlitz Basin Coastal Cutthroat Trout	Cowlitz Basin	Lower Cowlitz River	Sport	4,500	0	--
Harvest – Numerical	Cowlitz Basin Coastal Cutthroat Trout	Cowlitz Basin	Lower Cowlitz River	Total	4,500	0	--
Harvest – Numerical	Cowlitz Basin Coastal Cutthroat Trout	Cowlitz Basin	Above Mayfield Dam	Commercial	No Fishery	No Fishery	--
Harvest – Numerical	Cowlitz Basin Coastal Cutthroat Trout	Cowlitz Basin	Above Mayfield Dam	Tribal	No Fishery	No Fishery	--
Harvest – Numerical	Cowlitz Basin Coastal Cutthroat Trout	Cowlitz Basin	Above Mayfield Dam	Sport	0	0	--
Harvest – Numerical	Cowlitz Basin Coastal Cutthroat Trout	Cowlitz Basin	Above Mayfield Dam	Total	0	0	--
Harvest – Percentage	Cowlitz Basin Coastal Cutthroat Trout	Ocean	NA	Commercial	No Fishery	No Fishery	--
Harvest – Percentage	Cowlitz Basin Coastal Cutthroat Trout	Ocean	NA	Tribal	No Fishery	No Fishery	--

Metric	Management Unit	Fishery Location 1	Fishery Location 2	Fishery Type	Hatchery	Natural	References[1]
Harvest – Percentage	Cowlitz Basin Coastal Cutthroat Trout	Ocean	NA	Sport	No Fishery	No Fishery	--
Harvest – Percentage	Cowlitz Basin Coastal Cutthroat Trout	Ocean	NA	Total	No Fishery	No Fishery	--
Harvest – Percentage	Cowlitz Basin Coastal Cutthroat Trout	Columbia River	NA	Commercial	No Fishery	No Fishery	--
Harvest – Percentage	Cowlitz Basin Coastal Cutthroat Trout	Columbia River	NA	Tribal	No Fishery	No Fishery	--
Harvest – Percentage	Cowlitz Basin Coastal Cutthroat Trout	Columbia River	NA	Sport	<1%	0%	--
Harvest – Percentage	Cowlitz Basin Coastal Cutthroat Trout	Columbia River	NA	Total	<1%	0%	--
Harvest – Percentage	Cowlitz Basin Coastal Cutthroat Trout	Cowlitz Basin	Lower Cowlitz River	Commercial	No Fishery	No Fishery	--
Harvest – Percentage	Cowlitz Basin Coastal Cutthroat Trout	Cowlitz Basin	Lower Cowlitz River	Tribal	No Fishery	No Fishery	--
Harvest – Percentage	Cowlitz Basin Coastal Cutthroat Trout	Cowlitz Basin	Lower Cowlitz River	Sport	0%	0%	--
Harvest – Percentage	Cowlitz Basin Coastal Cutthroat Trout	Cowlitz Basin	Lower Cowlitz River	Total	0%	0%	--
Harvest – Percentage	Cowlitz Basin Coastal Cutthroat Trout	Cowlitz Basin	Above Mayfield Dam	Commercial	No Fishery	No Fishery	--
Harvest – Percentage	Cowlitz Basin Coastal Cutthroat Trout	Cowlitz Basin	Above Mayfield Dam	Tribal	No Fishery	No Fishery	--
Harvest – Percentage	Cowlitz Basin Coastal Cutthroat Trout	Cowlitz Basin	Above Mayfield Dam	Sport	--	--	--
Harvest – Percentage	Cowlitz Basin Coastal Cutthroat Trout	Cowlitz Basin	Above Mayfield Dam	Total	--	--	--

Notes:
NA indicates the metric is not applicable.
-- indicates the metric has not been established.

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APPENDIX B Analytical Methods

VSP-Abundance – Abundance of Adult Returns to Target River

Applies to: 15.14 VSP & Population: Abundance of Adult Returns to Target Populations

A permanent dam (Barrier Dam) and the adjacent sorting facility on the Cowlitz River (rkm 82.08) provide census counts of spring Chinook Salmon, fall Chinook Salmon, Coho Salmon, and winter steelhead trapped and hauled to the Upper Cowlitz Basin (Tilton, Upper Cowlitz, and Cispus rivers). Lower Cowlitz Tributary weirs provide return data for those tributaries.

VSP-Abundance – Abundance of Spawners

Applies to: Lower Cowlitz Chinook Spawner Abundance 15.1 VSP & Population: Abundance of Spawners

Peak Count Expansion of Redds – Lower Cowlitz Spring Chinook and Fall Chinook

Early count(s) (e.g., September) will be assigned to spring Chinook and later counts (e.g., October – November) will be assigned to fall Chinook. The maximum count for either spring or fall Chinook will be used as their respective peak count. Counts of Chinook redds are pooled across the entire lower river and summarized by survey date. Estimates of total abundance for spring- and fall-run Chinook are generated by multiplying the peak count by an expansion factor of 2.84 fish per redd that was originally developed for fixed wing aerial surveys using a carcass tagging mark-recapture study conducted in 1992 (Hymer 1994) and subsequently modified for helicopter aerial surveys (Serl et al. 2021).

Carcass Mark-Recapture – Lower Cowlitz Fall Chinook

This methodology and code were excerpted from Appendices A and B in Serl et al. (2021).

Multivariate, Random-Walk Mark-Recapture Jolly-Seber Model

Carcass survey data were queried from the TWS Access database and ran through a standardized set of summarizations in R (R Core Team 2022) via RStudio (RStudio Team 2022). Briefly, each tagged carcass was first designated as either a jack (i.e., males <60 cm), female, or male (males ≥60) based on field calls and/or associated biological data. Capture histories were then generated for each tagged carcass and mark-recapture (M-R) summary statistics were generated by carcass grouping (jack, female, male) and survey period/week using the R package *RMark* (Laake 2013). Biological data were summarized by carcass grouping and survey period/week where visual-stock identification was used to partition spring- and fall-run carcasses, adipose fin clip and CWT status were paired to identify and partition hatchery- and natural-origin carcasses, and scale-age readings were used to partition carcasses into total age 2 – 6.

Estimates of abundance were generated using the "super-population" Jolly-Seber (JS) estimator that was developed by Schwarz et al. (1993) and Schwarz and Arnason (1996) specifically for estimating salmon spawning escapement using mark-capture methods. The super-population JS model has been previously implemented in a Bayesian framework by WDFW and a comprehensive description of the model, including summary statistics, fundamental parameters, derived parameters, and likelihoods, is provided in Rawding et al. (2014). Previously model selection had compared four versions of this model, each with a time-dependent probability of entry, but with combinations of either time-dependent or constant probabilities of survival and capture. A limitation of this approach was that the model with

both time-dependent capture and survival probabilities had a considerably larger parameter count, and therefore greater variance, and could not be implemented without first pooling capture periods (thereby inducing bias) if the raw data lacked sufficient statistical support for identifiability without pooling.

To address these limitations, we modified the fully time-dependent version of the model (a.k.a. the "*ttt*" model). Specifically, the period-specific probabilities of survival (*phi*) and capture (*p*) were estimated using logit-normal random walks while the probability of entry (*pent*) was estimated via a softmax construction and subject to a simplex constraint where the log-components followed a random walk except for the first period, which by convention is fixed to 0. Additionally, the model was modified so that it could generate separate capture, survival, and entry probabilities for distinct groups of fish (e.g., jack, female, and male salmon), but rather than estimate their parameters entirely independently, it was assumed that temporal evolution in their probabilities of entry, survival, and capture might be correlated. Therefore, the process errors of their random walks were estimated via a multivariate-normal distribution with an inverse Wishart prior, allowing the model to estimate the extent of covariance in parameter evolution among the groups of fish. In contrast to the previous model version, this improved super-population JS model enables estimation of the full-rank time-dependent model regardless of data sparsity by enforcing parsimony through random effects "shrinkage"; probabilities of survival, capture, and entry experience shrinkage by modeling the period-to-period differences in as a random effect (i.e., a random walk model is a random-effects model on first-order differences). Definitions of the data, stochastic parameters, and derived parameters that comprise the model are outlined in Tables Appendix Table B-1, Appendix Table B-2, and Appendix Table B-3, respectively. Model code is provided below Appendix Table B-3.

Samples from the posterior distribution were obtained using Markov chain Monte Carlo (MCMC) simulations (Gilks 2005) in JAGS (Plummer 2007) using the R2jags package (Su and Yajima 2021). We ran four chains with 2,000,000 iterations, a burn-in period of 1,000,000, and a thinning rate of 400 so that the number of independent samples, as measured by effective sample size (ESS), was approximately 10,000 for each parameter of interest. Initial values for each chain were automatically generated within the JAGS package. Modeled convergence was assessed in the same manner as the JS models (i.e., assessment of ESS and BGR statistics).

Appendix Table B-1. Notation and definition of data used in the updated Jolly-Seber model.

Statistic	Definition
s	number of sample periods (note: each period denoted with an "i"; i = 1, …, s)
num_strata	number of carcass groupings (note: each grouping denoted with a "k"; k = 1, …, num_strata)
$time_i$	Amount of time (e.g., days) between subsequent periods (e.g., $time_i$ = time between $period_{i+1}$ and $period_i$); length of $time_i$ = s-1
$u_{i,k}$	number of carcasses that were handled per period that were unmarked (i.e., maiden captures)
$m_{i,k}$	number of carcasses that were handled per period that were previously marked (i.e., recaptures)
$n_{i,k}$	total number of carcasses that were handled per period (i.e., n = m + u)
$R_{i,k}$	number of carcasses that were marked and released back into the sample area per period (i.e., new marks deployed; subset of n)
$r_{i,k}$	Total number of marked carcasses from each specific period that were subsequently recaptured in any period after release (i.e., number of "R" that are recaptured)

Statistic	Definition
$T_{i,k}$	number of previously marked carcasses that are recaptured during or after a given period (T = m + z; z = number of previously marked carcasses that are recaptured after
$uTot_k$	total number of unmarked carcasses handled across all sample periods (i.e., sum of "u")
ex_tule_i	number of examined carcasses that were tules by period (note: current parameterization does NOT split up race bio-data by "strata" - not enough data)
ex_race_i	number of carcasses examined for race by period (note: current parameterization does NOT split up race bio-data by "strata" - not enough data)
$ex\_clip_{i,k}$	number of examined carcasses that were adipose clipped by period
$ex\_adfin_{i,k}$	number of carcasses examined for adipose clip status by period
$age\_dat_{i,k,1:num\_ages}$	number of examined carcasses by age and period
$age\_tot_{i,k}$	number of carcasses with a specified (read) age by period
num_ages	Number of age groups

Appendix Table B-2. Notation and definition of stochastic (a.k.a. fundamental) parameters used in the updated Jolly-Seber model.

Parameter	Definition
inv_Sigma_p	prior on process error variance/covariance matrix for p
inv_Sigma_phi	prior on process error variance/covariance matrix for phi
inv_Sigma_pent	prior on process error variance/covariance matrix for pent
$logit\_p_{1,k}$	prior on p (probability of capture) in the first period
$logit\_phi_{1,k}$	prior on phi (probability of survival) in the first period
$log\_delta_{1,k}$	prior on delta (probability of entry) in the first period
$logit\_p_{i,k}$	prior on p for periods 2:s
$logit\_phi_{i,k}$	prior on phi for periods 2:s
$log\_delta_{i,k}$	prior on delta for periods 2:s
$sigma\_lambda_k$	prior on shape and rate parameters for gamma distribution prior on total abundance (note: shape = rate = sigma_lambda^-2)
$v_{i,k}$	probability that a carcass that was handled in a given period will be marked and re-released back into the sample area
$Ntot_k$	continuous total abundance
$Nsuper_k$	discrete total abundance
inv_Sigma_pclip	prior on process error variance/covariance matrix for pclip
$logit\_ptule_1$	prior on ptule (portion of carcasses that were tule) in the first period
$logit\_pclip_{1,k}$	prior on pclip (portion of carcasses that were clipped) in the first period
$log\_delta\_age_{1,k,a}$	prior on delta_age (age distribution of carcasses) in the first period
$logit\_ptule_i$	prior on ptule for periods 2:s
$logit\_pclip_{i,k}$	prior on pclip for periods 2:s
$log\_delta\_age_{i,k,a}$	prior on delta_age for periods 2:s

Parameter	Definition
sigma_ptule$_i$	process error standard deviation for ptule
sigma_p.age	process error standard deviation for p.age

Appendix Table B-3. Notation and definition of derived parameters used in the updated Jolly-Seber model.

Parameter	Definition
$p_{i,k}$	probability that a carcass will be handled (i.e., captured) for a given period given that it is in the sample area
$phi_{i,k}$	probability that a carcass that is in the sample area for given period will remain (i.e., survive) in the sample area until the following sample period
$pent_{i,k}$	probability that a carcass enters the sample area between subsequent periods (i.e., the fraction of the total number of carcasses that enter the sample area between each period)
$psi_{i,k}$	probability that a carcass enters the sample area, is still available for capture, and is not seen before a specific period; $psi_{1,k} = pent_{1,k}$
$lambda_{i,k}$	probability that a carcass that has been captured will be captured again (i.e., recaptured); $lambda_{s,k} = 0$
$Bstar_{i,k}$	number of carcasses that enter the sample area between two subsequent sample periods (note: these include animals that enter and "leave" before the next sampling period)
$delta_{i,k}$	odds of entering in period
$temp_{i,k}$	probability of recovery = probability of survival ($phi_{i,k}$) X probability of capture ($p_{i,k}$)
$psiPtot_k$	overall probability of recovery a carcass in the sample area across all periods
$multP_{i,k}$	proportion of maiden captures in each period
$tau_{i,k}$	conditional probability that a carcass is recaptured during a specific period given that it was recaptured at or after that sampled period
$Sigma\_p_{k,k}$	Covariance matrix for p process errors; Inverse of "inv_sigma_p"
$Sigma\_phi_{k,k}$	Covariance matrix for phi process errors; Inverse of "inv_sigma_phi"
$Sigma\_pent_{k,k}$	Covariance matrix for pent process errors; Inverse of "inv_sigma_pent"
$sigma\_p\_process_k$	process error standard deviation for p
$sigma\_phi\_process_k$	process error standard deviation for phi
$sigma\_pent\_process_k$	process error standard deviation for pent
$rho\_p_{k,k}$	among strata process error correlation in p
$rho\_phi_{k,k}$	among strata process error correlation in phi
$rho\_pent_{k,k}$	among strata process error correlation in pent
$ptule_i$	proportion of total abundance that was of the run type tule (opposed to bright) by period
$pclip_{i,k}$	proportion of total abundance that was adipose clipped (opposed to UM - adipose intact) by period
$p.age_{i,k,a}$	proportion of total abundance that was of age "a" by period
$Sigma\_pclip_{k,k}$	Covariance matrix for the "pclip" process errors; Inverse of "inv_sigma_p"
$Sigma\_pclip\_process_k$	process error standard deviation for pclip
$rho\_pclip_{k,k}$	among strata process error correlation in pclip

Parameter	Definition
$delta\_age_{i,k,a}$	odds of the age distribution in carcasses' by period

JAGS Code for the Multivariate, Random-Walk Mark-Recapture Jolly-Seber Model to estimate the abundance of Chinook salmon in the lower Cowlitz River.

model{

```
#-----------------------
#Derived parameters
#-----------------------
Sigma_p<-inverse(inv_Sigma_p)
Sigma_phi<-inverse(inv_Sigma_phi)
Sigma_pent<-inverse(inv_Sigma_pent)
for(k in 1:num_strata){
 pent[1,k]<-1/(1+sum(delta[1:(s-1),k]))
 psi[1,k]<-pent[1,k]
 lambda[s,k] <- 0
 psiPtot[k] <- sum(temp[1:s,k])
 Bstar[1:s,k] ~ dmulti(pent[1:s,k], Nsuper[k])
 for (i in 1:(s-1)){
 phi[i,k] <- ilogit(logit_phi[i,k]) ^ time[i]
 delta[i,k]<-exp(log_delta[i,k]) * time[i]
 psi[i+1,k] <- psi[i,k]*(1-p[i,k])*phi[i,k] + pent[i+1,k] *(phi[i,k]-1)/log(phi[i,k])
 lambda[i,k] <- phi[i,k]*(p[i+1,k]+(1-p[i+1,k])*lambda[i+1,k])
 }
 for(i in 2:s){
 pent[i,k]<-delta[i-1,k]/(1+sum(delta[1:(s-1),k]))
 }
 for (i in 1:s){
 p[i,k] <- ilogit(logit_p[i,k])
 temp[i,k] <- psi[i,k]*p[i,k]
 multP[i,k] <- temp[i,k]/sum(temp[1:s,k])
 tau[i,k] <-p[i,k]/(p[i,k]+(1-p[i,k])*lambda[i,k])
 }
 #calculate process error variance and correlation matrix
 sigma_phi_process[k] <- sqrt(Sigma_phi[k,k])
 sigma_p_process[k] <- sqrt(Sigma_p[k,k])
 sigma_pent_process[k] <- sqrt(Sigma_pent[k,k])
 for (j in 1:num_strata){
 rho_phi[k,j] <- (Sigma_phi[k,j]/(sigma_phi_process[k]*sigma_phi_process[j]))
 rho_p[k,j] <- (Sigma_p[k,j]/(sigma_p_process[k]*sigma_p_process[j]))
 rho_pent[k,j] <- (Sigma_pent[k,j]/(sigma_pent_process[k]*sigma_pent_process[j]))
 }
}
#------
#priors
#------
for(k in 1:num_strata){
 sigma_lambda[k] ~ dt(hyper_value_sigma_lambda_mu, hyper_value_sigma_lambda_sd^-2, 1) T(0,)
 #nuisance variable to detect if n>0
```

```
 for (i in 1:s){
 v[i,k] ~ dbeta(hyper_value_beta_v, hyper_value_beta_v)
 }
 #Priors for first states in process model of prob capture, survival, birth:
 logit_phi[1,k] ~ dnorm(hyper_value_logit_phi_1_mu, hyper_value_logit_phi_1_sd^-2)
 logit_p[1,k] ~ dnorm(hyper_value_logit_p_1_mu, hyper_value_logit_p_1_sd^-2)
 log_delta[1,k] ~ dnorm(hyper_value_log_delta_1_mu, hyper_value_log_delta_1_sd^-2)
 #priors on abundance
 Ntot[k] ~ dgamma(sigma_lambda[k]^-2, sigma_lambda[k]^-2)
 Nsuper[k] ~ dpois(Ntot[k])
}
#process model priors
for (i in 2:(s-1)){
 logit_phi[i,1:num_strata] ~ dmnorm(logit_phi[i-1,1:num_strata], inv_Sigma_phi)
 log_delta[i,1:num_strata] ~ dmnorm(log_delta[i-1,1:num_strata], inv_Sigma_pent)#similar to
dirichlet trick except used additive log ratios
}
for(i in 2:s){
 logit_p[i,1:num_strata] ~ dmnorm(logit_p[i-1,1:num_strata], inv_Sigma_p)
}
#priors for process error covariance matrices
inv_Sigma_p ~ dwish(Rmat[1:num_strata,1:num_strata],num_strata + 1)
inv_Sigma_phi ~ dwish(Rmat[1:num_strata,1:num_strata],num_strata + 1)
inv_Sigma_pent ~ dwish(Rmat[1:num_strata,1:num_strata],num_strata + 1)
#-----------
#Likelihoods
#-----------
for(k in 1:num_strata){
 uTot[k] ~ dbin(psiPtot[k],Nsuper[k])
 u[1:s, k] ~ dmulti(multP[1:s,k],uTot[k])
 for (i in 1:(s-1)){
 R[i,k] ~ dbin(v[i,k], n[i,k])
 r[i,k] ~ dbin(lambda[i,k],R[i,k])
 }
 for (i in 2:(s-1)){
 m[i,k] ~dbin(tau[i,k],T[i,k])
 }
}
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
# Partition Bstar estimates by proportional data: race, clips, sex and age
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
#derived
Sigma_pclip<-inverse(inv_Sigma_pclip)
for(i in 1:s){
 ptule[i] <- ilogit(logit_ptule[i])
 pfall[i] <- ilogit(logit_pfall[i])
}
for(k in 1:num_strata){
sigma_pclip_process[k] <- sqrt(Sigma_pclip[k,k])
 for (j in 1:num_strata){
 rho_pclip[k,j] <- (Sigma_pclip[k,j]/(sigma_pclip_process[k]*sigma_pclip_process[j]))
 }
 for(i in 1:s){
```

```
 pclip[i,k] <-ilogit(logit_pclip[i,k])
 for(a in 1:num_ages){
 delta_age[i, k, a] <- exp(log_delta_age[i,k,a])
 p.age[i, k, a] <- delta_age[i,k,a]/sum(delta_age[i,k,1:num_ages])
 }
 }
}
#priors
inv_Sigma_pclip ~ dwish(Rmat[1:num_strata,1:num_strata],num_strata + 1)
sigma_ptule ~ dt(hyper_value_sigma_ptule_mu,hyper_value_sigma_ptule_sd^-2,1) T(0,)
sigma_pfall ~ dt(hyper_value_sigma_pfall_mu, hyper_value_sigma_pfall_sd^-2,1) T(0,)
sigma_p.age ~ dt(hyper_value_sigma_p.age_mu,hyper_value_sigma_p.age_sd^-2,1) T(0,)
for(i in 2:s){
 logit_ptule[i] ~ dnorm(logit_ptule[i-1],sigma_ptule^-2)
 logit_pfall[i] ~ dnorm(logit_pfall[i-1],sigma_pfall^-2)
 logit_pclip[i,1:num_strata] ~ dmnorm(logit_pclip[i-1,1:num_strata],inv_Sigma_pclip)
}
logit_ptule[1] ~ dnorm(hyper_value_logit_ptule_1_mu, hyper_value_logit_ptule_1_sd^-2)
logit_pfall[1] ~ dnorm(hyper_value_logit_pfall_1_mu, hyper_value_logit_pfall_1_sd^-2)
for(k in 1:num_strata){
 logit_pclip[1,k] ~ dnorm(hyper_value_logit_pclip_1_mu, hyper_value_logit_pclip_1_sd^-2)
 for(a in 1:num_ages){
 log_delta_age[1, k, a] ~
dnorm(hyper_value_log_delta_age_1_mu,hyper_value_log_delta_age_1_sd^-2)
 for(i in 2:s){
 log_delta_age[i, k, a] ~ dnorm(log_delta_age[i-1, k, a],sigma_p.age^-2)
 }
 }
}
#Likelihoods
for(k in 1:num_strata){
 for(i in 1:s){
 ex_clip[i, k] ~ dbin(pclip[i, k],ex_adfin[i, k])
 age_dat[i, k, 1:num_ages] ~ dmulti(p.age[i, k, 1:num_ages], age_tot[i, k])
}
for(i in 1:s){
 ex_tule[i] ~ dbin(ptule[i], ex_race[i])
 ex_fall[i] ~ dbin(pfall[i], ex_run[i])
}
}
```

Composition of Chinook Spawners in the Lower Cowlitz River

The composition of Chinook spawners was estimated by apportioning spawner abundance into sub-categories of interest using carcass recovery data. Overall, a similar approach is used to apportion both peak count and mark-recapture estimates (adapted from Serl et al. 2021):

Mark-Recapture Spawner Composition estimates were derived in the same J-S model used to estimate abundance. Briefly, carcass recoveries are pooled by survey period (i.e., week) and summarized by run (spring, fall), fin-clip status (adipose intact, adipose clipped), and age. Proportions by sub-categories are derived using binomial and multinomial likelihood distributions and total estimates of abundance by

sub-category are generated by multiplying period-specific proportional estimates by period specific estimates of abundance and summing.

Peak Count Expansion Method Spawner Composition: Carcass recoveries across the entire season are pooled, summarized into proportions by age and fin-clip status, and multiplied by the total peak count estimate of abundance for spring- and fall-run Chinook, separately, using the following equations:

$$N_{age_i} = N_{Total} \times Prop_{age_i}$$

$$N_{HOR,age_i} = N_{age_i} \times \frac{Prop_{AD}}{MR}$$

$$N_{NOR,age_i} = N_{age_i} \times \left(1 - \frac{Prop_{AD}}{MR}\right)$$

$$N_{HOR_{Total}} = \sum_{i}^{n} N_{HOR,age_i}$$

$$N_{NOR_{Total}} = \sum_{i}^{n} N_{NOR,age_i}$$

where

N_{Total} is the estimated total abundance derived via the peak count expansion method,

$Prop_{age_i}$ is the proportion of all carcasses that were read as total age$_i$,

N_{HOR,age_i} is the estimated hatchery-origin abundance for age$_i$ spawners,

$Prop_{AD}$ proportion of all carcasses that were adipose fin-clipped,

MR is the average mark-rate of hatchery-released Chinook from Cowlitz Falls Hatchery (i.e., the proportion of released smolts that were adipose fin-clipped prior to release),

N_{NOR,age_i} is the estimated natural-origin abundance for age$_i$ spawners,

$N_{HOR_{Total}}$ is the total estimate abundance of hatchery-origin spawners,

$N_{NOR_{Total}}$ is the total estimate abundance of natural-origin spawners, and

$pHOS$ is the proportion of all natural spawning Chinook on the that were of hatchery origin.

VSP-Abundance – Abundance of Lower Cowlitz Coho and Steelhead Spawners

Applies to: Lower Cowlitz Coho and Steelhead Spawner Abundance; 15.1 VSP & Population: Abundance of Spawners

Spawner abundance of coho and steelhead are estimated for Lower Cowlitz tributaries only. No spawner abundance estimate is generated for the Lower Cowlitz River mainstem.

The analytical approach for both species was similar and included 1) mark-recapture to estimate adult spawner abundance in areas above resistance board weirs, 2) redd counts in index reaches of variable length that were not necessarily representative of all habitat in the area an abundance estimate was being made, 3) redd counts in reaches selected to be representative of un-surveyed habitat which their densities were applied to generate total redd abundance estimates for each abundance estimation stratum or "subpopulation" 4) biological data including samples of live and dead fish for sex and mark status (presence or absence of a CWT and adipose fin).

The lower Cowlitz tributary habitat was divided into spatial strata to facilitate abundance estimation. This year, two resistance board weirs were operated on Lacamas and Olequa Creeks during the coho season and on Delameter and Ostrander creeks for the steelhead season to prevent hatchery origin (marked) spawners from spawning upstream. These weirs did not capture all fish due to submersion during high water periods. However, natural origin steelhead and coho that were captured during favorable water periods were tagged with two Floy® tags and an opercle punch and then released upstream, and a portion of them were recaptured or re-sighted as live spawners, kelts, or carcasses, in addition to untagged fish, facilitating adult abundance estimation via Lincoln-Petersen estimates (Seber 1982). By spatially pairing mark recapture estimates of adult abundance above these weirs with spawning ground surveys that counted redds above them to generate a total redd estimate and biological data to estimate the sex ratio of spawners, it was possible to estimate the number of observable redds constructed per female spawner. Estimates of observable redds per female from these above-weir areas were then used in conjunction with expanded total redd counts and sex ratio data collected in areas where mark-recapture was not possible (e.g., below weirs). The final abundance estimate was the sum of estimates from each stratum within the survey frame.

Models for both species were implemented in a Bayesian framework. The Bayesian analytical approach estimated the posterior probability distribution of each parameter in the models, which is the product of a prior distribution and the probability of the data given the model or likelihood (Gelman et al. 2004). In most cases, prior distributions selected for this analysis were vague and uninformative (Table 2). However, informative priors were used for the mean and dispersion of steelhead redd density (Table 4) and was necessary to facilitate convergence of the analysis model. Samples of the posterior distribution were obtained from Markov Chain Monte Carlo simulations (Gilks 2005) using JAGS (Plummer 2003) via the 'rjags' and 'R2jags' packages (Su and Yajima 2015, Plummer 2016) in the R statistical computing environment. For steelhead the simulations used three MCMC chains of 1,000,000 samples each. To minimize the impact of the initial values and autocorrelation on the final parameter estimate, we discarded the initial 200,000 samples (burn-in) and thinned the samples (1 in 1,000) included in the posterior distribution. For coho the simulations used four MCMC chains of 200,000 samples each. To minimize the impact of the initial values and autocorrelation on the final parameter estimate, we

discarded the initial 100,000 samples (burn-in) and thinned the samples (1 in 100) included in the posterior distribution. Model convergence was determined from visual assessment of traceplots for chain mixing, evaluation of the Brook-Gelman-Rubin statistic (Su et al. 2001), and the ensuring the effective sample size for the number of posteriors draws was >1,000 and preferably closer to 4,000. For each reported parameter, results are summarized by the median and 95% credible intervals of the posterior distribution. A more detailed description of the differences in the models used for steelhead and coho as well as the model equations, data, and likelihoods used for the analyses are provided in Tables 1 and 2 (coho) and Tables 3 and 4 (steelhead).

Coho Model

Coho abundance was estimated using a multivariate autoregressive state-space model. As a state-space model, the model was comprised of both a process model and observation model. The process model describes the relationships between parameters "states" and their co-evolution over time and is intended to represent the biology of the system. The parameters of the process model are informed by observation models which relate specific states to observed data via likelihoods. For purposes of estimating coho abundance, mean redd density in each sub-population was defined as the state which would evolve over time, and which through various transformations relationships with other parameters defined in the process model, could be used to estimate abundance VSP parameters of interest (abundance and the proportion of the population that was marked—adipose-clipped or CWT positive). The model was run for spawn years 2010-2018 for 27 sub-population monitoring units (denoted P) comprising the vast majority of the Lower Columbia Coho Evolutionarily Significant Unit (ESU) that occurs within Washington State, including five "sub-populations" which together comprised the Lower Cowlitz River Population. Strata for coho salmon included 1) lower Cowlitz tributary areas not above resistance board weirs, 2) Delameter Creek and tributaries above the resistance board weir, 3) Lacamas Creek and tributaries above the resistance board weir, 4) Olequa Creek and tributaries above the resistance board weir, 5) Ostrander Creek and tributaries above the resistance board weir.

Appendix Table B-4. Parameters, their descriptions, and equations (the process model; no likelihoods directly involving data) used to estimate coho spawner abundance in the lower Cowlitz River tributaries.

Process Model			
Parameters	**Description**	**Equation**	**Priors**
$log\_lambda_{p,}$	Log lambda is the density of spawners per mile	$log\_lambda_{p,y} = log\_lambda_{p,y-1} + w_{redd_{p,y}} + w_{redd\_all_y}$	
$w_{redd_{p,y}}$ $w_{redd\_all_y}$	w_{redd} was a population specific process error in annual redd density assumed to be normally distributed with mean of zero and standard deviation σ_{redd}. $w_{redd\_all_y}$ was a shared process	$w_{redd_{p,y}} \sim \mathrm{N}(0,)$	NA

Process Model			
Parameters	**Description**	**Equation**	**Priors**
	error among all populations in annual redd density assumed to be normally distributed with mean of zero and standard deviation σ_{redd_all}.		
Σ ρ σ_{redd}	The covariance matrix Σ was a square matrix with dimensions equal to the number of populations *P*. The covariance matrix had constant variance σ_{redd} and among-population correlations ρ.	$\Sigma = \rho\sigma_{redd}^2$ (off-diagonal elements) $\Sigma = \sigma_{redd}^2$ (diagonal elements)	$\rho \sim \text{Uniform}(0,1)$ σ_{redd}~ Normal (0,0.5) truncated [0,]
$redd\_tot_{p,y}$	The total redd abundance in each population and year *redd_tot* could be estimated by multiplying the redd density μ_{redd} by the total number of miles of coho habitat $miles_{tot_p}$	$redd\_tot_{p,y} = \mu_{redd_{p,y}} \times miles_{tot_p}$	NA
$F_{p,y}$	The female spawner abundance $F_{p,y}$ could be estimated by dividing the total redd abundance $redd\_tot_{p,y}$ by the apparent number of redds per female *RpF* (which was modeled as constant among populations and years).	$F_{p,y} = \frac{redd\_tot_{p,y}}{RpF}$	$RpF \sim \text{Gamma}(3,4)$
$S_{p,y}$	The total spawner abundance *S* could then be	$S_{p,y} = \frac{F_{p,y}}{pF_{p,y}}$	NA; see likelihoods for prior on pF

Process Model			
Parameters	**Description**	**Equation**	**Priors**
	estimated by dividing the female abundance $F_{p,y}$ by the proportion of females $pF_{p,y}$		
$HOS_{p,y}$ $NOS_{p,y}$	The marked (hatchery origin) HOS and unmarked NOS spawner abundance could be estimated by multiplying the total abundance by the proportion of marked spawners *pM*	$HOS_{p,y} = S_{p,y} \times pM_{p,y}$ $NOS_{p,y} = S_{p,y} - HOS_{p,y}$	NA
$pM_{p,y}$	The proportion of marked spawners *pM* was modeled as a random-walk, except a logit rather than log-link function was used.	$\text{logit}(pM_{p,y}) = \text{logit}(pM_{p,y-1}) + w\_pM_{p,y}$	$\text{logit}(pM_{p,y=1}) \sim \text{Normal}(0,100)$
$w_{pM_{p,y}}$	The process errors in the proportion marked w_{pM} were assumed to be independent among (univariate normal; no covariance among populations):	$w_{pM_{p,y}} \sim \text{Normal}(0, \sigma_{pM})$	σ^2_{pM} ~ Normal (0,0.5) truncated [0,2]
$redd\_I_{p,y}$ $redd\_G_{p,y}$ *pIndex*	The redd total *redd_tot* could be further apportioned into those redds located in index reaches *redd_I* where census surveys occurred, and redds located in the remainder of the basin *redd_G* by multiplying by the proportion of redds occurring in index reaches *pIndex* by the total.	$redd\_I_{p,y} = redd\_tot_{p,y} \times pIndex_{p,y}$ $redd\_G_{p,y} = redd\_tot_{p,y} \times (1 - p\_Index_{p,y})$	$pIndex_{p,y} = \begin{cases} miles_{G_{p,y}} = miles_{tot_p}; 0 \\ miles_{I_{p,y}} = miles_{tot_p}; 1 \\ miles_{G_{p,y}} + miles_{I_{p,y}} < miles_{tot_p}; \text{Beta}(0. \end{cases}$

Process Model			
Parameters	**Description**	**Equation**	**Priors**
$\mu_{G_{p,y}}$	The redd density (redds/mile) in non-index areas $\mu_{G_{p,y}}$, a subset of which were surveyed within GRTS reaches was estimated by dividing the total number of redds occurring outside of index census areas $redd\_G_{p,y}$ by the mileage of habitat outside of index areas *G_miles*.	$\mu_{G_{p,y}} = \frac{redd\_G_{p,y}}{miles_{G_{p,y}}}$	NA
$p_{p,y}$	The negative binomial probability parameter *p* was derived from redd density (redds/mile) in non-index areas $\mu_{G_{p,y}}$ and the negative binomial dispersion parameter *r*	$p_{p,y} = \frac{r_{p,y}}{r_{p,y} + \mu_{G_{p,y}}}$	NA
r_p $\sigma^2_{dispersion_p}$ $\mu_{hyper-disp}$ $\sigma_{hyper-dispersio}$	Since the negative binomial dispersion is equivalent to a gamma-poisson mixture, the overdispersion parameter *r* may be interpreted as shape parameter of the latent gamma distribution. An intuitive prior may be placed on *r* by transforming it into the standard deviation $\sigma^2_{dispersion_p}$ of the latent gamma distribution. This standard deviation for each population was	$r_p = \sigma^2_{dispersion_p}$ $\sigma^2_{dispersion_p} \sim$ lognormal$(\log(\mu_{hyper-disp}), \sigma_{hyper-disp}$	$\mu_{hyper-disp} \sim$ Cauchy (0,2.5) $\sigma_{hyper-dispersion} \sim$ Cauchy (0,2.5)

Process Model			
Parameters	**Description**	**Equation**	**Priors**
	then modeled as a log-normal random effect with hyper-parameters $\mu_{hyper-disp}$ and $\sigma_{hyper-dispersion}$.		

Appendix Table B-5. Data, their descriptions, and likelihoods (the observation model) used to estimate coho spawner abundance in the lower Cowlitz River tributaries.

Observation Model (Data and Likelihoods)			
Data/Parameters	**Description**	**Likelihood**	**Priors**
Data: $m_{2_{p,y}}$ $n_{2_{p,y}}$ Parameters: $p_{tag_{p,y}}$	The number of tagged carcasses and live fish recovered or observed upstream of tributary weir m_2 was binomially distributed based on proportion of the population that was marked p_{tag} and total the number of fish tagged and untagged fish recovered n_2 as carcasses, resighted as live spawners, or recovered as carcasses that washed up on weirs	$m_{2_{p,y}} \sim \text{Binomial}\ (p_{tag_{p,y}}, n_{2_{p,y}})$	$p_{tag_{p,y}} \sim \text{Beta}(0.5,0.5)$
Data: $n_{1_{p,y}}$ Parameters: $p_{tag_{p,y}}$ $S_{p,y}$	The number of live unmarked fish that were tagged and passed upstream of tributary weir n_1 was Poisson distributed, with lambda equal to the total population abundance $S_{p,y}$ multiplied by the proportion of the population that was marked p_{tag}	$n_{1_{p,y}} \sim \text{Poisson}\ (p_{tag_{p,y}} \times S_{p,y})$	NA; See process model
Data: $f_{p,y}$ $a_{p,y}$	The number of female carcasses or kelts that were	$f_{p,y} \sim \text{Binomial}\ (pF_{p,y}, a_{p,y})$ $\text{logit}(pF_{p,y}) \sim \text{Normal}\ (\mu_{pF}, \sigma_{pF})$	$\mu_{pF} \sim \text{Normal}(\text{logit}(0.45),1)$ $\sigma_{pF} \sim$ Normal (0,0.5) truncated [0,]

Observation Model (Data and Likelihoods)			
Data/Parameters	**Description**	**Likelihood**	**Priors**
Parameters: $pF_{p,y}$ μ_{pF} σ_{pF}	sampled for sex $f_{p,y}$ was binomially distributed as a function of the proportion of females in the population $pF_{p,y}$ and the total number of carcasses or kelts that were sampled for sex $a_{p,y}$. The proportion of females $pF_{p,y}$ was modeled as a logit-normal random effect among all populations and years with a hierarchical mean of μ_{pF} and a random effect standard deviation of σ_{pF}.		
Data: $h_{p,y}$ $ms_{p,y}$ Parameters: $pM_{p,y}$	The number of marked (CWT positive or adipose clipped) carcasses, kelts, or sighted live spawners $h_{p,y}$ was binomially distributed as a function of the proportion of marked fish in the population $pM_{p,y}$ and the total number of carcasses, kelts, or sighted live spawners for which origin (marked/unmarked) could be determined $ms_{p,y}$	$h_{p,y} \sim \text{Binomial}\ (pM_{p,y}, ms_{p,y})$	NA (see process model for prior on pF)
Data: $redd\_g\_obs_{p,y,s}$ $miles_{g_{p,y,g}}$ Parameters: $p_{p,y}$ r_p	The number of redds $redd\_g\_obs_{p,y,s}$ observed in GRTS reach *g* of population *p* in year *y* was negative binomially distributed with	$redd_{g_{obs}p,y,g} \sim \text{Negative Binomial}\ (p_{p,y}, r_p \times miles_{g_{p,y,g}})$	NA (see process model for priors on $p_{p,y}$ and r_p)

Observation Model (Data and Likelihoods)			
Data/Parameters	**Description**	**Likelihood**	**Priors**
	shape parameters $p_{p,y}$ and r_p. An offset $miles_{g_{p,y,g}}$ (the length in miles of reach *g* of population *p* in year *y*) was used to adjust r_p and accounted for the fact that not all reaches were exactly one mile in length.		
Data: $redd\_I\_obs_{p,y}$ Parameters $redd\_I_{p,y}$	The total number of redds $redd\_I\_obs_{p,y}$ observed in all index reaches in population *p* in year *y* was Poisson distributed with lambda equal to	$redd\_I\_obs_{p,y} \sim \text{Poisson}\ (redd\_I_{p,y})$	NA (see process model for estimation of $redd\_I_{p,y}$)
Data: $miles_{tot_p}$	the total number of miles of coho habitat $miles_{tot_p}$ for each population	NA; assumed to be measured without error	NA
Data: $miles_{I_{p,y}}$	The number of miles of "index" census spawning ground surveys $miles_{I_{p,y}}$	NA; assumed to be measured without error	NA
Data: $miles_{g_{p,y,g}}$	The length in miles of individual GRTS reach *g* in population *p* in year *y*	NA; assumed to be measured without error	NA
Data: $miles_{G_{p,y}}$	The total number of miles not in the index census portion of the watershed. A representative subset of this stream length was surveyed in individual GRTS surveys $miles_{g_{p,y,g}}$ however the sum of the GRTS surveys does not equal this parameter due to the "missed miles" the GRTS surveys	$miles_{G_{p,y}} = miles_{tot_p} - miles_{I_{p,y}}$ (not a likelihood; assumed to be measured without error)	NA

Observation Model (Data and Likelihoods)			
Data/Parameters	**Description**	**Likelihood**	**Priors**
	are intended to be representative of.		

Steelhead Model

The model used to estimate abundance for steelhead involved the same fundamental data inputs as the coho model and it is anticipated that in future years the same or very similar model will be used. However, a multivariate state space (multi-year) approach has not yet been developed for steelhead and therefore the model was implemented with data from single year (spawn year 2018), which necessitated some structure changes relative to the coho model. Spatial strata for steelhead estimates included 1) lower Cowlitz tributary areas not above resistance board weirs (except Blue creek), 2) Delameter Creek and tributaries above the resistance board weir, 3) Lacamas Creek and tributaries above the resistance board weir, 4) Olequa Creek and tributaries above the resistance board weir, 5) Ostrander Creek and tributaries above the resistance board weir, and 6) Blue Creek, which did not have weir but was separated for estimation purposes to due to the high proportion of hatchery spawners.

Appendix Table B-6. Parameters, their descriptions, and model equations (no likelihoods directly involving data) used to estimate steelhead spawner abundance in the lower Cowlitz River tributaries.

Model Equations (no likelihoods directly involving data)			
Parameter(s)	**Description**	**Equation**	**Priors**
$redd\_miss_p$	The number of missed redds which occurred in reaches not surveyed within the GRTS frame of the below-weir subpopulation	$redd\_miss_p \sim \text{Negative Binomial}(\text{p}, \text{r} \times \text{miles\_miss}_p)$	NA (see likelihoods for *p* and *r* priors)
$redd\_tot_p$	The total redd abundance in each population and year *redd_tot* was estimated by adding the index (census) redds $redd\_I\_obs_p$, the sum of the redds number of redds $redd\_g\_obs_s$ observed in each one mile GRTS reach *g*, and the estimate of missed redds based on the miles the GRTS redd density was applied to	$redd\_tot_p = redd\_I\_obs_p + redd\_miss_p + \sum_{g}^{G} redd\_g\_obs_g$	NA

Model Equations (no likelihoods directly involving data)			
Parameter(s)	**Description**	**Equation**	**Priors**
F_p	The female spawner abundance F_p could be estimated by dividing the total redd abundance $redd\_tot_p$ by the apparent number of redds per female RpF	$F_p = \frac{redd\_tot_p}{RpF}$	NA
RpF	The apparent number of redds per female RpF was modeled as a single parameter jointly across weir basins.	NA	$RpF \sim$ LogNormal(log (1),1)
S_p	The total spawner abundance *S* could then be estimated by dividing the female abundance F_p by the proportion of females pF_p	$S_{p,y} = \frac{F_p}{pF_p}$	NA
HOS_p NOS_p	The marked (hatchery origin) HOS and unmarked NOS spawner abundance could be estimated by multiplying the total abundance by the proportion of marked spawners *pM*	$HOS_p = S_p \times pM_p$ $NOS_p = S_p - HOS_p$	NA

Appendix Table B-7. Data, their descriptions, and likelihoods used to estimate steelhead spawner abundance in the lower Cowlitz River tributaries.

Data and Likelihoods			
Data/ Parameters	**Description**	**Likelihood**	**Priors**
Data: m_{2_p} n_{2_p} Parameters: p_{tag_p}	The number of tagged carcasses and live fish recovered or observed upstream of tributary weir m_2 was binomially distributed based on proportion of the population that was marked p_{tag} and total the number of	$m_{2_p} \sim$ Binomial (p_{tag_p}, n_{2_p})	$p_{tag_p} \sim$ Beta(0.5,0.5)

Data and Likelihoods			
Data/ Parameters	**Description**	**Likelihood**	**Priors**
	fish tagged and untagged fish recovered n_2 as carcasses, resighted as live spawners, or recovered as carcasses that washed up on weirs		
Data: n_{1_p} Parameters: p_{tag_p} S_p	The number of live unmarked fish that were tagged and passed upstream of tributary weir n_1 was Poisson distributed, with lambda equal to the total population abundance S_p multiplied by the proportion of the population that was marked p_{tag_p}	$n_{1_p} \sim \text{Poisson}\ (p_{tag_p} \times S_p)$	NA
Data: f_p a_p Parameters: $pF_{p,y}$ μ_{pF} σ_{pF}	The number of female carcasses or kelts that were sampled for sex f_p was binomially distributed as a function of the proportion of females in the population pF_p and the total number of carcasses or kelts that were sampled for sex a_p. The proportion of females pF_p was modeled as a logit-normal random effect among all sub-populations with a hierarchical mean of μ_{pF} and a random effect standard deviation of σ_{pF}	$f_{p,y} \sim \text{Binomial}\ (pF_{p,y}, a_{p,y})$ $\text{logit}(pF_{p,y}) \sim \text{Normal}\ (\mu_{pF}, \sigma_{pF})$	$\mu_{pF} \sim \text{Normal}(\text{logit}(0.5),1)$ σ_{pF} ~ half-Cauchy (0,0.5)
Data: h_p ms_p	The number of marked (CWT positive or adipose clipped) carcasses, kelts, or sighted live	$h_p \sim \text{Binomial}\ (pM_p, ms_p)$	$77777pM_p \sim \text{Beta}(0.5,0.5)$

Data and Likelihoods			
Data/ Parameters	**Description**	**Likelihood**	**Priors**
Parameters pM_p	spawners h_p was binomially distributed as a function of the proportion of marked fish in the population pM_p and the total number of carcasses, kelts, or sighted live spawners for which origin (marked/unmarked) could be determined $ms_{p,y}$		
Data: $redd\_I\_obs_p$	The total number of redds $redd\_I\_obs_p$ observed in all index (census) reaches in population *p*.	NA; assumed to be measured without error	NA
Data: $redd\_g\_obs_s$ Parameters: p μ_G r $\sigma_{dispersion}$	The number of redds $redd\_g\_obs_s$ observed in each one mile GRTS reach *g*. This likelihood was only used for the below weir subpopulation were negative binomially distributed with shape parameters *p* and *r*. The negative binomial probability parameter *p* was derived from mean redd density (redds/mile) in non-index areas $\mu_{G_{p,y}}$ and the negative binomial dispersion parameter *r* , which was reparameterized as a standard deviation $\sigma_{dispersion}$ to facilitate an uninformative Cauchy prior.	$redd\_g\_obs_g$ $\sim$Negative Binomial (p, r) $p = \frac{r}{r + \mu_G}$ $r = \sigma_{dispersion}^{-2}$ $\sigma_{dispersion}$	$\mu_{redd} \sim \text{LogNormal}(\log(0.14), 1)$ A vague Empirical Bayes prior with mean equal to 0.14 (the observed arithmetic mean number of redds per mile) was used. This vague prior has a 95% CI of 0.1 – 7.1 redds per mile, in order to let the data dominate the likelihood in estimating redds per mile. NA $\sigma_{dispersion} \sim \text{half} - \text{Cauchy}(0, 2.5)$
Data: $miles_{tot_p}$	the total number of miles of coho habitat $miles_{tot_p}$ for each population	NA; assumed to be measured without error	NA

Data and Likelihoods			
Data/ Parameters	**Description**	**Likelihood**	**Priors**
Data: $miles_{I_{p,y}}$	The number of miles of "index" census spawning ground surveys $miles_{I_{p,y}}$	NA; assumed to be measured without error	NA
Data: $miles_{g_{p,g}}$	The length in miles of individual GRTS reach *g* in population *p*	NA; assumed to be measured without error	NA
Data: $miles_{miss_p}$	The total number of miles not in the index census or GRTS reaches.	$miles_{miss_p} = miles_{tot_p} - miles_{I_p} - \sum_{g=1}^{G} miles_{g_{p,g}}$ (not a likelihood; assumed to be measured without error)	NA

Demographic Replacement

Applies to: 16.10 Hatchery Assessment: Demographic Replacement

Programs intended to supplement populations may inadvertently fail to achieve demographic replacement of natural-origin fish collected as broodstock, and thus, removed from the naturally spawning population. Demographic replacement means that hatchery-origin spawners in nature must produce at least an equivalent number of estimated offspring as would have been produced by natural-origin broodstock had they spawned in nature instead of the hatchery.

Equation:

$d = N_{NOB}/(r(N_{HOR} - f))$

where: d = the demographic replacement rate
N_{NOB} = the number of natural-origin fish collected as broodstock from the population
N_{HOR} = the number of hatchery-origin returns in nature (potential spawners in the population)
r = the estimated relative reproductive success of hatchery-origin fish to natural-origin fish (from studies or literature)
f = the number of hatchery-origin fish removed by mark-selective harvest

Note: *f* is the harvest rate after enumeration of hatchery origin returns
Note: if the number of hatchery-origin spawners is used instead of returns, *f* = 0.

Interpretation of results:
When $d < 1$, demographic replacement has not been achieved. The population is experiencing mining.
When $d = 1$, demographic replacement has been achieved
When $d > 1$, demographic replacement has been exceeded and supplementation achieved.

See Anderson et al. (2020) for a more in depth assessment of the effects of pHOS, pNOB and fitness of the interaction of hatchery programs and natural populations.

pHOS, pNOB, PNI

Applies to: 16.2 Hatchery Assessment: Proportion of Hatchery Origin Spawners; 16.3 Hatchery Assessment: Proportions of Natural- and Hatchery-Origin Broodstock; 16.4 Hatchery Assessment: Proportionate Natural Influence

$pHOS$ is the proportion of natural-spawning salmon (spring Chinook, fall Chinook, Coho) and winter steelhead that were of hatchery origin.

$$pHOS = \frac{N_{HOS}}{N_{Total}}$$

Where

N_{HOS} is the abundance of hatchery origin spawners,

N_{Total} is the abundance of hatchery origin plus natural origin spawners (i.e., total spawner abundance), and

$pNOB$ is the proportion of natural-origin salmon (spring Chinook, fall Chinook, Coho) and winter steelhead in the hatchery broodstock.

$$pNOB = \frac{N_{NOB}}{N_{Total}}$$

Where

N_{NOB} is the abundance of hatchery origin spawners,N_{Total} is the total broodstock composed of hatchery origin plus natural origin adults, and

PNI is the proportionate natural influence of the composition of the naturally spawning fish and the hatchery broodstock on the natural population (spring Chinook, fall Chinook, Coho, winter steelhead).

$$PNI = \frac{pNOB}{pNOB + pHOS}$$

Where

$pNOB$ is the proportion of natural origin adults in the broodstock, and

$pHOS$ is the proportion of hatchery origin spawners on the spawning grounds.

Harvest

Applies to: 18 Fishery/Harvest Metrics, Hypotheses, Analytical Approaches

Spot Creel Surveys

Spot creel surveys are conducted for winter steelhead, spring and fall Chinook, coho and summer steelhead. Surveys are conducted up to six days per week, typically with a single surveyor per day. Occasionally, a second surveyor is available and surveys areas can be divided among surveyors. Each

survey day, the creel surveyor visits each of the 11 interview locations between Gerhart Gardens at the mouth of the Cowlitz River and Barrier Dam and interviews subsets of all boat and shore anglers at each location. Time spent at each interview location is proportional to the relative number of anglers at that location. Additional surveys, below the I-5 Bridge, are sometimes conducted by WDFW staff from the Region 5 Ridgefield office. Information collected includes fishing method (boat, shore, gear), start time, count of fish kept by species and origin (hatchery, natural). Coho are assigned as jacks in the field when less than 47cm fork length (FL). Chinook are assigned as jacks in the field when less than 56cm FL for fall Chinook and less than 59cm FL for spring Chinook. Landed catch are sampled for scales and coded-wire tags. Angler reported information includes count of fish released by species and origin (hatchery, natural).

Effort (number of anglers, hours fished) is summarized by month and location for boat and shore anglers. Summarized effort data are an index representing relative effort among locations; an estimate of total effort will require a different and more rigorous statistical design for the creel surveys. Catch (NOR released, HOR retained) is summarized by location for boat and shore anglers. The summarized catch data are an index of catch representing relative differences among locations on the lower Cowlitz River.

Catch of Natural-Origin Fish in the Cowlitz River Fishery – Catch Card Methodology

Catch Record Cards (CRCs) are used to produce species specific kept-catch estimates for the Cowlitz River winter steelhead, spring and fall Chinook Salmon, Coho Salmon, and summer steelhead fisheries. The CRC system depends primarily on voluntary participation and compliance by anglers. In order to fish for salmon and steelhead, an angler is required to purchase a CRC. When an angler catches and lands a salmon or steelhead, they are required to record that catch on their CRC card. CRC are valid for a one year time frame (April-March). At the end of the year, the angler is to return their CRC to the WDFW. Anglers holding in-sample cards are sent reminders to return their CRC to WDFW.

CRCs require the angler to enter the location where they caught and landed their fish. For the Cowlitz River, there are several different locations that can be recorded: (561 Cowlitz River below Mayfield; 563 Cowlitz River between Mayfield Dam and Cowlitz Falls Dam; 559 Cowlitz River above Cowlitz Falls Dam and Lake Scanewa; and 555 Cispus River). Data recorded on CRCs is then summarized to determine the total number of fish recorded by species and fishing location (harvest summary), which is expanded to estimate total annual catch by species and fishing location. A bias adjustment factor is applied for some species and in some areas to account for successful anglers returning cards at a higher rate than unsuccessful anglers. Accurate harvest rates in fisheries are needed to calculate several key metrics used to evaluate various production program options, including natural origin spawner (NOS) and hatchery origin spawner (HOS) abundance estimates. In general, estimates based on CRCs have a lower level of accuracy as compared to statistical creel programs. Over the next 3 to 5 years, data collected through an improved abundance estimation methodology should be used to determine if increased precision in catch estimates is needed to achieve the precision goal (CV = 15%) for NOS and HOS abundance estimates.

Work Elements

- Summarize recorded catch by species and location

- Expand recorded catch to estimate total annual catch by species and location

Deliverables

The number of hatchery fish kept by species and location as determined by catch record cards.

Estimates of catch are generated for non-retained (i.e., caught and released; C&R) natural-origin (NOR) salmon and steelhead in the lower Cowlitz River recreational fishery using the expanded catch record card (CRC) methodology (Conrad and McHugh 2008, Alexandersdottir et al. 2013, Bentley 2016). The expanded CRC method generates estimates of catch by pairing estimates of retained (i.e., harvested) hatchery-origin (HOR) fish that are generated from the WDFW's off-site CRC reporting system (Kraig and Scalici 2020) and compositional catch data collected from on-site (spot) creel surveys (Appendix Table B-8). Although the actual statistical model is constructed in a different manner, in essence, estimates of released NORs are generated by subtracting the CRC estimate of harvested HORs from an estimate of total catch consisting of both harvested HORs and released NORs by period (i.e., month). The estimates of total catch are generated by expanding the CRC estimate of harvested HORs by the proportion of catch that was consisted of harvested HORs that is estimated from angler surveys collected from on-site creel surveys. The expanded CRC method should provide unbiased estimates of NOR catch when (1) the fishery allows for retention of hatchery-origin fish, (2) the run timing of natural-origin and hatchery-origin fish overlap in the fishery, (3) the creel surveys provide a representative sample of the true catch composition of hatchery- and natural-origin fish, and (4) the proportion of unmarked (adipose intact) hatchery fish in the catch is low.

Appendix Table B-8. Crosswalk between the fin-clip status of a fish sampled during on-site creel surveys and its final origin designation (HOR = hatchery, NOR = natural).

Origin	Fin-Clip Status	Description
NOR	UM$^{\Psi}$	No Adclip + No Other external marks
HOR	AD+LV+RV	Adclip + Left Ventral fin clip + Right Ventral fin clip
	RV	No Adclip + Right Vent fin clip
	AD+LV	Adclip + Left Ventral fin clip
	LV	No Adclip + Left Vent fin clip
	AD	Adclip clip + No other external marks
	AD+RV	Adclip + Right Ventral fin clip
	AD+RP	Adclip + Right Pectoral fin clip
	RP	No Adclip + Right Pectoral fin clip
	AD+UNK	Adclip + Unknown fin clip
	AD+LP	Adclip + Left Pectoral fin clip
	LP	No Adclip + Left Pectoral fin clip
	UNKAD+RP	Unknown Adipose + Right Pectoral fin clip
	UNKAD+LV	Unknown Adipose + Left Ventral fin clip
	UNKAD+LP	Unknown Adipose + Left Pectoral fin clip
	UNKAD+RV	Unknown Adipose + Right Ventral fin clips
UNK	UNK	Unknown Adipose + Unknown fin clip
	NULL	Blank

Note: $^{\Psi}$ A small portion of UM fish are likely double-index tagged (DIT) hatchery-origin.

Summarized catch data were analyzed using a model that implemented a Bayesian state-space framework. Detailed summary statistics and equations used for analysis are provided in Appendix Table B-9 and Appendix Table B-10. The Bayesian analytical approach provides a posterior distribution that represents the probable values of each derived parameter and is derived as the product of a prior distribution and the probability of the data given the model or likelihood (Gelman et al. 2004). The posterior distribution was obtained using the software program Stan (Carpenter et al. 2017) to generate posterior probabilities of all unknown parameters in the model. Stan implements gradient-based MCMC methods termed "Hamiltonian Monte-Carlo" via the "No-U-Turn" sampler. We interfaced with Stan using Program R and the *rstan* package (Stan Development Team 2018a). We ran four Markov chains each with a total of 10,000 iterations that included a warm-up (i.e., burn-in) of 5,000 iterations and a thin-rate of one resulting in a total of 20,000 posterior draws. Models were accessed for convergence using a range of diagnostic tools offered in the *ShinyStan* package (Stan Development Team 2018b) including, visual examination of posterior distributions and trace plots, calculation of effective sample sizes (ESS) and evaluation of the Brook-Gelman-Rubin statistic ($\hat{R}$).

Appendix Table B-9. Summary statistics (i.e., data) used for estimating catch of natural-origin fish in the lower Cowlitz River fishery.

Statistic	Definition
P	Total number of periods (i.e., months) over which catch estimates will be generated for a given species
n_CRC	Total number of periods (i.e., months) used in likelihood to estimate *CRC_true*
n_creel	Total number of periods (i.e., months) used in likelihood to estimate *prop_HOR*
Lifestage_CRC	Life stage number associated with each *CRC_est* and *CRC_CV*
Lifestage_creel	Life stage number associated with each *c_HOR* and *c_NOR*
Period_CRC	Period number associated with each *CRC_est* and *CRC_CV*
Period_creel	Period number associated with each *c_HOR* and *c_NOR*
CRC_est	Estimate of catch for harvested hatchery-origin fish generated from CRCs by period for a given species and life stage
CRC_CV	Estimated coefficient of variation of catch for harvested hatchery-origin fish generated from CRCs by period for a given species and life stage. *CRC_CV* is converted to *CRC_SD*, which is the lognormal standard deviation of catch using the equation: sqrt(log(*CRC_CV*)^2 + 1)
c_HOR	total observed catch of harvested hatchery-origin fish from creel surveys by period for a given species and life stage
c_NOR	total observed catch of released natural-origin fish from creel surveys by period for a given species and life stage and life stage
c_total	Summation of observed catch of harvested hatchery-origin and released natural-origin fish by period for a given species and life stage

Appendix Table B-10. Priors, likelihoods, and parameters used for estimating catch of natural-origin fish in the lower Cowlitz River fishery.

Parameter	Description	Likelihood/Equation
CRC_true	Reconstructed posterior distribution of the number of harvested hatchery-origin fish estimated with catch record cards by period for a given species and life-stage	$CRC_{true} = NOR_{true} \times \frac{prop\_HOR}{1 - prop\_HOR}$ $CRC\_est \sim lognormal(\log(CRC\_true, CRC\_SD)$
$prop\_HOR$	Proportion of the total estimated catch comprised of harvested hatchery-origin fish	$prop\_HOR_p = inv\_logit(logit(prop\_HOR_{p-1}) + eps\_pHOS_{p-1} \times sigma\_proc\_pHOS))$ $c\_HOR \sim binomial(c\_total, prop\_HOR])$

Parameter	Description	Likelihood/Equation
	by period for a given species and life stage	
$sigma\_proc\_pHOS$	Process error for *prop_HOR*	$sigma\_proc\_pHOS \sim std\_normal()$
eps_pHOS	Non-centered process error for *prop_HOR*	$eps\_pHOS \sim std\_normal()$
prop_HOR_0	*prop_HOR* in initial period	$prop\_HOR\_0 \sim beta(0.5, 0.5)$
NOR_true	Estimated number of released natural-origin fish caught in the fishery by period for a given species and life stage	$NOR\_true_p \sim lognormal(\log(NOR\_true_{p-1}), sigma\_proc))$ NOR_true[1] ~ lognormal (0, 3)
$sigma\_proc$	Process error for *NOR_true*	$sigma\_proc \sim std\_normal()$
C_NOR_sum	Realized total estimated number of released natural-origin fish caught in the fishery by period for a given species	$C\_NOR\_sum = poisson\_rng(NOR\_true)$

Ocean Fisheries

A stratified statistical creel program will provide effort estimates and stock specific catch estimates for recreational ocean fisheries. Ocean fisheries are partitioned into catch areas based on port of landing. Effort levels are estimated by counting the number of boats that leave a given port on a given day. Subsequent sampling of anglers upon their return provides an average number of anglers per boat that is applied to the number of boats to provide an estimate of total anglers per day. Anglers are randomly contacted to collect data regarding fishing effort (number of anglers and duration of trip) and success (number of fish kept and released). Catch data from angler surveys is applied to effort estimates to provide daily catch estimates. Daily effort and species-specific catch estimates are aggregated for each catch area from the northern Canadian border to Southern California to provide total effort and catch estimates. Landed catch is sampled for biological data and to recover CWTs. CWT recovery data is used to further apportion the species-specific catch estimates to produced stock specific catch estimates for each catch area. Stock specific catch estimates by catch area are then aggregated to produce stock specific catch estimates for ocean fisheries in their entirety.

CWT marking programs are in place for salmon production from the Cowlitz River. Recoveries of CWT marked fish released from the Cowlitz River provide data necessary to estimate catch of Cowlitz salmon in ocean fisheries. CWT marks are applied only to hatchery fish; therefore, catch estimates are for hatchery fish only. For mark selective fisheries, natural-origin fish released will be estimated using marked to unmarked ratios of fish handled in each catch area. This catch ratio will be applied to estimates of kept hatchery fish to estimate the number of natural-origin fish released. Released fish will then be apportioned by stock using the stock composition of hatchery fish landed in the same catch area. Stock specific estimates of natural fish handled will be estimated for each catch area and then aggregated to provide ocean wide estimates.

Additional details regarding sampling methodology and annual catch estimates can be found in (Lai et al. 1991).

Mainstem Columbia River – Recreational Fisheries

Daily effort and species-specific catch estimates are aggregated for each catch area from the northern Canadian border to Southern California to provide total effort and catch estimates. Landed catch is sampled for biological data and to recover CWTs. CWT recovery data are used to further apportion the species-specific catch estimates in order to produce stock specific catch estimates for each catch area. Stock specific catch estimates by catch area are then aggregated to produce stock specific catch estimates for ocean fisheries in their entirety. The stratified statistical creel program will provide effort estimates and stock specific catch estimates. The lower Columbia River (downstream of Bonneville Dam) is partitioned into 10 catch areas. Effort levels are estimated by conducting twice-a-week aerial surveys to provide and instantaneously count the number of boats and bank anglers. For boat fisheries, subsequent sampling of anglers at boat ramp provides an estimate of number of anglers per boat that is applied to the number of boats to provide an estimate of total number of anglers. Effort estimates from twice-a-week aerial counts are expanded to estimate total effort by month. Anglers are randomly contacted to collect data regarding fishing effort (number of anglers and duration of trip) and success (number of fish kept and released). Catch data from angler surveys is applied to effort estimates to prove monthly catch estimates. Effort and catch estimates are stratified by angling method (boat or bank) and days (weekends or weekdays) and subsequently aggregated to produce monthly effort and species-specific catch estimates for each catch area in the lower Columbia River. Landed catch is sampled for biological data and to recover CWTs. CWT recovery data is used to further apportion the species-specific catch estimates to produce monthly stock specific catch estimates for each catch area in lower Columbia River. CWT marking programs are in place for Cowlitz River salmon production. Recoveries of CWT-marked fish released from the Cowlitz River provide data needed to estimate catch of Cowlitz salmon in lower Columbia River fisheries. CWT marks are applied only to hatchery production; therefore, catch estimates are for hatchery fish only. For mark selective fisheries, natural-origin fish released will be estimated using marked to unmarked ratios of fish handled in each catch area. This catch ratio will be applied to estimates of kept hatchery fish to estimate the number of natural-origin fish released. Released fish will then be apportioned by stock using the stock composition of hatchery fish landed in the same catch area. Stock specific estimates of natural fish handled will be estimated for each catch area and then aggregated to provide estimates for the lower Columbia River.

Additional details regarding sampling methodology and annual catch estimates can be found in (U.S. v Oregon TAC 2008).

Commercial Fisheries

All landed catch from commercial fisheries in the ocean and lower Columbia River must be recorded on fish tickets and submitted to the state in which those fish are landed. Fish tickets include the poundage of fish landed by species, but not the number. Fish landed at processing plants are randomly sampled to determine the average weight of fish landed by species, which can be applied to the weight reported on the fish tickets to determine the number of fish landed by species. Landed catch is also sampled to collect biological data and recover CWTs. CWT recovery data is applied to catch estimates to produce a stock specific estimate of the number of fish landed. CWT marking programs are in place for salmon production from the Cowlitz River. Recoveries of CWT-marked fish released from the Cowlitz River

provide data needed to estimate catch of Cowlitz salmon in ocean and Columbia River commercial fisheries (U.S. v Oregon TAC 2008).

Precision Levels
Accurate harvest rates in fisheries are necessary to calculate several key metrics in the AHA model used to evaluate various production program options, including NOS and HOS abundance estimates. Statistical creel programs in place for lower Columbia River and ocean sport fisheries, plus sampling programs in place for commercial fisheries, all provide accurate species-specific catch estimates. In contrast, catch estimates within the Cowlitz River have a much lower level of accuracy. Over the next 3 to 5 years, data collected through improved abundance estimation methodology should be used to determine if increased precision in catch estimates is needed to achieve the precision goal (CV = 15%) for NOS and HOS abundance estimates.

Creel Survey Work Elements

For Sport Fisheries

- Conduct fishing effort counts
- Sample anglers for effort and success
- Sample catch for biological data and to recover CWTs
- Summarize and analyze data to produce stock specific catch estimates

For Commercial Fisheries

- Summarize fish ticket data
- Sample catch for biological data and to recover CWTs
- Summarize and analyze data to produce stock specific catch estimates

Deliverables

- For Columbia River and ocean sport fisheries (statistical creel): number of angler days, kept and released catch (NORs and HORs) by stock and recoveries of CWTs.
- For Columbia River and ocean commercial fisheries (statistical sampling program): kept and released catch (NORs and HORs) by stock and recoveries of CWTs.
- For Cowlitz River fisheries (random angler survey): kept and released catch (NORs and HORs).

Barrier Dam Adult Returns

Applies to: Barrier Dam Adult Returns

Estimation of the number, origin, and disposition of adults returning to the hatchery for all populations.

Tacoma Power handles all adult salmonids that enter the ladder and separator facility at the Cowlitz Salmon Hatchery. The facility operates year-round and data is collected on the origin of all fish handled. The disposition of all fish (hatchery broodstock, upstream, surplus or downstream), by origin, is recorded into an Access database. The data is reviewed weekly and provided to the WDFW. It is then checked by WDFW and, after quality control, included in the Cowlitz Complex annual report.

Deliverables
Weekly summary of the number, timing, origin and disposition of adult salmonids handled at the Cowlitz Salmon Hatchery adult fish separator.

Adult salmon and steelhead returning to the Cowlitz River and hatcheries are collected as they ascend a fish ladder on the Barrier Dam. Fish accumulate in a holding pool and are processed Monday through Friday, excluding holidays, and seven days per week during peak migration times. A hydraulic weir is used to attract the fish to swim volitionally from the holding pool to an electro anesthesia (EA) basket. If the fish numbers are low or the fish are not volitionally entering, mechanically operated bar-stock panel crowders are used to force the fish into the electro anesthesia basket. Fish are batched at up to 50 fish at a time. A two-stage electro anesthesia is applied and after approximately two minutes the basket is raised, and the stunned fish slide out of the basket onto stainless steel work up tables.

The Adult Handling Protocol, which is a document developed as a collaborative effort by WDFW and Tacoma Power is used to determine the disposition of each fish depending on the species, sex, life stage, and marks and tags. The first table contains tubes to route fish collected for broodstock needs to nine hatchery holding ponds. All other fish above hatchery needs are sent through a CWT detection system (NMT T13) on their way to the lower tables. A positive CWT detection will divert fish onto a separate part of the sorting table. CWT positive fish are manually detected to confirm tag presence. Fish transported upstream are routed to holding tanks that are designed to mate with Tacoma Power fish transportation trucks via a water-to-water transfer. Fish that are donated to the food bank can be routed to a separate surplus tank to be euthanized and removed from the hatchery. Fish are enumerated by species, sex and mark. This data are captured in the Cowlitz Salmon Separator database maintained by Tacoma Power (Scott Gibson, Tacoma Power, personal communication).

Hatchery Broodstock Sampling & Composition

Applies to: 16.1 Hatchery Assessment: Biological Sampling in Hatchery

Cowlitz hatchery broodstock will be sampled annually by collecting age, length, sex, and coded wire-tags (CWT). After spawning, the fish are held in totes in the spawning room and then all fish are sampled for origin (HOR versus NOR). A random sample is collected for the other metrics. Scales are removed and placed on scale cards. Broodstock fish are wanded for coded wire-tags (CWTs) and heads are removed if a tag is found for later recovery of the CWT. Individual fish measurements are collected. All data collected will be entered into the WDFW Region 5 biological database.

Estimation of sex, length, age and origin (NOR vs. HOR) of hatchery broodstock for all hatchery programs.

Deliverables

- Scales, sex, and lengths of fish spawned at the Cowlitz Salmon Hatchery.
- CWT data.

Chinook and coho spawner disposition at the Cowlitz Salmon Hatchery were summarized from the Cowlitz Salmon Separator database maintained by Tacoma Power (Scott Gibson, Tacoma Power, personal communication). Data were summarized as jack, male, and female using pre-established length cutoffs between jacks and adult males for spring Chinook (>59 cm FL= adult), fall Chinook (>56 cm FL= adult), and coho (>47 cm FL= adult) salmon.

Spring Chinook, fall Chinook and coho retained for brood stock were biologically sampled. Spring Chinook were sampled at a one in three rate. NOR fall Chinook (collected from the river and used in the

integrated program) were sampled at a one in one rate and adipose-clipped fall Chinook (used for either the integrated or segregated hatchery program) were sampled at a one in three rate. NOR coho with a coded-wire tag (upper Cowlitz origin, used for integrated program) and HOR coded-wire tagged coho (integrated hatchery-origin) were sampled at a one in three rate. Data collected included species, run, sex, FL (cm), scales, coded-wire tag status (present or absent, snouts were retained from all positive scans), and mark status (unmarked, adipose clip, other clips). Additionally, tissue samples for potential genetic analysis were collected from spring and fall Chinook. Sampling data, scale information and CWT recovery information were handled and archived following regional WDFW practices.

Weir Operation and Lower Cowlitz Adult Capture

Applies to: Weir Operation and Lower Cowlitz Adult Capture

Estimation of natural spawner abundance, controlling pHOS, and collection of natural origin broodstock for:

- Lower Cowlitz Coho
- Lower Cowlitz steelhead
- Lower Cowlitz fall Chinook

Operation of weir on selected tributaries of the lower Cowlitz River achieves three key objectives: 1) control number of hatchery fish on spawning grounds, 2) collect naturally produced winter steelhead for use in an integrated hatchery broodstock program, and 3) provide data to assist in producing abundance estimates for naturally produced winter steelhead and coho.

Weirs

Floating Resistance Board weirs will be operated in three selected tributaries of the lower Cowlitz River: Olequa Creek, Salmon Creek and Ostrander Creek. Weirs will be operated year-round. A single crew will rotate between all four weirs with the goal of checking traps every 1 to 2 days.

Weirs are operated to prevent all summer steelhead from entering the area upstream of the weirs. All summer steelhead captured by these weirs are either returned to the stream below the weir or removed from the system completely. Hatchery fish are only returned to the Cowlitz River during the summer months prior to the fall freshets (September) when the sport fishing effort levels are high. All fish returned to the river are documented and marked to determine their fate after release. No additional data or information are collected from summer steelhead.

For winter steelhead, weirs are operated to control number of hatchery fish escaping to natural spawning areas, to collect naturally produced fish to develop an integrated broodstock, and to provide data that assists in producing annual abundance estimates. During the early period of winter steelhead returns (November through February), all hatchery steelhead (winters and summer stock) that are collected at the weir will be removed from the river. During this time, hatchery winter steelhead entering these tributaries are predominantly summer steelhead or Chambers Creek stock winter steelhead, both of which have a negative impact on natural production. For the duration of this FHMP Update, no hatchery steelhead collected during the November to February time frame will be used for broodstock purposes; however, as time goes on and the Chambers Creek stock is eliminated from the

system, naturally produced fish returning during this time frame could be used to expand the return timing of integrated hatchery program winter steelhead.

During the late period of winter steelhead returns (March through early June), weirs are operated for all of the aforementioned purposes. Access by hatchery steelhead to natural spawning areas is controlled. Some hatchery fish are passed into natural spawning areas where abundance of naturally produced fish is critically low. Hatchery fish not passed upstream are removed from the system completely. Some naturally produced fish may be retained for use in developing an integrated broodstock. Naturally produced fish not used for broodstock purposes are marked prior to passing upstream above the weir for use in a mark-recovery study to estimate abundance of naturally produced winter steelhead in these select tributaries. Data collected in these mark-recapture studies assists in estimating overall abundance of naturally produced winter steelhead in the lower Cowlitz Basin.

During the coho migration (late September through January), weirs are operated to control hatchery coho on spawning grounds and provide data to assist in producing abundance estimates for naturally produced coho. All hatchery coho returning to these tributaries will are removed from the system. Naturally produced coho are marked prior to passing upstream above the weir for use in a mark-recovery study to estimate abundance of naturally produced coho in these select tributaries. Data collected in these mark-recapture studies help estimate overall abundance of naturally produced coho in the lower Cowlitz Basin.

Weirs are expected to function properly for summer steelhead, but weather conditions may pose a challenge during periods of extreme flows for winter steelhead and coho.

Deliverables

From tributary collection:

- Number of hatchery summer steelhead returned to the Cowlitz River
- Number of hatchery summer steelhead, winter steelhead and coho removed from the Cowlitz Basin
- Number of naturally produced winter steelhead collected for broodstock purposes
- Number of hatchery and naturally produced winter steelhead and coho passed upstream of weirs
- Number of marked naturally produced winter steelhead and coho passed upstream of weirs

Adult Sampling Summaries

Fall Chinook Carcasses:

- Representative sample of tissue from adults/carcasses and juveniles of sufficient size to meet the precision standards.
- Representative sample of biological data (length, sex, origin, scales) from adults/carcasses of sufficient size to meet the precision standards.
- Representative sample of biological data (length, sex, origin, scales) from juvenile outmigrants of sufficient size to meet the precision standards.
- Entry of data into genetic, age and scales, juvenile migrant, and spawning ground survey databases for future analysis
- Operation and maintenance of genetic, age and scales, juvenile

Coho Adults:

- Capture-mark-recapture sufficient coho adults to meet the precision standards and estimate survey life and observer efficiency.
- Collect genetic and biological data (length, sex, origin, scales) from all adults to meet the precision standards.
- Conduct AUC and redd surveys as described and record individual redd locations.
- Entry of data into trap, genetic, age and scales, juvenile migrant, and spawning ground survey databases for future analysis.
- Operation and maintenance of trap, genetic, age and scales, juvenile migrant, and spawning ground survey databases.

Steelhead Adults:

- Capture-mark-recapture sufficient steelhead adults to meet the precision standards.
- Collect genetic and biological data (length, sex, origin, scales) from all adults to meet the precision standards.
- Conduct redd surveys as described and record individual locations.
- Entry of data into trap, genetic, age and scales, juvenile migrant, and spawning ground survey databases for future analysis.
- Operation and maintenance of trap, genetic, age and scales, juvenile migrant, and spawning ground survey databases.

In-Hatchery Monitoring and Record Keeping

Applies to: In-Hatchery Monitoring and Record Keeping

Estimation of in-hatchery survival by life stage and release numbers (and sizes), monitoring of disease and hatchery operations for all hatchery programs.

WDFW collects data on all aspects of hatchery operations including egg survival, fry survival, fingerling survival, release numbers and pathological testing results. Quarterly reports and a final annual report are generated from these data as part of the operations contract with Tacoma Power. All data collected are entered into “Fish Books”, a database maintained by WDFW. The data are then checked by WDFW and, after quality control, included in the WDFW Region 5 biological database.

Deliverables

- Pre-spawn survival, egg survival, egg to smolt survival
- Number of fish released
- Incidence of disease.

Juveniles from Upper Cowlitz

Applies to: 15.2 VSP & Population: Smolt Population Estimate; 15.11 VSP & Population: Juvenile Migration Timing

Juveniles from Upper Cowlitz and Cispus Rivers

The CFFF is operated throughout the spring-summer smolt migration in the upper Cowlitz River basin. Seasonal operations begin April 16 and extend to August 31. The CFFF is staffed at all times while operating and staff operations include inspections, monitoring and adjusting flow across the separator,

and debris removal. Staff also monitor flap gate operation and fish condition in the holding tanks. Smolts collected are carefully handled, examined and transported to the stress-relief ponds at the Cowlitz Salmon Hatchery prior to their release into the adjacent Cowlitz River to continue their migration. Parr, fry, and rainbow trout are released back into the reservoir above Cowlitz Falls Hydroelectric Project. Non-salmonids are released below the project.

Deliverables

- Abundance by species
- Marks and tags (if present)
- Subsample of lengths of juvenile salmonid outmigrants collected at the CFFF
- Mark-recapture estimation of Fish Capture Efficiency (FCE)
- Marking all out-migrants.

Juveniles at Mayfield – Tilton River

Estimation of smolt outmigration abundance and mark-recapture collection efficiency for:

- Tilton spring Chinook
- Tilton Coho
- Tilton steelhead

The juvenile salmonid bypass system is operated year-round at Mayfield Dam. The secondary separator pumps are turned off during the winter; however, the bypass system continues to operate in a passive mode. While in passive mode all fish are bypassed directly into the downstream transport pipeline. Beginning April 1st, the secondary separator pumps are turned on and the fish are routed into holding raceways at the Mayfield counting facility. The raceways are checked for accumulated fish up to six days/week from April through December. All juvenile salmonids are examined for visual marks and clips. Adult salmonids and non-salmonid fish are not examined for marks. All salmonids (except rainbow trout, Atlantic salmon, tiger musky, and Arctic char) are released downstream with or without tagging. Fish not released below Mayfield Dam are returned alive to Mayfield Lake or sacrificed after recording.

Deliverables

- Abundance by species
- Marks and tags (if present)
- Subsample of lengths of juvenile salmonid outmigrants collected at the Mayfield Dam downstream collection facility.

References

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Serl, J., C. Gleizes, C. Nissell, T. Fryer, K. Bentley, and T. Buehrens. 2021. Lower Cowlitz River Monitoring and Evaluation Annual Report, 2021, FPA 21-xx. Washington Department of Fish and Wildlife, Olympia, Washington.

APPENDIX C Directed Study Plans

To be populated with provided Directed Study Plans

APPENDIX D Data Gaps

Appendix D contains tables identifying current areas of monitoring and existing data gaps as presented in the fish species and population chapters of the 2020 FHMP (Tacoma Power 2020). Separate tables are presented below, by species. The data gaps and/or monitoring needs shall be updated as needed.

Appendix Table D-1. Data Gaps and Potential Future Monitoring Needs for Fall Chinook Salmon

Topic/Theme	Summary of Data Gap/Potential Future Monitoring Need	Affected Populations
Data Collection	Summarize Data and Assumptions for Fall Chinook Salmon into a single shared database for Analysis and Reporting	All
	Consider Methods to Improve Estimating Abundance in Harvest and on Spawning Grounds	All
	Incorporate Data into Consolidated Database Characterizing Age Structure and Sexes	All
	Incorporate Lower Cowlitz Salmon Hatchery Program Data into Consolidated Database and Consider Additional Improvements in M&E to Inform Fisheries Strategies	All
Stock Identification	Genetic Structure of the Fall Chinook Salmon Populations in the Cowlitz Basin	All
	Differentiating Natural-Origin Fall vs. Spring Chinook Salmon	UCS/TS
	Genetic Structure of the Fall Chinook Salmon Populations in the Cowlitz Basin	All
Smolt Monitoring	Monitoring and Estimating Abundance of Smolts Leaving the Cowlitz River	All
	Understanding Fall Chinook Salmon Production from the Lower Cowlitz Subbasin	LCS
	Understanding Fall Chinook Salmon Production from the Tilton Subbasin	UCS/TS
	Natural Mortality of Outmigrating Juveniles	All
	Monitor Dam Passage Survival for Tilton Subbasin Fall Chinook Salmon and Fish Guidance Efficiency at Mayfield Dam	UCS/TS
Survival, Productivity, and Age Composition	Smolt-to-Adult Return and Total Smolt-to-Adult Survival for Hatchery-Origin and Natural-Origin Fall Chinook Salmon	All
	Productivity (Recruits/Spawner) of Hatchery-Origin and Natural-Origin Fall Chinook Salmon	All
	Juvenile Productivity (Smolts/Spawner)	All
	Adult Productivity (Adult Recruits/Parental Spawner)	All
	Consolidate Age Composition of Hatchery-Origin and Natural-Origin Fall Chinook Salmon into Single Database for Analysis and Reporting	All
Spawning in Nature	Estimate Adult Fall Chinook Salmon Transported Above Mayfield Dam	UCS/TS
	Estimates of Total Fall Chinook Salmon in the Lower Cowlitz Subbasin	LCS
	Estimate Straying in the Lower Cowlitz Subbasin and Elsewhere	All
Hatchery Practices	Develop Methods to Evaluate Strategies for Improving Survival in the Hatchery, After Release, and Age Composition (Including Precocious Maturation)	All
	Develop Methods to Evaluate Rearing and Release Strategies to Improve Survival and Age Composition	UCS
Pathology	Effects of *Ceratonova shasta* on Upper Cowlitz Subbasin Fall Chinook Salmon	UCS/TS

Note:
LCS = Lower Cowlitz Subbasin; TS = Tilton Subbasin; UCS = Upper Cowlitz Subbasin

Appendix Table D-2. Data Gaps and Potential Future Monitoring Needs for Spring Chinook Salmon

Topic/Theme	Summary of Data Gap/Potential Future Monitoring Need	Affected Populations
Data Collection	Summarize Data and Assumptions for Spring Chinook Salmon into a Single Shared Database for Analysis and Reporting	All
	Consider Improvements for Monitoring, Evaluation, and Data Collection Efforts for UCS Spring Chinook Salmon	UCS
	Harvest Estimates of UCS Spring Chinook Salmon in the Pacific Ocean, Columbia River, Lower Cowlitz River, and Upper Cowlitz Subbasin	UCS
	Monitor Trend of Hatchery-Origin Spring Chinook Salmon Mini-jacks and Jacks and Natural-Origin Jacks	UCS
	Document Returns of Hatchery-Origin and Natural-Origin Spring Chinook Salmon by Age and Additional Data Needs to Estimate SAR, TSAR, Productivity, and Age Composition	UCS
Stock Identification	Identify the True Origin of NOR Spring Chinook Salmon Returning to Barrier Dam Adult Facility	UCS
	Ability to Distinguish between Spring and Fall Chinook Salmon smolts Originating from the Upper Cowlitz Subbasin	UCS
	Mis-clip Rates for Returning Adults	UCS
Smolt Monitoring	Ability to Distinguish between Spring and Fall Chinook Salmon smolts Originating from the Upper Cowlitz Subbasin	UCS
	Spring Chinook Smolt Migration Timing and Survival	UCS
Survival, Productivity, and Age Composition	Smolt-to-Adult Return and Total Smolt-to-Adult Survival for Hatchery-Origin and Natural-Origin Spring Chinook Salmon	UCS
	Productivity (Recruits/Spawner) of Hatchery-Origin and Natural-Origin Spring Chinook Salmon	UCS
	Juvenile Productivity (Smolts/Spawner)	UCS
	Adult Productivity (Adult Recruits/Parental Spawner)	UCS
	Consolidate Age Composition of Hatchery-Origin and Natural-Origin Spring Chinook Salmon into Single Database for Analysis and Reporting	UCS
Spawning in Nature	Estimate Spawner Abundance and Pre-spawn Survival of Upper Cowlitz Subbasin Spring Chinook Salmon	UCS
Hatchery Practices	Number of Upper Cowlitz Subbasin Spring Chinook Salmon Jacks vs. Adults Spawned at Cowlitz Salmon Hatchery	UCS
	Develop Methods to Evaluate Rearing and Release Strategies to Improve Survival and Age Composition	UCS
	Monitor Trend of UCS Spring Chinook HOR Mini-jacks and HOR and NOR Jacks	UCS
Proportionate Natural Influence	Identify Limiting Factors for Spring Chinook Salmon that Influence PNI and pHOS	UCS
VSP Parameters	Develop Criteria using VSP Parameters for the Eventual Release of Spring Chinook Salmon into the Tilton Subbasin	UCS

Note:
UCS = Upper Cowlitz Subbasin

Appendix Table D-3. Data Gaps and Potential Future Monitoring Needs for Coho Salmon

Topic/Theme	Summary of Data Gap/Potential Future Monitoring Need	Affected Populations
Data Collection	Summarize Data and Assumptions for Coho Salmon into a Single Shared database for Analysis and Reporting	All
	Incorporate Data into Consolidated Database Characterizing Age, Sex, and Origin of all Recoveries	All
	Determine Goal of the Creel Survey (Coho)	All
	Maintain M&E Program for Lower Cowlitz Subbasin Coho Salmon	LCS
	Continue Spawning Ground Surveys for Lower Cowlitz Subbasin Coho Salmon (including Estimates for Pre-spawn Mortality, Spawner Abundance)	LCS
	Numbers of Natural-Origin Upper Cowlitz Subbasin Coho Salmon that Return at Maturation and their Disposition	UCS/TS
	Consider Spawning Ground Surveys for Upper Cowlitz Subbasin and Tilton Coho (Pre-spawn Mortality, Spawner Abundance)	UCS/TS
	Baseline and Directed Studies for Upper Cowlitz Subbasin Coho Salmon	UCS
	Document and Consider Testing Assumptions for Fallback Rates (e.g., 12%) and Pre-spawn Mortality Rate (e.g., 10%) for Tilton Subbasin Coho Salmon	TS
Stock Identification	Origin of Spawners in the Lower Cowlitz River vs. Tilton Subbasin	LCS; TS
Smolt Monitoring	Estimates of Natural Smolt Abundance for Lower Cowlitz Subbasin Coho Salmon	LCS
	Natural-Origin Smolt Production from the Tilton Subbasin	TS
	Age of Coho Salmon Migrants Leaving the Upper Cowlitz Subbasin and Tilton Subbasin - Scale Age and Length assumptions	UCS/TS
	Natural Mortality of Outmigrating Juveniles	All
	Monitor Dam Passage Survival for Tilton Subbasin and Upper Cowlitz Coho Salmon and Fish Guidance Efficiency at Mayfield Dam and Cowlitz Falls Dam	UCS/TS
Survival, Productivity, and Age Composition	Smolt-to-Adult Return and Total Smolt-to-Adult Survival for Hatchery-Origin and Natural-Origin Coho Salmon	All
	Calculation of Separate Survival Estimates for the Segregated and Integrated Hatchery Programs for LCS Coho	All
	Productivity (Recruits/Spawner) of Hatchery-Origin and Natural-Origin Coho Salmon	All
	Juvenile Productivity (Smolts/Spawner)	All
	Adult Productivity (Adult Recruits/Parental Spawner)	All
	Consolidate Age Composition of Hatchery-Origin and Natural-Origin Coho Salmon into Single Database for Analysis and Reporting	All
Spawning in Nature	Estimates of Coho Salmon Successfully Reproducing in Nature	All
	Estimates of Coho Spawning in the Lower Cowlitz River, Including Strays from the Tilton and Upper Cowlitz Subbasins	All
	Estimate HOR Coho Salmon that Stray to Other Spawning locations (outside the Cowlitz Basin)	Hatchery
Hatchery Practices	Calculation of Separate Survival Estimates for the Segregated and Integrated Hatchery Programs for LCS Coho	All
Proportionate Natural Influence	Consider Hatchery Influence on Cowlitz Basin Coho Salmon Populations	All
	Consider Data Necessary to Make Informed Management Decisions with Natural Coho Salmon Spawning in the Mainstem Lower Cowlitz Subbasin and its Tributaries (to decrease pHOS)	LCS
Pathology	Effects of *Ceratonova shasta* on Coho Salmon	TS
Harvest	Consolidate Harvest Estimates of Hatchery-Origin and Natural-Origin Coho Salmon in the Pacific Ocean, Columbia River, Lower Cowlitz River, Tilton Subbasin, and Upper Cowlitz Subbasin into a Single Database for Reporting and Analysis	All

Note:
LCS = Lower Cowlitz Subbasin; TS = Tilton Subbasin; UCS = Upper Cowlitz Subbasin

Appendix Table D-4. Data Gaps and Potential Future Monitoring Needs for Winter Steelhead

Topic/Theme	Summary of Data Gap/Potential Future Monitoring Need	Affected Populations
Data Collection	Summarize Data and Assumptions for Winter Steelhead into a Single Shared Database for Analysis and Reporting	All
	Estimates of Total Run Size for Hatchery-Origin and Natural-Origin Winter Steelhead	All
	Adult Winter Steelhead vs. Jacks returning to the Basin	All
	Incorporate Data into Consolidated Database Characterizing Age Structure and Sexes	All
	Characterize Metrics for Natural-Origin Survival, Productivity, and Age Composition	All
	Steelhead Used for Broodstock and Sampled for Scales for Age Estimates	All
Stock Identification	Distinguishing Smolts Produced Naturally in the Lower Cowlitz Subbasin from those Produced Upstream of Mayfield Dam	All
Smolt Monitoring	Monitoring and Estimating Abundance of Smolts Leaving the Cowlitz River	All
	Understanding Winter Steelhead Production from the Lower Cowlitz Subbasin	LCS
	Understanding Winter Steelhead Production from the Upper Cowlitz Subbasin	UCS
	Understanding Winter Steelhead Production from the Tilton Subbasin	TS
	Natural Mortality of Outmigrating Juveniles	All
	Monitor Dam Passage Survival for Tilton Subbasin Winter Steelhead and Fish Guidance Efficiency at Mayfield Dam	TS
Survival, Productivity, and Age Composition	Smolt-to-Adult Return and Total Smolt-to-Adult Survival for Hatchery-Origin and Natural-Origin Fall Chinook Salmon	All
	Productivity (Recruits/Spawner) of Hatchery-Origin and Natural-Origin Fall Winter Steelhead	All
	Juvenile Productivity (Smolts/Spawner)	All
	Adult Productivity (Adult Recruits/Parental Spawner)	All
	Consolidate Age Composition of Hatchery-Origin and Natural-Origin Winter Steelhead into Single Database for Analysis and Reporting	All
	Age Composition of Adult Steelhead Being Transported Upstream of Mayfield Dam	TS
Spawning in Nature	Estimates of Winter Steelhead Successfully Reproducing in Nature	All
	Locations of Spawning Areas in the Upper Cowlitz, and Cispus Rivers and their Accessible Tributaries	UCS
	Estimates of Natural Steelhead Spawning Abundance and Pre-spawn Mortality	All
	Lack of Estimates of Steelhead Spawners by Subbasin in the Upper Cowlitz Subbasin	UCS
	Spawning Surveys to Account for Other Losses (e.g., Fallback, Predation, and Pre-Spawn Mortality)	All
	Effects on Steelhead Adult NOR Abundance from Adult Returns Spawning out of Location	All
Hatchery Practices	Hatchery Data for Winter Steelhead – Total Eyed Eggs, Fertility, and Scale Information, Sex Ratio, Rate of Precocious Maturation for HORs Incorporated into Single Analysis and Reporting Database	All
Proportionate Natural Influence	Estimates of pHOS and PNI for Winter Steelhead	All

Topic/Theme	Summary of Data Gap/Potential Future Monitoring Need	Affected Populations
Harvest	Estimates of Population-specific Harvest Rates for Hatchery-Origin Steelhead Fisheries in the Pacific Ocean, Columbia River, Lower Cowlitz Subbasin, Upper Cowlitz Subbasin, and Tilton Subbasin	All
	Population-Specific Estimates of Indirect Mortality Rates for Natural-Origin Steelhead Fisheries in The Pacific Ocean, Columbia River, Lower Cowlitz Subbasin, Upper Cowlitz Subbasin, and Tilton Subbasin	All

Note:
LCS = Lower Cowlitz Subbasin; TS = Tilton Subbasin; UCS = Upper Cowlitz Subbasin

Appendix Table D-5. Data Gaps and Potential Future Monitoring Needs for Cutthroat Trout, Chum Salmon, and M&E

Topic/Theme	Summary of Data Gap/Potential Future Monitoring Need	Affected Populations
Cutthroat Trout	Summarize Data and Assumptions for Cutthroat Trout into a Single Shared Database for Analysis and Reporting	UCS/TS
	Estimate Popularity of the Cowlitz Basin Cutthroat Trout Hatchery Program	All
	Consider Studies to Improve the Efficacy and Management of the Cutthroat Trout Hatchery Program	Hatchery
Chum Salmon	Summarize Data and Assumptions for Chum Salmon into a Single Shared Database for Analysis and Reporting	LCS
M&E	Estimate Abundance and Productivity of Salmonid Populations in Tributaries	All
	Data Inputs for One- and Two-Stage Life Cycle Models	All
	Big Tables as “Data Warehouse”	All

Note:
TS = Tilton Subbasin; UCS = Upper Cowlitz Subbasin

Reference

Tacoma Power. 2020. Fisheries and Hatchery Management Plan (FHMP): Final. October 2020. Cowlitz River Project FERC No. 2016.