PacifiCorp and Cowlitz County PUD No. 1

Aquatic Monitoring and Evaluation Plan for the Lewis River – Second Revision (Version 3)

Spawned-out Salmon Carcass on the North Fork Lewis River Upstream of Swift Dam.
Photo by Jason Shappart, Meridian Environmental, Inc.

Prepared by:

PacifiCorp

and

Public Utility District No. 1 of Cowlitz County

April 1, 2022

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DEFINITION OF TERMS AND ACRONYMS USED IN THIS PLAN

Adult Trap Efficiency (ATE): Defined in Table 4.1.4 of the Settlement Agreement as the percentage of adult Chinook, coho, steelhead, bull trout and sea-run cutthroat actively migrating to a location above a hydroelectric facility and successfully captured for transport.

Alternative Dispute Resolution (ADR): A process of mediation described in the Agreement.

Annual Operating Plan (AOP): An annual planning document that describes the methods and protocols needed to implement the Hatchery and Supplementation Plan and program.

Annual Operating Report (AOR): An annual report that compiles all information gathered from implementation of the H&S Plan.

Aquatic Coordination Committee (ACC): Committee formed of signatories to the Lewis River Settlement Agreement acting as the governing body for implementation of the aquatic provisions in the Settlement Agreement.

Aquatic Monitoring and Evaluation Plan (M&E Plan): A planning document required by Section 9 of the Agreement focused on monitoring and evaluation activities upstream of Merwin Dam, including fish passage, surveys for salmon, steelhead and bull trout, and estimates of ocean recruits.

Aquatic Technical Subgroup (ATS): A group formed under the ACC to provide technical expertise to the ACC and to develop and review planning documents related to implementation of the Settlement Agreement. Formerly referred to as the Hatchery and Supplementation Subgroup (HSS).

Biological Opinion: A document that states the opinion of either the U.S. Fish and Wildlife Service or the National Marine Fisheries Service as to whether an action is likely to jeopardize the continued existence of listed species or result in the loss or adverse modification of critical habitat.

Blank Wire Tag (BWT): A small, uncoded wire tag inserted in the snout of fish and detectible through hand-held or fixed detectors.

Catch Plus Escapement (CPE): A method of estimating adult recruitment that includes all fish that are either harvested in ocean or freshwater fisheries or escape to the spawning grounds.

Coded-wire Tag (CWT): A 0.5 to 1.1 mm length of magnetized stainless steel wire 0.25 mm in diameter with each tag containing a row of numbers. Tags are inserted into fish (typically the snout) to identify individual or groups of fish.

Coefficient of Variation (CV): A statistical measure of the relative dispersion of data around the mean.

Collection Efficiency (CE): The percentage of juvenile anadromous fish of each of the species designated in Section 4.1.7 of the Settlement Agreement that is available for collection and that is actually collected.

Collection Survival (CS): The percentage of juvenile anadromous fish of each of the species (designated in Section 4.1.7) collected that leave the Release Ponds alive.

Confidence Interval (CI): A range of values indicating the degree of uncertainty associated with a statistical metric, such as a mean.

Cubic feet per second (cfs): A measure of streamflow.

Distinct Population Segment (DPS): Pacific salmon that represents an evolutionarily significant unit (ESU) for the purposes of listing, delisting, and reclassifying.

Double Index Tag (DIT) group: Paired release groups, each tagged with a unique CWT code, where both groups are presumed identical except that one group is externally marked with an adipose fin clip (AD+CWT) and the other is not (CWT only). DIT groups are used to determine differential exploitation rates on marked and unmarked fish subjected to mark-selective fisheries.

Endangered Species Act (ESA): Federal law passed in 1973 providing a framework to conserve and protect endangered and threatened species and their habitats. https://www.fisheries.noaa.gov/national/endangered-species-conservation/endangered-species-act

Environmental DNA (eDNA): Organismal DNA that can be found in the environment. Environmental DNA originates from cellular material shed by organisms (via skin, excrement, etc.) into aquatic or terrestrial environments that can be sampled and monitored using molecular methods.

Evolutionarily Significant Unit (ESU): A Pacific salmonid population that is substantially reproductively isolated from other conspecific population units and represents an important component in the evolutionary legacy of the species.

Exploitation Rate (ER): The proportion of fish removed by harvest activity.

FEMA: Federal Emergency Management Agency

FERC: Federal Energy Regulatory Commission

Fishery Regulation Assessment Model (FRAM): Model that integrates fishery catches, stock information, and CWT recovery data to produce a calibrated reference pattern of stock distributions and stock-specific exploitation rates by year and fishery.

Floy tag™: External tags providing a visible means of identifying individual fish through different color and alphanumeric coding combinations.

Fry: A recently hatched fish that has reached the stage where its yolk-sac has almost disappeared and its swim bladder is operational to the point where the fish can actively feed. Juveniles referred to as fry are <45 mm and are not large enough to safely PIT tag.

Hatchery-origin (HOR): Fish spawned in a hatchery or reared in a controlled environment prior to release into the natural environment.

Hatchery and Supplementation Plan (H&S Plan): A planning document required by Section 8 of the Agreement developed by the ATS providing the strategic direction for implementing the Hatchery and Supplementation Program.

Hatchery Scientific Review Group (HSRG): An independent scientific review group established by the U.S. Congress to initiate hatchery reform balancing both conservation and harvest goals.

Integrated Population Model (IPM): Integrated population models are a type of life cycle model that may be used to evaluate the potential effects of management activities and environmental variability on salmonid populations (Buhle et al. 2018). Such models integrate all available data into a joint likelihood function that accounts for all (known) sources of uncertainty in the data (Schaub and Abadi 2011), resulting in more accurate and precise estimates of model outputs (Tavecchia et al. 2009, Johnson et al. 2010). An IPM represents a single, unified analysis of population count data and demographic data. Model framework can be implemented within the classical or the Bayesian mode of statistical inference.

Juvenile: For purposes of this plan, juvenile refers to actively swimming young fish (e.g., fry, parr and smolts) that have not yet reached sexual maturation.

Kelt: A post-spawn iteroparous fish such as a steelhead or cutthroat.

Lewis River Bull Trout Recovery Team (LBTRT): Team comprised of federal, state, and non-governmental biologists and scientists.

Licensees (or Utilities): PacifiCorp and Cowlitz PUD, collectively the owner and operators of the Lewis River Hydroelectric Projects.

Mark-selective Fisheries (MSF): Mark-selective fisheries target hatchery-origin fish, which are typically marked with an adipose fin-clip, and release any incidentally caught natural-origin fish.

Mean Sea Level (MSL): is the datum for measurement of elevation and altitude. Mean Sea Level is the equipotential surface of the Earth as described by the WGS84 geoid.

Merwin Fish Collection Facility (MFCF): An adult trapping, collection and sorting facility located at the base of Merwin Dam.

M&E: Monitoring and Evaluation.

Natural-origin (NOR): Progeny of fish that spawn naturally, including progeny of hatchery-origin fish or strays that spawn naturally. For fish management purposes, any fish possessing an adipose fin (and no tags) are considered of natural origin.

N_e: The genetically effective population size (N_e) is arguably the most important metric in conservation biology, because unlike census size (N), e.g., escapement, it determines the rate at which a population evolves through natural selection.

NMFS (or NOAA Fisheries): National Marine Fisheries Service, informally referred to as NOAA Fisheries.

NOAA: National Oceanic and Atmospheric Administration is part of the Department of Commerce and oversees the NMFS.

Ocean Recruits: Total adult recruitment of hatchery and natural origin fish including escapement, returns to the hatchery, and harvest in ocean and freshwater fisheries.

Overall Downstream Survival (ODS): The percentage of juvenile salmonids that enter the project from natal streams and survive to enter the Lewis River below Merwin Dam by collection, transport and release via the juvenile fish passage system, passage via turbines, or some combination thereof.

Pacific Fishery Management Council (PFMC): The PFMC manages salmon fisheries in Federal waters (3-200 miles offshore) off the West Coast of the United States. One of eight regional fishery management councils established by Congress in 1976.

Pacific States Marine Fisheries Commission (PSMFC): Established in 1947 by consent of Congress, the Pacific States Marine Fisheries Commission (PSMFC) is an interstate compact agency that helps resource agencies and the fishing industry sustainably manage Pacific Ocean resources in a five-state region. Member states include California, Oregon, Washington, Idaho, and Alaska. Each represented by three Commissioners.

Parr: A young salmonid that is older than a fry and younger than a smolt, having dark marks (i.e., parr marks) on their sides. Juveniles referred to as parr generally range in size from 45 to 120 mm.

PIT tag: Passive Integrated Transponder (PIT) tags are electronic tags each having a unique code allowing identification of individual tagged fish throughout their life with specialized readers that activate the tags indefinitely.

PM&E: Protection, mitigation and enhancement.

PTAGIS: The Columbia Basin PIT Tag Information System (PTAGIS) is the centralized database for PIT tagged fish in the Columbia River Basin. PTAGIS provides custom software for contributors to collect tagging and interrogation data, manages the database, and coordinates with fishery agencies and organizations. In addition, PTAGIS collects automated detection data and designs, installs, and maintains the equipment that records those detections. All data are available online (www.ptagis.org).

Radio tag: Tag that transmits a unique code at a specified frequency allowing individual detection of nearby fish with specialized fixed or mobile receivers.

Recovery Unit Implementation Plan (RUIP): Coastal Recovery Unit Implementation Plan for Bull Trout. Recovery unit implementation plans were developed for each of the six bull trout recovery units in the Unites States by individuals familiar with the populations within the recovery unit. The RUIPs describe threats to population persistence, recommend actions necessary to promote recovery, and identify research, monitoring and evaluation needs.

Recruits per Spawner (R/S): A measure of productivity in salmonids. Calculated as a ratio of the number of adult recruits per naturally spawning fish.

RM: River mile.

RMIS: Regional Mark Information System. Database for coded-wire tag releases, recoveries, and locations for anadromous salmonids throughout the Pacific region.

Salmon Conservation Reporting Engine (SCoRE): WDFW online tool that consolidates current information about salmon populations, hatchery production, conservation guidelines, and other aspects of salmon management in Washington state.

Self-Sustaining Population: A population that can perpetuate itself and persist at a viable salmonid population (VSP) level for a specified period of time in the absence of (or despite) external intervention.

Services: Includes the U.S. Fish and Wildlife Service and the National Marine Fisheries Service.

Settlement Agreement: A binding agreement between the Utilities, federal and state regulatory agencies, tribal entities and non-governmental organizations specifying the Utilities' obligations to mitigate effects of hydropower operation on fisheries, wildlife, recreation, cultural, and aesthetic resources.

Smolt: A juvenile salmon that is ready to migrate out to the sea, smolts can be described as losing their camouflage bars (i.e., parr marks) and are in the process of physiological changes that allow them to survive a shift from freshwater to saltwater. Smolts are silvery in color and shed scales readily. Smolts can range in size from 120 to 300 mm depending on fish species.

Smolt to Adult Ratio (SAR): Survival rate measured from the point from which a juvenile fish is released or naturally migrates to its return as an adult. SARs based on CWT data include all recoveries (escapement, returns to the hatchery, and harvest). SARs based on PIT tag data generally do not include fish that were harvested.

Swift Floating Surface Collector (Swift FSC): A floating barge located in the forebay of Swift Dam designed to provide attraction flow at the surface of the reservoir in order to capture out-migrating juvenile salmonids and adult steelhead (kelt) for transport downstream of Merwin Dam.

Terrestrial Coordination Committee (TCC): Committee formed of signatories to the Lewis River Settlement Agreement acting as the governing body for implementation of the terrestrial provisions in the Settlement Agreement.

Upstream Passage Survival (UPS): Percentage of adult fish of each species (designated in Section 4.1.7 of the Settlement Agreement) that are collected that survive the upstream trapping-and-transport process. For sea-run cutthroat and bull trout, “adult” means fish greater than 13 inches in length.

USACE: U.S. Army Corps of Engineers

USFWS: U.S. Fish and Wildlife Service

Utilities: PacifiCorp and Cowlitz PUD, collectively the owner and operators of the Lewis River Hydroelectric Projects.

Viable Salmonid Population (VSP): A Viable Salmonid Population (VSP) is defined as an independent population of any Pacific salmonid that has a negligible (<5%) risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year time frame.

WDFW: Washington Department of Fish and Wildlife

WDOE: Washington Department of Ecology

YOY: Young-of-the-year.

Zone of Influence (ZOI): Defined as the area approximately 150 feet radius immediately outside the exclusion net that is influenced by the flow entering the Swift FSC.

EXECUTIVE SUMMARY

This Aquatic Monitoring and Evaluation Plan (M&E Plan) provides the framework for implementing activities associated with Section 9 (Aquatic Monitoring and Evaluation) of the Lewis River Settlement Agreement (Settlement Agreement) dated November 30, 2004. Section 9.1 of the Settlement Agreement directs PacifiCorp and Cowlitz PUD (Licensees or Utilities) to consult with the Aquatic Coordination Committee (ACC) as necessary, but no less often than every five years, to determine if modifications to the M&E Plan are warranted. The original M&E Plan was filed in June 2010 and updated in April 2017 (Figure E-1). This M&E Plan (2022) represents the third version (second update) of the M&E Plan, and includes several key updates from previous versions to address recommendations from an initial technical review of the 2017 M&E Plan (see Appendix B), and comments provided by the Lewis River Aquatic Technical Subgroup (ATS):

1. PIT tag more juvenile fish of all target species (spring Chinook, coho, late winter steelhead, and cutthroat) to estimate overall downstream survival by size/age class.

2. Implement a two-year feasibility study to:

    - Determine if overall downstream survival parameters are not significantly different ($p = 0.10$) between naïve fish (fish tagged and released before entering Swift Reservoir) compared to non-naïve fish (captured and tagged at the Swift Floating Surface Collector (Swift FSC) then transported and released upstream at the head of Swift Reservoir).

    - Determine if substantially more juvenile salmonids can be captured and tagged by running a screw trap at the head of Swift Reservoir over a longer seasonal time period and/or if tributary sampling and tagging may be more effective.

    - Estimate the total number of juvenile target species captured and transported downstream of the Swift FSC by size/age class.

3. Suspend annual spawning surveys for coho; estimate the proportion of coho that spawn in the Swift Reservoir drawdown zone; and use existing regionally accepted pre-spawn mortality rates (to be provided by WDFW) to estimate the proportion of transported adults that likely spawn upstream of the reservoir each year.

4. Suspend annual late winter steelhead spawning surveys, and use existing regionally accepted pre-spawn mortality rates to estimate the proportion of transported adults that spawn each year.

5. Revise and simplify the run reconstruction methods and choose one approach to estimate ocean recruits. Simplify the methods for calculating SARs and R/S for species reintroduced above Swift Dam.

6. Develop an Integrated Population Model (IPM) for each of the target species in the North Fork Lewis River (i.e., spring Chinook, coho, and late winter steelhead populations) with the primary goal of estimating: (1) juvenile production and survival, and (2) adult production and survival, based on production of adults

transported upstream of Swift Dam. The models will be used to independently estimate specific M&E Plan objectives such as juvenile production and survival, ocean recruits, smolt-to-adult survival rates, and recruits per spawner.

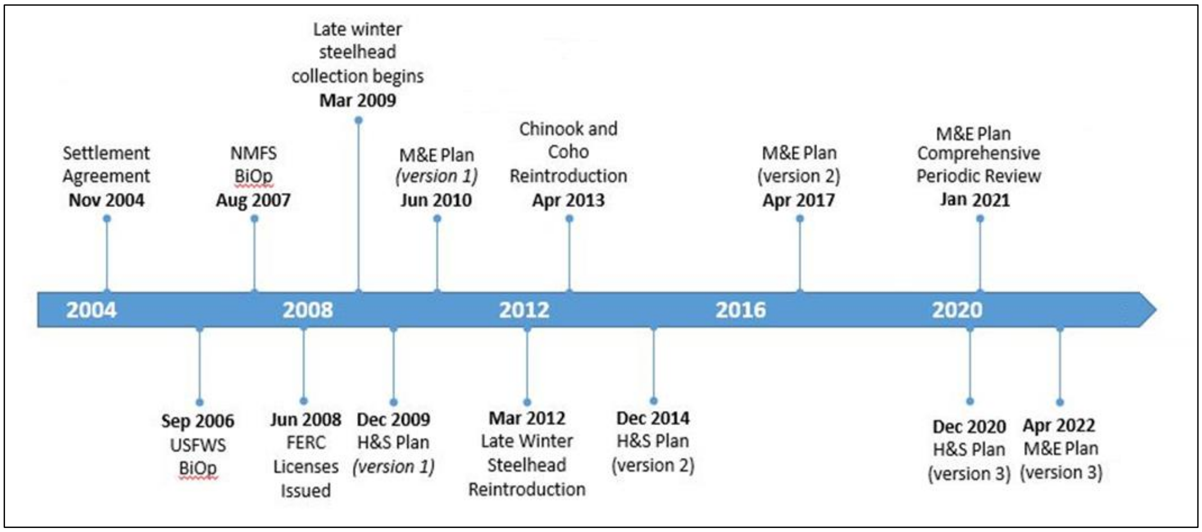

Figure E-1. Timeline of milestones related to the Monitoring and Evaluation Program and associated activities.

Deviations from Settlement Agreement

The M&E Plan is structured to be consistent with Section 9 of the Settlement Agreement. However, in an effort to reduce redundancy between the M&E Plan and the Lewis River Hatchery and Supplementation Plan (H&S Plan), some M&E Plan components are addressed in the H&S Plan. Deviations from the Settlement Agreement that could pertain to aquatic monitoring and evaluation are described below.

- Fall Chinook and Chum Monitoring and Evaluation (Section 9.3): The ACC made a decision to separate tasks originally identified in the Settlement Agreement into monitoring upstream of Merwin Dam (M&E Plan Tasks) and monitoring downstream of Merwin Dam (H&S Plan Tasks). Because of that distinction, Objective 16, which is a downstream activity, has been transferred to the H&S Plan and is covered under Objective 1 of that plan. For consistency, Objective 16 remains in this current M&E Plan and serves as reference point for this monitoring work.

- Juvenile Supplementation (Section 8.5): The Settlement Agreement states that juvenile supplementation shall occur for all three transport species (i.e., spring Chinook, coho, and late winter steelhead). The intent of this program was to acclimate and release juvenile hatchery fish upstream of Swift Dam. However, juvenile supplementation was discontinued due to low performance of juvenile supplementation fish and challenges with the remoteness of the acclimation sites. In addition, adults transported upstream have been found to distribute extensively in the upper basin and appear to utilize much of the available habitat. In 2019, the juvenile supplementation program was temporarily suspended, and the reintroduction program currently relies exclusively on transport of adults upstream of Swift Dam. Adults used for the supplementation program are sourced from adult traps at Merwin Fish Collection Facility (MFCF) at Merwin Dam and the Lewis River Fish Hatchery.

- The Settlement Agreement uses the term '*supplementation'* to describe transport of juveniles upstream of Swift Dam. However, the H&S Plan uses adults to meet the supplementation goals of the Settlement Agreement. The use of adults is often referred to as 'reintroduction' which can cause confusion. However, to remain consistent with the Settlement Agreement, this plan continues to use the term supplementation to refer to both juvenile and adult transport activities and considers the term *reintroduction* to be synonymous with *supplementation*.

Review and Comment Periods

Section 9.1 of the Settlement Agreement requires that the Utilities prepare this plan in Consultation with the ACC.

Potential Amendments to the Plan

In-Lieu Decision

Section 7.6 of the Settlement Agreement directs PacifiCorp to establish an In-Lieu fund if the Services determine that anadromous fish passage into Yale or Merwin Reservoirs is not required. The Services determined on October 27, 2021 that reintroduction of anadromous fish into Yale Reservoir is warranted and that downstream fish passage facilities at Yale Dam are to be completed by June 26, 2026. On December 23, 2021 the Services informed parties of their determination on appropriateness of anadromous fish passage into Merwin Reservoir.

Presently, this plan only describes M&E efforts upstream of Swift Dam and at the MFCF at the base of Merwin Dam. Additional anadromous fish reintroduction M&E efforts will be developed and incorporated into this M&E plan prior to the completion of any future fish passage facilities.

1.0 INTRODUCTION

The Lewis River Settlement Agreement for the Lewis River Hydroelectric Projects dated November 30, 2004 includes a comprehensive suite of salmon and steelhead protection, mitigation, and enhancement (PM&E) measures that will be implemented over the terms of the new project licenses (PacifiCorp and Cowlitz PUD 2004). As described in Section 8 (Hatchery and Supplementation Program), a key feature of the Settlement Agreement is the reintroduction of spring Chinook, coho and late winter steelhead into their historical range above Merwin Dam using hatchery supplementation and newly constructed fish passage facilities. The Hatchery and Supplementation (H&S) Plan provides guidance for implementing activities associated with Section 8 of the Settlement Agreement, and Section 9 of the Settlement Agreement calls for the development of an Aquatic Monitoring and Evaluation Plan (M&E Plan) to monitor and evaluate the effectiveness of aquatic PM&E Measures and to assess achievement of the Reintroduction Outcome Goals. Development of the H&S and M&E plans are a requirement of both the Settlement Agreement and the Federal Energy Regulatory Commission (FERC) Hydroelectric Project Licenses (Figure 1.1.1). The Settlement Agreement directs the Licensees to include in the M&E Plan elements to determine whether the Reintroduction Outcome Goals have been achieved, provided that for such purposes the Licensees shall be required to monitor and evaluate only elements that are under the control of the Licensees (such as the functioning of fish passage facilities) and that are affected by the Projects.

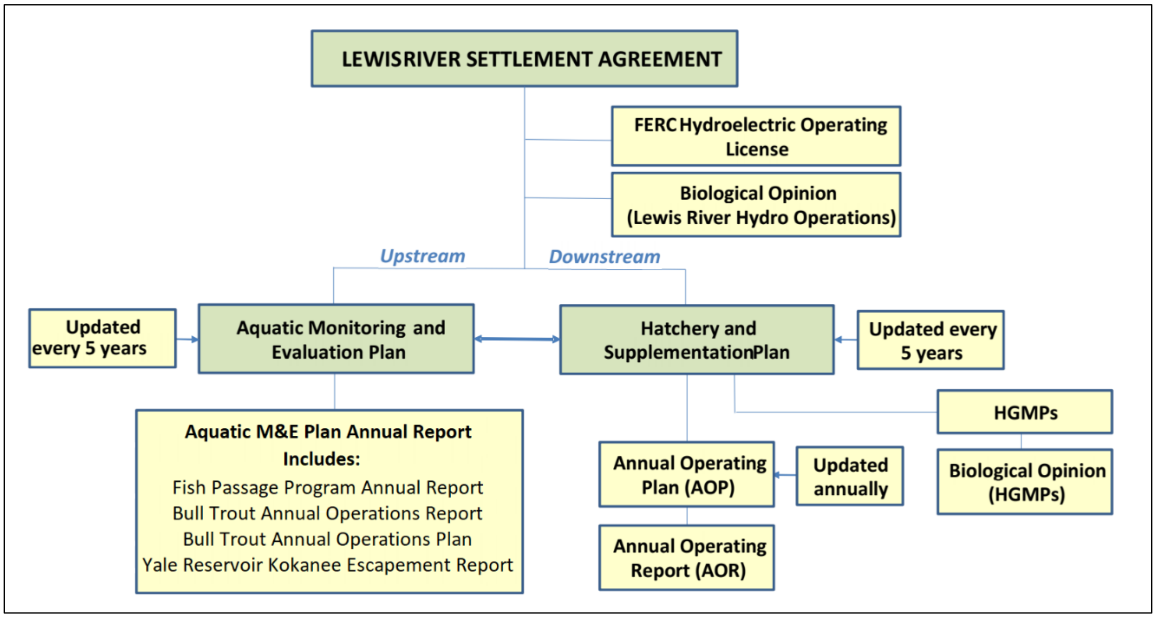

Figure 0.1.1. Structure and relationship between the Lewis River Settlement Agreement and required plans and reports for upstream and downstream fish passage and fish production programs.

1.1 M&E PROGRAM GOALS

The M&E Plan is designed to meet the monitoring and evaluation requirements outlined in Section 9 of the Settlement Agreement as they relate to fish passage facilities and infrastructure associated with Phase 1 Reintroduction Goals (Section 3.1.1 of the Settlement Agreement). The primary focus of this M&E Plan is the evaluation of the reintroduction program for spring Chinook, coho and late winter steelhead upstream of Swift Dam, including the upstream transport of adult fish captured at the Merwin Fish Collection Facility (MFCF) located at the base of Merwin Dam, and downstream transport of juvenile outmigrants captured at the Swift Floating Surface Collector (Swift FSC) located in the forebay of Swift Dam (Figure 1.1.2). At this time, this plan only pertains to monitoring at Merwin Trap and upstream of Swift Dam; other areas may be monitored as decisions are made about future fish passage facilities.

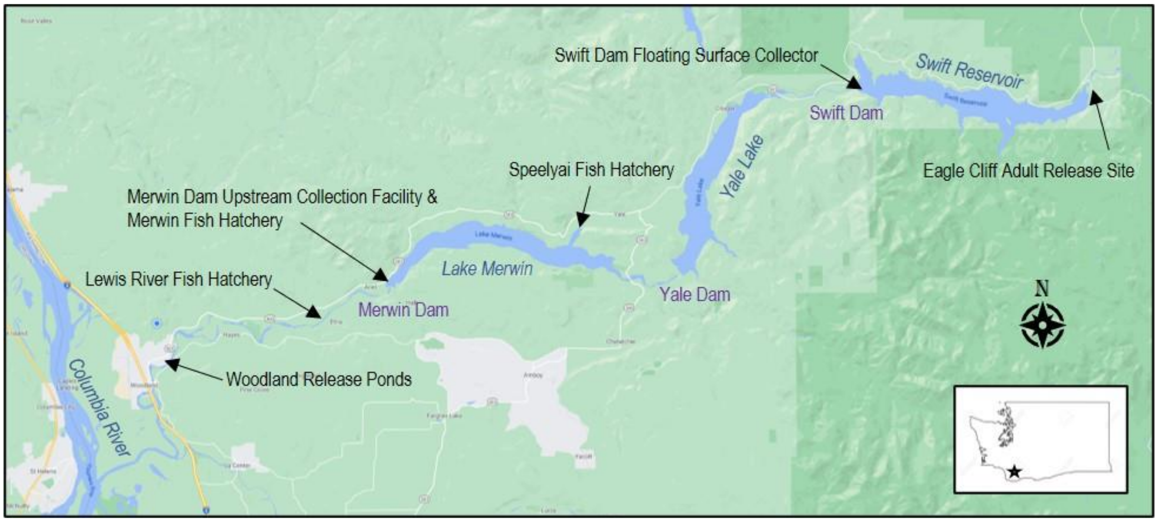

Figure 0.1.2. Area map showing locations of Lewis River fish hatcheries, collection facilities, hydroelectric projects and reservoirs.

As described in Section 9.1 of the Settlement Agreement, the M&E Plan shall provide the approach to:

> *"…monitor and evaluate the effectiveness of aquatic PM&E Measures and to assess achievement of the Reintroduction Outcome Goals. The M&E Plan shall address the tasks, and the methods, frequency and duration of those tasks, necessary to accomplish the monitoring and evaluation items…"*

Anadromous fish reintroduction goals were established in the Settlement Agreement for coho, spring Chinook and late winter steelhead for the portion of the Lewis River basin located upstream of Merwin Dam. The measures to be monitored and evaluated are described primarily in Section 4 and Section 9 of the Settlement Agreement. The intent of the M&E Plan is to identify monitoring actions needed to determine the success of constructed fish passage systems and the overall success of the fish reintroduction effort. The reintroduction outcome goal is to:

> *"…achieve genetically viable, self-sustaining, naturally reproducing, harvestable populations above Merwin Dam greater than minimum viable populations ("Reintroduction Outcome Goal")."*

However, it needs to be noted that the metrics for determining whether the Reintroduction Outcome Goal is being met have yet to be developed[1] by the US Fish and Wildlife Service and National Marine Fisheries Service (the Services). Because these metrics are unavailable, the M&E Plan focuses on those studies needed to determine when the performance standards outlined in Section 4 of the Agreement are achieved. A definition of each performance standard and its benchmark value are presented in Table 1.1.1.

The M&E Plan also provides the methods used to monitor and evaluate adult spawning escapement, fish passage facility hydraulic performance, flow and ramping rates, resident and anadromous fish interactions, and bull trout and kokanee populations. PacifiCorp and

[1] The time frame for the Services to identify this metric is described in Section 3.1.1 of the Settlement Agreement.

Cowlitz PUD will provide an annual report to FERC (ACC/TCC Annual Report), the Aquatic Coordination Committee (ACC), the Terrestrial Coordination Committee (TCC) and Washington Department of Ecology (WDOE) in approximately June of each year. The ACC/TCC Annual Report will contain a summary of all monitoring activities included in the M&E Plan as well as a summary of all terrestrial monitoring activities from the previous year.

Table 1.1.1. Reintroduction performance standard definitions and benchmark values.

Performance Standard	Definition[1]	Benchmark Value
Adult Trap Efficiency (ATE)	The percentage of adult spring Chinook, coho, late winter steelhead, bull trout, and sea-run cutthroat that are actively migrating to a location above the trap and that are collected by the trap.	Determined by the ACC[3] to be 98%
Collection Efficiency (CE)	The percentage of juvenile anadromous fish of each of the species designated in Section 4.1.7[2] that is available for collection and that is actually collected.	95%
Collection Survival (CS)	The percentage of juvenile anadromous fish of each of the species (designated in Section 4.1.7) collected that leave the Release Ponds alive.	Smolts $\geq$ 99.5% Fry $\geq$ 98% Adult Bull Trout $\geq$ 99.5%
Injury	Visible trauma (including, but not limited to hemorrhaging, open wounds without fungus growth, gill damage, bruising greater than 0.5 cm in diameter, etc.), loss of equilibrium, or greater than 20% descaling . "Descaling" is defined as the sum of one area on one side of the fish that shows recent scale loss. This does not include areas where scales have regenerated or fungus has grown.	$\leq$ 2% for smolts
Overall Downstream Survival (ODS)	The percentage of juvenile anadromous fish of each of the species designated in Section 4.1.7 that enter the reservoirs from natal streams and survive to enter the Lewis River below Merwin Dam by collection, transport and release via the juvenile fish passage system, passage via turbines, or some combination thereof (calculated as provided in Schedule 4.1.4. of the Settlement Agreement).	Interim > 80% > 75% after installation of Yale Downstream Collector
Upstream Passage Survival (UPS)	Percentage of adult fish of each species (designated in Section 4.1.7) that are collected that survive the upstream trapping-and-transport process. For sea-run cutthroat and bull trout, "adult" means fish greater than 13 inches in length.	$\geq$ 99.5%

[1]Definitions are taken from Settlement Agreement for the Lewis River Hydropower Projects (PacifiCorp and Cowlitz PUD 2004)

[2]Species designated in Section 4.1.7 of the Settlement Agreement are spring Chinook, late winter steelhead, coho, bull trout and sea-run cutthroat trout.
[3]The Settlement Agreement calls for ATE to be determined by the ACC pursuant to Section 4.1.4c of the Settlement Agreement. All other benchmarks are established in sections 4.4.1a and 4.4.1b of the Settlement Agreement.

1.2 ADAPTIVE MANAGEMENT

Adaptive management of the M&E program is critical to ensuring the program's goals and objectives remain relevant and allows managers to modify objectives as the program matures. The Settlement Agreement provides managers the opportunity to review and modify the M&E Plan at least every five years. The Lewis River ACC is the avenue for managers to review and modify the M&E Plan. As part of monthly ACC meetings, the ACC is provided status updates on the M&E Program. When necessary, the ACC shall make decisions regarding recommended changes to the program proposed by the ATS or Utilities. Decisions by the ACC follow consensus-based protocols provided in the ACC and TCC ground rules document, which requires the use of a Request for Decision Template and Record of Decision Template (PacifiCorp and Cowlitz PUD, 2000). Final decisions are documented in the ACC meeting notes and recorded in the Utilities' annual operations report to the FERC. The ATS provides technical expertise and recommendations to the ACC and helps develop and review planning documents related to implementation of the Settlement Agreement.

The M&E Plan will be updated at a minimum every five years and continues to emphasize the methods for evaluating the success of the reintroduction program upstream of Swift Dam, the Swift FSC, and the MFCF, and will incorporate other passage facilities as they come online. The Swift FSC is used to collect juvenile and adult anadromous salmonids migrating downstream from stream reaches upstream of Swift No. 1 Dam. The MFCF is used to collect adults returning to this same portion of the basin or to hatchery facilities. The performance standards shown in Figure 1.1.3 will be used to determine not only the success of the Swift FSC but also provide the justification for making adjustments and/or modifications to this facility over time to improve fish passage performance.

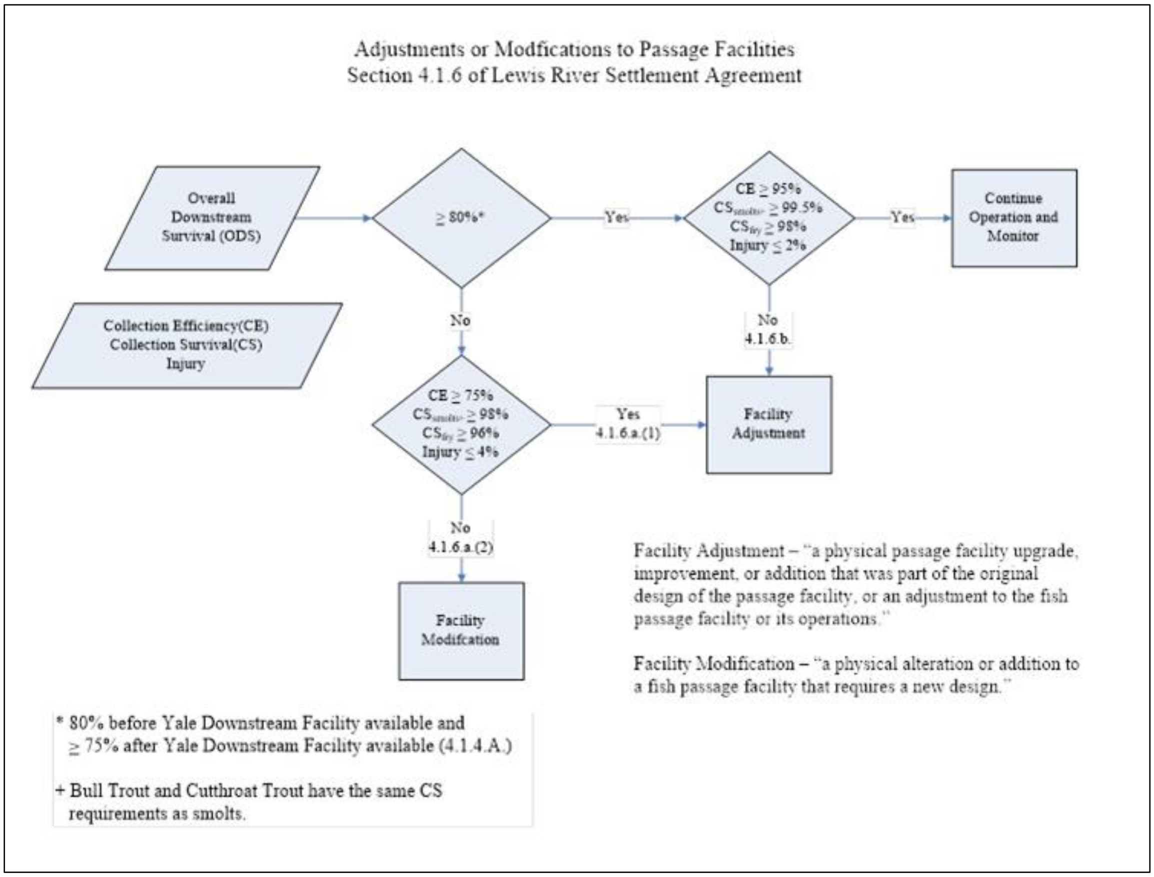

Figure 1.1.3. Swift Floating Surface Collector decision flow chart.

This document represents the second revision (third version) of the M&E Plan following the reintroduction of anadromous fish above Swift Dam. The ACC provided input on the initial M&E Plan (completed in 2010), the first revision (completed in 2017), and a 90-day review draft of this second revision (completed in 2021). To revise the 2017 M&E Plan, an initial technical review was first performed by the Licensees, which included recommendations for updating the 2017 M&E Plan based on a technical review of the objectives, methodologies, and data collected from work under the M&E Plan from 2016 through 2020 (Appendix B). This revised draft of the M&E Plan was prepared to incorporate the initial technical review recommendations; see Appendix B, Table 7.1 for a summary of the 2017 M&E Plan evaluation and recommendations, which were used to help inform and update this second revision of the M&E Plan.

2.0 MONITORING AND EVALUATION OBJECTIVES

The M&E Plan has been designed to achieve twenty-two objectives. The objectives are as follows:

Objective 1 Quantify overall juvenile fish downstream survival (ODS) which includes reservoir survival, collection survival, transport survival, and survival at the release ponds.

Objective 2 Quantify Swift FSC collection efficiency.

Objective 3 Quantify the percentage of juvenile fish available for collection that are not captured by the Swift FSC and that enter the powerhouse intakes.

Objective 4 Quantify juvenile and adult collection survival.

Objective 5 Quantify juvenile injury and mortality rates during collection at the Swift FSC (includes injury and mortality of adult bull trout, adult sea-run cutthroat, and steelhead kelts).

Objective 6 Quantify the number, by species, of juvenile and adult fish collected at the Swift FSC.

Objective 7 Estimate the number of juveniles entering Swift Reservoir.

Objective 8 Develop an index of juvenile migration timing.

Objective 9 Quantify adult upstream passage survival.

Objective 10 Quantify adult trap efficiency at each upstream fish transport facility (emphasizes analysis of the Merwin Adult Trapping Facility).

Objective 11 Quantify the number, by species, of adult fish collected at the projects (emphasizes Merwin Dam).

Objective 12 Develop estimates of ocean recruits.

Objective 13 Develop performance measures for index stocks.

Objective 14 Document upstream and downstream passage facility compliance with hydraulic design criteria.

Objective 15 Determine spawn timing, distribution and abundance of transported anadromous adults.

Objective 16 Evaluate lower Lewis River wild fall Chinook and chum populations *Note: Objective 16, because it is a lower Lewis River monitoring activity, is now monitoring Objectives 5.0 and 6.0 in the H&S Plan revised in 2020.*

Objective 17 Monitor bull trout populations.

Objective 18 Determine interactions between reintroduced anadromous salmonids and resident fish (Upstream of Merwin Dam).

Objective 19 Document Project compliance with flow, ramping rate and flow plateau requirements.

Objective 20 Determine when reintroduction outcome goals are achieved.

Objective 21 Develop a Hatchery and Supplementation Plan to support and protect Lewis River native anadromous fish populations and provide harvest opportunity.

Objective 22 Develop a Coordination Table that cross-references Objectives of the H&S Plan and the M&E Plan.

For Objectives 1-22, the tasks, methods, frequency and duration of sampling, assumptions, results and reporting are discussed in the sections that follow. Objective 22 of this M&E Plan identifies the need for a summary of all monitoring efforts and results for the North Fork Lewis River, including those called for by both the M&E Plan and the H&S Plan, and is intended to combine various population estimates from upstream and downstream of the Lewis River Projects to evaluate population status of the listed species in the North Fork Lewis River basin annually.

2.1 OBJECTIVE 1: QUANTIFY OVERALL JUVENILE DOWNSTREAM SURVIVAL

The Settlement Agreement requires that the Utilities achieve an overall downstream survival (ODS) rate of greater than or equal to 80%[2]. ODS is defined in Section 4.1.4 of the Settlement Agreement as:

> *The percentage of juvenile anadromous fish of each of the species designated in Section 4.1.7 that enter the reservoirs from natal streams and survive to enter the Lewis River below Merwin Dam by collection, transport and release via the juvenile fish passage system, passage via turbines, or some combination thereof, calculated as provided in Schedule 4.1.4.*

In other words, ODS is the percentage of the fish entering the Lewis River hydroelectric project reservoirs (the Project) that migrate, or are transported to the lower Lewis River (i.e., downstream of Merwin Dam) and released successfully (i.e., alive). It should be noted that Schedule 4.1.4 of the Settlement Agreement contains a caveat that the methodology described in the Schedule needs to be ground-truthed and refined.

2.1.1 Task 1.1- Estimate ODS for Anadromous Fish Species above Swift No. 1 Dam

Initially, ODS will be measured from the head of Swift Reservoir to the exit of the Release Ponds located downstream of Merwin Dam (Figure 2.1.1). Estimates of ODS will be developed for coho, spring Chinook, late winter steelhead and, to the extent possible, sea-run cutthroat trout. ODS estimates for sea-run cutthroat trout will be delayed until data indicate that this cutthroat life history is present in the upper Lewis River basin and that the number of juveniles produced is sufficient, as determined by the USFWS, for experimental purposes.

Passive Integrated Transponder (PIT) tags, compatible with those used throughout the Columbia Basin for salmonid evaluations, and direct enumeration of fish collected and

[2] An ODS of greater than or equal to 80% is required until such time as the Yale Downstream Facility is built or the Yale in Lieu Fund becomes available to the Services, after which ODS shall be greater than or equal to 75%. The parties to the Settlement Agreement acknowledge that ODS rates of 80% or 75% are aggressive standards and will take some time to achieve.

transported from the Swift FSC will be used to develop estimates of ODS. All PIT tags used will be entered into the Columbia Basin PIT Tag Information System (PTAGIS) database.

Consistent with the Settlement Agreement, juveniles passing Swift Dam either through the turbines or spill will not be counted toward meeting the ODS standard because they are unlikely to survive passage through multiple dams and reservoirs not equipped with passage facilities.

2.1.1.1 Methods

The methods proposed for developing estimates of ODS are as follows:

- A two-year feasibility study will evaluate the difference in recapture probability between naïve and non-naïve release groups (i.e., fish captured at a screw trap operated at the head of Swift Reservoir at Eagle Cliff Park vs. at the Swift FSC) by size/age class. The primary goal of this feasibility study is to determine if substantially more naïve fish can be captured and tagged, and then recaptured at the Swift FSC. Fish captured at the Swift FSC will be PIT tagged, and transported upstream and released at the head of Swift Reservoir to determine if there is a significant difference in recapture probability between 1) test fish captured at the Swift FSC and returned back upstream and released (non-naïve fish) and 2) fish collected and tagged at a screw trap operated at the head of Swift Reservoir at Eagle Cliff Park (naïve fish; $p = 0.10$). Preliminary assessment of this data suggests that a substantial portion of juvenile fish enter the reservoir at a much smaller size than when they are captured at the Swift FSC as outmigrants, which indicates that reservoir rearing prior to outmigration occurs. Therefore, during the two-year feasibility study, the focus will be on PIT tagging juvenile salmonids at the Swift FSC over a wider size range (including smaller fish, to the extent available), similar to the size range typically captured at the Eagle Cliff Park screw trap, in order to make a statistically valid comparison of the S_1 parameter between the two marking locations (i.e., to compare naïve and non-naïve fish of the same species/size class). The S_1 parameter is the joint probability of survival through the reservoir and collection at the Swift FSC. Or in other words, the S_1 parameter is the proportion of outmigrants that enter the reservoir that are then collected at the Swift FSC[3].

- During the two-year feasibility study, a similar number and size of each species will be PIT tagged at the Swift FSC as are captured and tagged at the Eagle Cliff Park screw trap (to the extent possible based on the size and number of fish captured at each location).

- Test fish will be identified to species, measured for length and tagged with 12-mm PIT tags. Only fish greater than or equal to 69 mm in length will be PIT tagged as recommended by Vollset et al. (2020).

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[3] The S_1 Parameter is not the same as collection efficiency under Objective 2. Collection efficiency under Objective 2 is used to assess facility performance compared to standards outlined in Section 4.1.4 of the Settlement Agreement and is the proportion of outmigrants that arrive at the Swift FSC zone of influence that are then collected within the Swift FSC. Population level collection efficiency is assessed as part of ODS and is embedded in the S_1 parameter.

- Fish captured at the Swift FSC will be released at the head of Swift Reservoir. Releases will be conducted weekly throughout the year, but will be subject to the capture methodology constraints if naïve fish are used (such as screw trap operation timing and capture abundance, see Section 2.7.3) and Swift FSC seasonal operation constraints (typically October through mid-July). Based on the estimated S_1 parameter from 2019 through 2020 (about 20%), it is estimated that 1,035 Chinook and coho of each size/age class, respectively, would need to be marked annually to meet the sample size recommendations (Table 2.1.1) assuming tag detection probability of 95% and a precision of 0.025. Based on the measured S_1 parameter from 2019 through 2020 for steelhead and cutthroat (about 10%), the annual sample size would need to be about 582 given the same detection probability and precision assumptions. The total number of fish to be tagged annually will be distributed monthly in approximate proportion to the run timing of each species' size/age class as observed in prior years. The approximate proportion will be adjusted based on run timing observed during the two-year feasibility study described in Section 2.7 below.

- Size/age classes (i.e., cohort determination) will be determined for each species by assessing the seasonal length frequency distributions of fish collected at the Eagle Cliff Park screw trap and the Swift FSC, and by comparing the length data for PIT tagged fish that are recaptured at the Swift FSC to assess growth (length) between two points in time. It is anticipated that fork length bins for evaluation would be in 10 mm increments for fish smaller than 300 mm, and 25 mm increments for fish 300 mm or larger. The fork length distributions will be produced following the methods described under Section 2.6.1.1 below.

Table 2.1.1. Release sizes to estimate $S_1 = S_{RES} * P_{COL}$ at the Swift Reservoir for alternative values of survival and collection S_1, and detection probability (p_1) at the slide gates for a precision of $\varepsilon = 0.025$, $1 - \alpha = 0.95$.

S_1	p_1	$\varepsilon = 0.025$	S_1	p_1	$\varepsilon = 0.025$
0.5	0.85	1808	0.8/0.2	0.85	1157
	0.9	1707		0.9	1093
	0.95	1618		0.95	1035
	0.98	1568		0.98	1004
0.6/0.4	0.85	1735	0.9/0.1	0.85	651
	0.9	1639		0.9	615
	0.95	1553		0.95	582
	0.98	1505		0.98	564
0.7/0.3	0.85	1519	0.95/0.05	0.85	343
	0.9	1434		0.9	324
	0.95	1359		0.95	307
	0.98	1317		0.98	298

- Literature values for general PIT tag mortality and tag retention can be applied within the estimation method as required.

- Multiple PIT tag detectors will be located on the Swift FSC and at the exit of the release ponds and will generate the tag detection histories necessary and associated efficiencies for estimating ODS.

- The Swift FSC, transport trucks, and release ponds will be examined daily by biologists to determine the number of fish killed during the handling and transport processes. All dead fish will be examined for the presence of a PIT tag. Dead tagged fish found in the Swift FSC and release ponds will be assigned to collection loss (S_{COL}) and transport loss (S_{TRAN}), respectively in accordance with Section 2.4 below.

The single release-recapture model will be used to estimate the probability of surviving passage to the lower Lewis River (Appendix Table B-1) for each cohort (based on the size/age class determinations). ODS will be calculated as:

$ODS = S_1 * (S_{COL} * S_{TRAN})$,

Where:

S_1 = Proportion of tagged outmigrants that enter Swift Reservoir that are collected at the Swift FSC, which represents the joint survival probability through the reservoir (S_{RES}) and collection of fish arriving at Swift Dam (P_{COL})[4]. Alternatively, the S_1 parameter may be estimated as the total number of fish estimated to have entered the reservoir divide by the total number of fish estimated to have been collected within the FSC;
S_{COL} = survival probability through the collector; and
S_{TRAN} = survival probability through the smolt transport system.

A 95% confidence interval for ODS will be calculated based on a large-sample approximation for a binomial probability (Bowerman and Budy 2012) as:

$ODS \pm 1.96 * SE$,

Where:

$SE = \sqrt{\frac{ODS*(1-ODS)}{N}}$; and

N = the number of marked fish.

A diagram of each of these parameters (S_{RES}, P_{COL}, S_{COL} and S_{TRAN}) is shown in Figure 2.1.1.

[4] The S_1 parameter is estimated as a whole; S_{RES} and P_{COL} are embedded within S_1, but are not individual estimated.

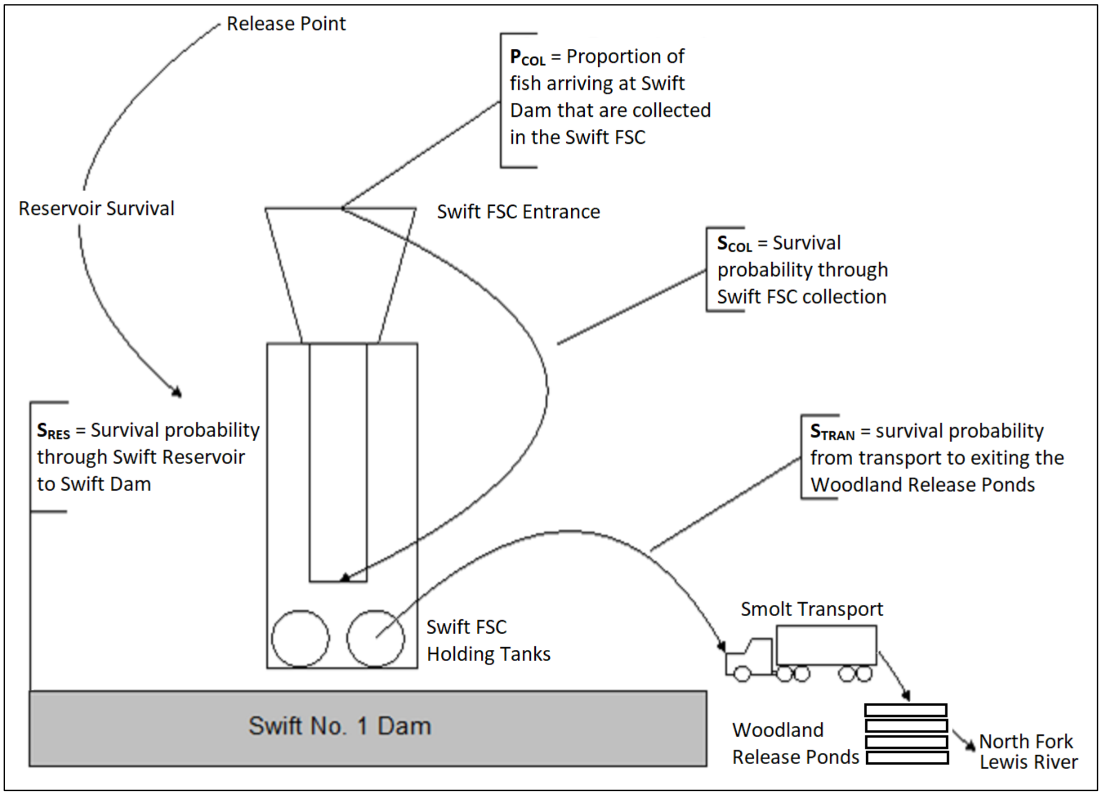

Figure 2.1.1. Schematic showing evaluation parameters for calculating ODS.

The annual ODS estimate will be based on pooling release–recapture data over the season for each species' cohort. Because some proportion of tagged fish are likely to overwinter in the reservoir, any fish captured in subsequent years will be retrospectively added to the ODS estimate for their specific cohort analysis. Ultimately, ODS will be calculated by cohort and will be iterative in nature, and will likely occur over a two or three year period, as fish from the same cohort enter the reservoir and then are captured at the Swift FSC.

Following the two-year feasibility study, data will be evaluated to make the following determinations:

- Determine if there is no significant difference ($p = 0.10$) in recapture rate between fish PIT tagged at the Swift FSC and returned to the head of the reservoir for release (non-naïve) and fish captured, PIT tagged, and released at the Eagle Cliff Park screw trap (naïve) by species size/age class.

- If no significant difference is found, then use only Swift FSC PIT tagged fish to measure the S_1 parameter for estimating ODS.

- If there is a significant difference found in the recapture rates between the screw trap and Swift FSC PIT tagged fish, then determine which method or combination of methods is most efficient to meet the ODS sample size recommendations and revise ODS estimator as warranted to account for the difference.

- At the end of the feasibility study, the alternative methods will be presented to the ATS and evaluated to determine which method or combination of methods best meets the PIT tag sample size requirements for calculating ODS, and most accurately represents the abundance of juvenile fish entering the reservoir. At that time, a long-term methodology will be developed and proposed in consultation with the ATS, and/or additional recommendations will be made to further refine a selected methodology.

Further discussion regarding the S_1 parameter and the use of naïve vs. non-naïve test is provided in Section 2.7.

In addition to the methods above, output from Integrated Population Models (IPM) developed as part of Objective 20 will also be eventually used to independently estimate ODS for juvenile coho, spring Chinook, and late winter steelhead. Model derived estimates of ODS will be compared to estimates generated under this Objective. If estimates differ significantly between these two approaches, then analysis will be conducted to assess what may be driving any difference. Methods may be revised in the future if warranted based on this comparative assessment in consultation with the ATS. See Section 2.20 within this Plan for more information on the development of the IPM, timelines and intended outputs.

2.1.1.2 Frequency and Duration

The evaluation of naïve vs. non-naïve fish recapture rates will be completed during a two-year feasibility study, and then results and recommendations on future tagging protocols going forward to address this Objective will be presented to the ATS for review and approval. Estimates of ODS will be made annually until study results show that the 80% ODS standard has been met for each species for three consecutive years. The study will be repeated upon completion of any future downstream collection facilities at Yale and/or Merwin dams to determine if the 75% ODS criteria called for in the Settlement Agreement is achieved. Once ODS is met then reassessment will occur at least once every five years. If ODS is not met with each reassessment, the study will be performed annually until study results show that the ODS standard has been met for each species for three consecutive years.

2.1.1.3 Assumptions

Assumptions associated with conducting the analysis include:

1. All fish act independently;
2. Survival and recapture probability of fish is not significantly different between initial tagging location (i.e., same for naïve vs. non-naïve fish), or can be measured and accounted for;
3. Release size is known without error;
4. There is no post-release handling mortality, tag failure or loss, or these parameters can be estimated and the survival estimates adjusted accordingly;
5. Downstream detection is conditionally independent of detection upstream;
6. Tagged fish are uniquely identifiable at all detection sites;
7. Fry and parr mortality due to extended reservoir rearing is accepted as a Project impact and does not need to be corrected for; and

8. Any fish passing through spill and turbine discharge at Swift Dam will not count toward meeting the ODS standard.

2.1.1.4 Results and Reporting

The results of the study will be summarized by month and reported in text and tabular format with a narrative in the Aquatic M&E Annual Report and will include percent ODS, by species cohort, per month of assessment. Information will also be presented on how cohort size classes were assessed and defined. A total estimate of ODS for the migration season will also be developed and reported by species cohort. Biologists will investigate and present any information that indicates ODS values vary by fish size class or project operations. This information would be used to adjust study protocols to better estimate ODS and implement corrective actions if ODS is not being achieved.

2.2 OBJECTIVE 2: QUANTIFY SWIFT FSC COLLECTION EFFICIENCY (P_{CE})

Biotelemetry will be used to measure juvenile collection efficiency (P_{CE}) at the Swift FSC. Section 4.1.4 of the Settlement Agreement defined collection efficiency as:

> *The percentage of juvenile anadromous fish of each of the species designated in section 4.1.7 that is available for collection and that is actually collected.*

A juvenile that is “available for collection” is one that is found (detected) within the zone of influence (ZOI) at the entrance of the Swift FSC[5]. The ZOI is defined as the area approximately 150 feet radius immediately outside the exclusion net that is influenced by the flow entering the Swift FSC (Figure 2.1.2). The dimensions of the ZOI were determined by the fish passage subgroup in part based on the hydraulic influence observed in the fluid dynamics modeling. As stated in the Settlement Agreement, the performance standard for Collection Efficiency is 95% or greater[6].

Additionally, estimates of the proportion of fish encountering the Swift FSC (P_{ENC}), fish entrance efficiency (P_{ENT}), and retention efficiency (P_{RET}) will also be calculated as part of this analysis using active tag detections. Collecting these data will give biologists the ability to determine where improvements in the design or configuration of the Swift FSC may be needed to meet the P_{CE} and ODS standards. The importance of each parameter in diagnosing Swift FSC operations are as follows:

- P_{ENC} – A low encounter value indicates that few fish arriving at Swift Dam were detected within the ZOI of the Swift FSC. This condition would indicate that fish are not finding or transitioning into the ZOI from the upper reservoir. This may be attributed to a high rate of residualization or low reservoir survival, or perhaps fish are simply not finding the entrance of the Swift FSC once entering the forebay. Unfortunately, the first two scenarios are difficult to resolve; however, the third

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[5] The Zone of Influence is the area in front of the Swift FSC entrance where all flow lines upstream of the exclusion nets lead to the collector.

[6] Collection efficiency is the proportion of outmigrants that arrive at the Swift FSC zone of influence that are then collected within the Swift FSC. This is not to be confused with the proportion of the total number of outmigrants that enter Swift Reservoir that are then collected within the Swift FSC, which is embedded in the S_1 parameter as defined under Objective 1.

scenario may be resolved by installation of a guide or lead net that would help guide or otherwise orient fish to the entrance of the Swift FSC.

- P_{ENT} – Fish that have encountered the ZOI may not actually enter the Swift FSC. This condition would be indicated by a low entrance efficiency value for P_{ENT}. The problem may be caused by poor or confusing hydraulics at the mouth of the collector or a sudden decrease or increase in water velocity just inside the Swift FSC. Such problems may be corrected by altering the hydraulics at the entrance of the Swift FSC.

- P_{RET} – Fish that enter the Swift FSC may also swim back out of the system, resulting in low Swift FSC retention efficiency (P_{RET}). Low Swift FSC retention efficiency may be the result of water velocities through the Swift FSC that are too slow to trap the fish, or result in fish turning around within the collection channel. This condition may be alleviated by changing screen openings to increase water velocities and hydraulic characteristics within the collection channel.

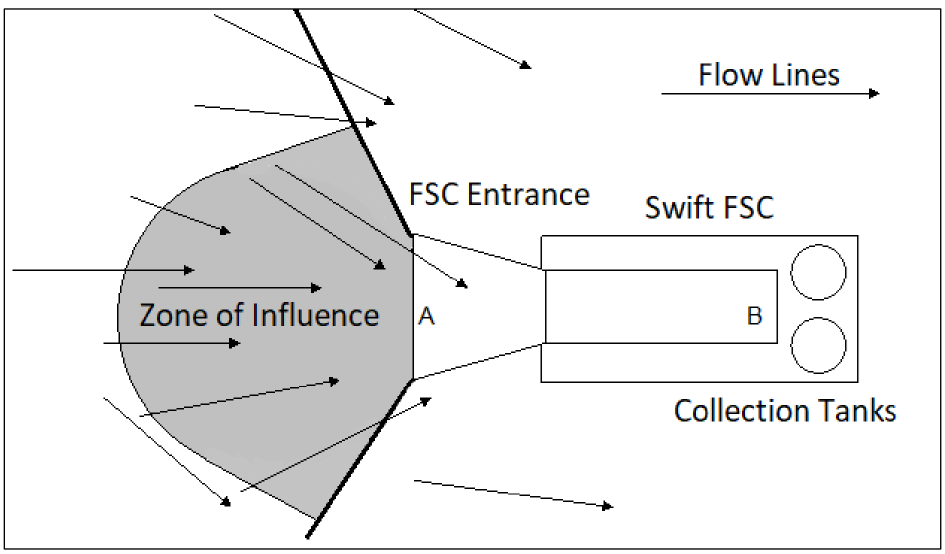


Figure 2.1.2. Schematic of Swift FSC and detection area associated with the ZOI (diameter of 150 feet) and locations of antenna array (A) and PIT Tag detector (B).

2.2.1 <u>Task 2.1- Estimate Swift FSC Collection Efficiency (P_{CE})</u>

2.2.1.1 Methods

A brief description of the methods to be used in estimating Swift FSC collection efficiency (P_{CE}) is presented below.

- Biotelemetry tags (radio or acoustic) will be used for estimating Swift FSC collection efficiency (P_{CE}).

- The number of fish tagged per species will be determined based on achieving approximately a 90% confidence level (CL) at a 0.05 precision level when P_{CE} and tag detection probability is 95% (Table 2.2.1). Information collected during previous evaluation years will be used to guide sample size allocations.

Table 2.2.1. Release sizes to estimate P_{CE} at the Swift FSC for alternative values of reservoir survival and detection probability at the ZOI for a precision of ε = 0.05, 1 – α = 0.90.

		Required n, given reservoir survival						
Detection Probability	**P_{CE} (π_obs)**	**100%**	**95%**	**90%**	**80%**	**70%**	**60%**	**50%**
0.95	0.10	103	108	114	128	146	171	205
0.95	0.20	182	192	203	228	260	304	365
0.95	0.30	239	252	266	299	342	399	479
0.95	0.40	273	288	304	342	391	456	547
0.95	0.50	285	300	316	356	407	475	570
0.95	0.60	273	288	304	342	391	456	547
0.95	0.70	239	252	266	299	342	399	479
0.95	0.80	182	192	203	228	260	304	365
0.95	0.90	103	108	114	128	146	171	205
0.95	0.95	54	57	60	68	77	90	108
0.95	0.99	11	12	13	14	16	19	23
		Required n, given reservoir survival						
Detection Probability	**P_{CE} (π_obs)**	**100%**	**95%**	**90%**	**80%**	**70%**	**60%**	**50%**
0.99	0.10	98	104	109	123	141	164	197
0.99	0.20	175	184	194	219	250	292	350
0.99	0.30	230	242	255	287	328	383	459
0.99	0.40	262	276	292	328	375	437	525
0.99	0.50	273	288	304	342	390	456	547
0.99	0.60	262	276	292	328	375	437	525
0.99	0.70	230	242	255	287	328	383	459
0.99	0.80	175	184	194	219	250	292	350
0.99	0.90	98	104	109	123	141	164	197
0.99	0.95	52	55	58	65	74	87	104
0.99	0.99	11	11	12	14	15	18	22

Overall collection efficiency ($\underline{P_{CE}}$) will be estimated by the fraction:

$$\hat{P}_{CE} = \frac{a_2}{a_1}$$

with associated variance estimator

$$\operatorname{Var}\left(\hat{P}_{CE}\right) = \frac{\hat{P}_{CE}\left(1-\hat{P}_{CE}\right)}{a_1},$$

Where:

a_1 = number of unique tagged fish identified in the vicinity of the Swift FSC; and
a_2 = number of unique tagged fish identified in the fish collection ponds inside the Swift FSC.

- Previous attempts at collecting adequate numbers of outmigrants at the Eagle Cliff Park screw trap demonstrating smoltification and of the appropriate size to dual tag has failed to meet sample size recommendations. Therefore, test fish will be collected from the Swift FSC, tagged and returned to the head of the reservoir for release. The need to evaluate the potential effect of trapping on non-naïve test fish will be resolved by the feasibility study discussed previously in Section 2.1 for ODS.

- Tagged fish from the Swift FSC will be transported by boat and released at the head of Swift Reservoir in the old river thalweg across from the Swift Forest Camp Boat Launch approximately 8.5 miles upstream of the Swift FSC.

- Only fish greater than 90 mm will be tagged, as this is currently the minimum size fish that can be used for active tag studies. Tagging smaller fish may result in high mortality rates or negatively affect fish behavior (CBFWA 1999). Tagging fish smaller than 90 mm will not occur until technological improvements make such tagging practicable.

- Test fish will be selected that visually indicate smoltification, which are assumed to be actively migrating downstream.

- Fish will be tagged by qualified experienced taggers.

- All test fish will be dual tagged with an active tag along with a PIT tag to quantify tag failure and confirm passage at the Swift FSC.

- A similar number of fish will only be PIT tagged (as were marked with active tags) and released upstream to assess tagging effects on dual tagged fish (control) and to improve estimates of P_{CE}.

- Fish will be tagged and released in proportion to the run timing curve developed in Section 2.6 below.

- Monitoring sites will be deployed and maintained in and around the Swift FSC as necessary (in consultation with the ATS). Functionally, there are a series of monitoring stations that will be deployed about 100 feet upstream of the Swift FSC to detect fish entering the forebay after passing through the reservoir. Additional monitoring stations will be deployed in and around the entrance of the Swift FSC to monitor the ZOI to determine when fish pass into or leave the ZOI. Monitoring stations within the fish passage channel itself will be used to determine fish behavior once they enter the Swift FSC and will be used to confirm passage. Fish detections at these monitoring stations will be used to calculate fish passage metrics: P_{CE}, P_{ENC}, P_{ENT}, and P_{RET}.

- Environmental variables (such as weather conditions, debris cleaning activities, and acoustic noise generated in and around the Swift FSC) will be evaluated at the Swift FSC to assess their relationship with behavior and passage success of downstream migrants.

- A comparison of fish size, passage attempts, and timing of passage will be made and will be associated with the behavior of downstream outmigrants to characterize fish passage.

- For fish that are not successfully captured, a similar assessment will be made to characterize their behavior and progress once they enter the forebay to their last location of detection. Also included in this assessment will be detection timing in various monitoring zones, fish size, passage attempts, and last known location.

- Any predation of test fish will be determined through changes in fish behavior from tag detections and will be reported. Any fish detected on the downstream side (i.e., dam intake/spillway side) of the barrier net will also be reported.

2.2.1.2 Frequency and Duration

Collection efficiency (P_{CE}) will be quantified during the expected peak migration period(s) for each transport species. Historically this period occurs from March through June annually for all transport species. Annual calculations of P_{CE} will be made until the P_{CE} standard has been met. At that point, the ACC and the Services will review existing information and decide whether future studies are necessary. Future studies would not be implemented if the ACC and the Services determine that improvement in Swift FSC collection efficiency is not possible.

2.2.1.3 Assumptions

All of the assumptions associated with the single release-recapture model described in Section 2.1.1.3 above apply here as well. In addition, the estimate for P_{CE} assumes the detection efficiency of the PIT tag monitoring array can be measured.

The pooled estimator used to calculate P_{CE} may potential be biased high if all of the assumptions cannot be reliably met. A stratified estimator will also be used to calculate P_{CE} when the estimate's upper confidence interval approaches the performance goal to give further confidence that the performance goal is actually being attained, or at the next M&E Plan update interval, whichever is sooner.

2.2.1.4 Results and Reporting

The results of the study will be reported in the Aquatic M&E Annual Report in tabular and narrative format and will include collection efficiency by species per month of assessment as well as combined. A total estimate of Swift FSC collection efficiency for the migration season will also be developed and reported by species in the Aquatic M&E Annual Report.

2.2.2 Task 2.2- Estimate the Number of Juveniles Encountering the Swift FSC Entrance (P_{ENC})

2.2.2.1 Methods

The number of juveniles (smolts) encountering the Swift FSC will be determined by tracking releases of active tagged fish as they arrive near Swift Dam. Detection arrays will be maintained as during past monitoring and/or as necessary (in consultation with the ATS).

The proportion of tagged juveniles encountering the Swift FSC (P_{ENC}) will be calculated as:

$P_{ENC} = DET_{Swift\ FSC} / DET_{SWIFT},$

Where:

$DET_{Swift\ FSC}$ = number of juveniles detected at antenna arrays on the Swift FSC; and
DET_{SWIFT} = number of juveniles detected entering Swift Dam forebay and the Swift FSC.

P_{ENC} will provide a simple index to describe the proportion of the tagged fish that were available for collection.

2.2.2.2 Frequency and Duration

P_{ENC} estimates will be calculated until the collection efficiency (P_{CE}) standard is achieved or the ACC and the Services determine that additional improvement in Swift FSC collection efficiency is not possible.

2.2.2.3 Assumptions

The detection efficiency of antenna arrays can be determined.

2.2.2.4 Results and Reporting

Results will be reported in the Aquatic M&E Annual Report. Data will be presented in tabular format.

2.2.3 Task 2.3- Estimate Juvenile Entrance Efficiency (P_{ENT}) and Retention Efficiency (P_{RET}) for the Swift FSC

2.2.3.1 Methods

Juvenile entrance (P_{ENT}) will be estimated using active tag detections at the entrance channel to the Swift FSC. Detection history of each tagged fish will be used to determine the pertinent variables as described below where detection zone A is an array of antennas at the Swift FSC entrance and detection zone B are PIT tag detectors within the Swift FSC (Figure 2.1-2).

P_{ENT} will be calculated as:

$$P_{ENT} = \frac{\#\ of\ tagged\ fish\ detected\ at\ A}{DET_{ZOI}}$$

With associated variance estimator:

$$\mathrm{Var}(P_{ENT}) = \frac{P_{ENT}(1-P_{ENT})}{DET_{ZOI}}$$

Retention efficiency (P_{RET}) will be estimated using active tag detections at zone B (Retention Zone in the Swift FSC channel). Detection history of each tagged fish will be used to determine the pertinent variables as described below.

P_{RET} will be calculated as:

$$P_{RET} = \frac{\#\ of\ tagged\ fish\ detected\ at\ B}{\#\ of\ tagged\ fish\ detected\ at\ A}$$

With associated variance estimator:

$$\mathrm{Var}(P_{RET}) = \frac{P_{RET}(1-P_{RET})}{\#\ of\ tagged\ fish\ detected\ at\ A}$$

2.2.3.2 Frequency and Duration

Performed at any time Swift FSC collection efficiency estimates are being developed.

2.2.3.3 Assumptions

Key assumptions of the analysis include:

1. Monitoring stations can be adjusted such that detection zones can be estimated.
2. Monitoring stations can be placed within the Swift FSC without impacting Swift FSC operations or fish behavior.

2.2.3.4 Results and Reporting

Study results will be provided as a stand-alone report at the conclusion of each evaluation season. A summary of the report will also be provided in the Aquatic M&E Annual Report.

2.3 OBJECTIVE 3: QUANTIFY THE PERCENTAGE OF JUVENILE FISH AVAILABLE FOR COLLECTION THAT ARE NOT CAPTURED BY THE SWIFT FSC AND THAT ENTER THE POWERHOUSE INTAKES

The FERC License (Section 9.2.f) stipulates: Monitoring and Evaluation/Turbine Entrainment, i.e., the percentage of juvenile anadromous fish of each of the species designated in Section 4.1.7 available for collection and that (i) are not collected by the downstream passage facility, and (ii) enter the turbines. The proportion of fish entering the intake of the Swift No. 1 powerhouse will not be quantified until downstream collection systems are installed at Yale and Merwin Dams. Once these systems are operational, the M&E Plan will be updated to include study protocols designed to determine turbine entrainment and loss. It is important to note that a barrier net is currently in place to prevent entrainment of outmigrants at Swift Dam except when it is lowered during infrequent spill events. In the interim, the number of active-tagged fish that get behind the Swift Dam entrainment barrier net will be determined each year.

2.4 OBJECTIVE 4: QUANTIFY JUVENILE AND ADULT COLLECTION DOWNSTREAM SURVIVAL

The objective of this task is to quantify survival from the time the fish (i.e., spring Chinook, coho, late winter steelhead, and sea-run cutthroat smolts and fry, and adult bull trout and steelhead kelts) enter the Swift FSC to their release downstream of Merwin Dam[7]. This survival rate is defined in the Settlement Agreement as collection survival (CS). The CS standard varies by fish size and species as shown below:

- Spring Chinook, coho, late winter steelhead, and sea-run cutthroat smolts = 99.5%
- Spring Chinook, coho, late winter steelhead and sea-run cutthroat fry = 98%
- Bull trout = 99.5%

The PIT tag data collected to estimate ODS (Section 2.1.1) can also be used to estimate CS for fish ≥ 69 mm in length (minimum size to PIT tag), but not for smaller fish. For fish smaller than 69 mm, collection survival is recorded based on enumeration of live and dead individuals observed in the fry tank in the Swift FSC. It is the intent that fry be returned to the reservoir once collection efficiencies of transport species consistently reach at least 50% or higher. Until that time, any fry collected at the Swift FSC are transported downstream separately from other outmigrants (to avoid predation during transport) and are released in the grassy shoreline habitat immediately downstream of the boat access point below Merwin Dam (to avoid predation at the release ponds). Therefore, transport survival cannot be functionally calculated for fish smaller than 69 mm in length.

Because fish mortality may occur both in the collection and/or transport processes, separate estimates of survival through each process will help determine the cause of any observed mortality and will be used to develop appropriate remedial measures. Therefore, CS will be broken into two components, collection survival (S_{COL}) and transport survival (S_{TRAN}).

Estimates of CS, S_{COL} and S_{TRAN} will be developed for spring Chinook, coho, late winter steelhead, sea-run cutthroat trout (if a run is established) and bull trout captured in the Swift FSC.

2.4.1 Task 4.1- Estimate Fish Collection and Transport Survival Rates

2.4.1.1 Methods

The methods to be used for quantifying S_{COL}, S_{TRAN} and CS are presented below.

[7] Bull trout survival estimates will also be made for other release sites identified by the USFWS. Steelhead kelt mortality and injury rates, although not required in the Settlement Agreement will be based on visual observation.

Determine Fish Survival through the Collection System (S_{COL})

Survival estimates for juvenile fish ≥ 69 mm collected at the Swift FSC (S_{COL}) will be collected daily by using a subsample of captured fish prior to their entry into the transport system. Subsampling will be accomplished through the use of gates located on the Swift FSC that can be programmed to automatically divert fish to the sample tanks. The diverted fish will be physically examined to determine the proportion of fish that die from collection activities. In addition, dead fish throughout the facility will also be quantified (such as at the separator bars, adult fish and fry tanks, etc.). Monthly estimates will be developed which will collectively create an annual estimate of S_{COL} and will be based on binomial sampling with the estimator:

$$S_{COL} = \frac{Fish_{SUB}}{Fish_{EX}},$$

Where:

$Fish_{SUB}$ = number of fish ≥ 69 mm found alive in subsample; and
$Fish_{EX}$ = number of fish ≥ 69 mm examined in subsample.

With associated variance estimator:

$$\mathrm{Var}(S_{COL}) = \frac{S_{COL}(1-S_{COL})}{Fish_{EX}}$$

Estimates of S_{COL} will be made each month and will then be combined for an annual estimate.

Fish smaller than 69 mm are captured in the fry holding tank on the Swift FSC in which all fish are enumerated and inspected for health conditions on a daily basis. Survival calculations for smaller fish collected at the Swift FSC will be developed on a monthly and annual basis by dividing the total number of fish collected in the fry tank that are alive by the total number of fish collected in the fry tank during the respective time frame.

Determining Survival through the Transport System (S_{TRAN})

Juvenile survival, from the time they enter the transport system until they exit the release ponds downstream of Merwin Dam, is defined as S_{TRAN}.

The method used for determining S_{TRAN} is as follows:

- A representative sample of fish ≥ 69 mm in length will be PIT tagged and released directly into the transport tanks located on the Swift FSC on a weekly basis (one test per week). The test fish used for these releases will be collected from the Swift FSC sample tanks.

- Fish in the holding tanks will then be loaded onto trucks, transported and released to the Woodland Release Ponds located below Merwin Dam. The fish will be held in these ponds for approximately 24 hours.

- Prior to releasing fish from the ponds, the ponds will be checked for dead fish. Dead or dying fish will be collected, examined for marks and injury, and identified to species. The pond's gates will then be opened and the fish allowed to volitionally exit over a 24-hour period.

- After 24 hours, the ponds will once again be examined for dead fish. Any dead fish will be collected, examined for marks and injury, and identified to species. Live fish remaining in the ponds at this time will be forced out of the ponds.

For fish ≥ 69 mm in length, S_{TRAN} will be calculated using the formula:

$$S_{TRAN} = \frac{Fish_{alive}}{Fish_{REL}},$$

Where:

$Fish_{REL}$ = number of PIT tagged fish released in transport system; and
$Fish_{alive} = Fish_{REL} - \#of\ tagged\ fish\ found\ dead\ in\ release\ pond$

With associated variance estimator:

$$\mathrm{Var}(S_{TRAN}) = \frac{S_{TRAN}(1-S_{TRAN})}{Fish_{REL}}$$

An estimate of S_{TRAN} will be developed on a monthly and annual basis for spring Chinook, coho, late winter steelhead, sea-run cutthroat trout and bull trout (adults and juveniles) captured in the Swift FSC. Survival will be estimated by size class (age class) to the extent possible. It should be noted that S_{TRAN} values for bull trout adults (and steelhead kelts) will be based on observed mortalities during transport and release at all release sites identified by the resource agencies.

<u>Calculating Juvenile Collection Survival (CS)</u>

CS is the combined juvenile mortality observed for collection (S_{COL}) and transport (S_{TRAN}), calculated as:

$$\mathrm{CS} = S_{COL} * S_{TRAN}$$

With associated variance estimator:

$$\mathrm{Var}(CS) = \frac{CS(1-CS)}{Fish_{REL}+Fish_{EX}}$$

An estimate of CS will be developed monthly for spring Chinook, coho, late winter steelhead, sea-run cutthroat trout and bull trout (adults and juveniles) captured in the Swift FSC. The monthly estimates will be pooled to develop an overall estimate of CS for the monitoring season.

2.4.1.2 Frequency and Duration

Collection survival estimates will be developed daily until it is determined that the annual standards have been met. Once met, survival estimates will be developed for one week each month to document compliance with the collection survival standard.

2.4.1.3 Assumptions

The major assumptions inherent in the proposed methods include:

1. The subsample fish are representative of the population being collected and transported.
2. Diversion of juvenile fish into the subsample system does not bias mortality estimates.
3. Fish handling protocols for determining S_{TRAN} do not bias juvenile mortality estimates.

2.4.1.4 Results and Reporting

Results of the analysis will be presented in tabular format in the Aquatic M&E Annual Report and will include Collection Survival, Transport Survival and Overall Collection Survival per species on a monthly basis along with an annual summary. The CS standard will be considered met if the calculated confidence interval (CI) spans the target survival rate of smolts with an absolute standard error of 2.5% or less.

2.5 OBJECTIVE 5: QUANTIFY JUVENILE INJURY AND MORTALITY RATES DURING COLLECTION AT THE SWIFT FSC (INCLUDES INJURY AND MORTALITY OF ADULT BULL TROUT, ADULT SEA-RUN CUTTHROAT, AND STEELHEAD KELTS)

The objective of this analysis is to determine the injury rate for fish collected at the Swift FSC. The Settlement Agreement establishes a Swift FSC design performance objective for injury of less than or equal to 2% for all fish examined. While the original title of this objective in the Settlement Agreement includes mortality rates, this metric is covered under Objective 4 in this M&E Plan.

Injury is defined in Settlement Agreement Table 4.1.4 as:

> *Visible trauma (including, but not limited to hemorrhaging, open wounds without fungus growth, gill damage, bruising greater than 0.5 cm in diameter, etc.), loss of equilibrium, or greater than 20% descaling. "Descaling" is defined as the sum of one area on one side of the fish that shows recent scale loss. This does not include areas where scales have regenerated or fungus has grown.*

2.5.1 Task 5.1- Determine Collection Injury Rate (P_{CINJ})

The method proposed for estimating the proportion of fish injured (P_{CINJ}) each day from collection activities at the Swift FSC is presented below.

2.5.1.1 Method

Estimates of P_{CINJ} will be determined by closely examining a minimum of 10% of the total juvenile population collected each day. Sample fish will be diverted (through the use of automatic gates on the Swift FSC) into small holding tanks where they will be anesthetized and examined for injury. Due to the facility design, all adult sized fish are collected in the adult tank and are censused (not subsampled) before transport downstream. Therefore, all adult sized fish (including large bull trout, adult cutthroat and steelhead kelts) will be inspected for injury. All injured fish will be classified into the categories shown in Table 2.5.1.

Table 2.5.1. Categories used for documenting visible injury at the Swift FSC collection and transport system.

Hemorrhaging	Open Wound (No Fungus)	Open Wound (Fungus)[1]
Gill Damage	Bruising > 0.5 cm diameter	Bruising ≤ 0.5 cm diameter
Loss Of Equilibrium	Descaling > 20%	Descaling ≤ 20%

[1]Open wound fish with fungus will not be counted as an injured fish. The presence of fungus indicates the wound likely occurred prior to entry into the Swift FSC.

The proportion of juvenile fish injured (P_{CINJ}) will be calculated using the formula:

$$P_{CINJ} = \frac{\#\ of\ fish\ injured}{\#\ of\ fish\ sampled}$$

With associated variance estimator:

$$\mathrm{Var}\left(P_{CINJ}\right) = \frac{P_{CINJ}\left(1-P_{CINJ}\right)}{\#\ of\ fish\ sampled}$$

2.5.1.2 Frequency and Duration

Injury rates will be determined daily for as long as the Swift FSC is operational.

2.5.1.3 Assumptions

The major assumptions for measuring P_{CINJ} include:

1. The subsample fish are representative of the population being collected.
2. Diversion of juvenile fish into the subsample system does not bias estimates of injury.
3. Fish handling protocols do not result in an increase in fish injury.

2.5.1.4 Results and Reporting

Results of the injury analysis will be summarized in the Aquatic M&E Annual Report in tabular format along with a narrative that shows weekly injury observations by species and an annual summary. The CS standard will be considered met if the calculated CI spans the target survival rate of smolts with an absolute standard error of 2.5% or less.

2.6 OBJECTIVE 6: QUANTIFY THE ABUNDANCE AND MIGRATION TIMING, BY SPECIES, OF JUVENILE AND ADULT FISH COLLECTED AT THE SWIFT FSC

The objective of this analysis is to quantify the number of juvenile and adult fish collected at the Swift FSC by species. Prior versions of the M&E Plan called for the number of juvenile fish entering the Swift FSC to be calculated through subsampling. In addition, an AquaScan CSE-1600 (Scanner) would automatically count all fish passing through the Swift FSC. A combination of these two methods was chosen for estimating this parameter as it was unknown how accurate the Scanner would be at enumerating small juvenile salmonids under field conditions. Many tests and calibrations took place during operating years 2013-2015. The Scanners were found to be unreliable and falsely counted debris and turbulence as fish. Because the automatic fish counters were shown to be unreliable for long-term daily operation, estimating the total number of fish collected at the Swift FSC is done by expanding subsampling methods.

2.6.1 Task 6.1- Calculate Juvenile and Adult Collection Numbers Using Swift FSC Subsampling

The methods proposed for quantifying the number of juveniles and adult collected at the Swift FSC are detailed below.

2.6.1.1 Methods

There are three possible routes fish may travel once entering the Swift FSC sorting building. Smaller sized fish (less than about 120 mm in length including fry, parr, and subyearling transitionals/pre-smolts) pass through the first set of separator bars and are collected in a “fry” holding tank. All fish collected via this route are enumerated daily (total census). The second route is through the “smolt” separation system in which smolt size fish (~ 121mm – 280mm) pass through the separator bars and are then distributed to either a general population tank or a sample tank. The intent of the general population tank is to hold excess smolt sized fish not needed for sampling prior to being loaded for truck transport; once fish are in the general population, there is no safe way to handle them. This design was originally incorporated into the facility through initial consultation with the Services to reduce handling effects on large numbers of fish as they pass downstream of Swift Dam. The third route applies to fish large enough to pass over both “fry” and “smolt” separator bars, which are then collected in the “adult” tank. All fish collected in the adult tank are enumerated daily (total census). Smolt-sized fish are also sometimes collected in the adult tank. In addition to enumeration, fish sampled from all tanks (i.e., fry tank, smolt sample tank, and adult tank) are also anesthetized and checked for marks, measured for length, and identified to species.

During periods of low collection numbers, all smolt-sized fish are diverted to the sample tanks and are enumerated daily (i.e., census of all smolt-sized fish). During periods of high collection numbers (approximately 500 fish or more being collected in the smolt sample tank per day), a portion of fish are directed to the smolt sample tanks while the remaining fish are directed to the general population tank. When operating in a smolt tank subsampling mode, all fish directed to the fry and adult tanks continue to be a census of all fish entering the Swift FSC as there is no capability to re-direct fish to the general population tank instead of the adult or fry tanks. Note that exceeding the approximate 500 fish limit in the smolt tank can result in increased mortality due to overcrowding and abrasion with debris. The smolt sample tank can accommodate about 400 fish with some debris loading and not result in excessive mortality. However, it has been found that when more than about 500 fish are collected in the smolt sample tank with moderate debris loading, mortality has routinely exceeded mortality criteria specified in the FERC license. Extensive debris loading has been an ongoing problem at the Swift FSC since it was commissioned in 2012, and is generally most prevalent in the spring during the smolt out-migration season. While a number of facility upgrades and modifications designed to improve debris management and reduce the effects on fish passage have been made, operational experience still limits the number of fish in the sample tank to 500.

During typical subsampling, diversion gates are operated one continuous minute of every 10 minutes throughout the entire day to provide a 10% subsample rate for fish directed to the smolt tank. While it has been the intent to set a constant subsample rate during the out-migration season, mid-season adjustments to the subsample rate have been made in some years in response to lower numbers of fish entering the Swift FSC (e.g., increased from 10% to 25% due to lower fish numbers in 2020) or during brief periods to collect more fish for biological monitoring (e.g., to collect more fish for radio/acoustic tagging).

The estimators below assume that fish in the sample tanks are measured and enumerated once per day. Also, it is assumed that during most of the juvenile fish migration period, fish will be systematically sampled at a constant rate (i.e., 10%, 25%, etc.) and the subsample rate will stay constant throughout the season. The subsample rate will be chosen to minimize the chance of overwhelming the smolt tank capacity to minimize the potential for fish mortality, generally beginning with 25% and then decreasing based on actual capture rates. It is also assumed that at the beginning and end of the migration season, when collection numbers are lower (i.e., resulting in total smolt tank captures of about 500 fish or less each day), 100% of fish will be diverted to the smolt sample tanks and enumerated.

Total Number of Fish (subsampling period):

$$T = N\bar{y} = \frac{N}{n}\sum_{i=1}^{n} y_i \, ,$$

Where:

T = total number of fish during the subsampling period;
r = subsampling rate;
n = number of sampling periods (days sampled);
N = n/r (sampling intensity);
y_i = discrete daily fish count; and
$\bar{y}$ = average number of fish counted per day.

With associated variance estimator:

$$s^2 = \frac{1}{n-1}\sum_{i=1}^{n}(y_i - \bar{y})^2$$

95% Confidence Interval:

$$O + T \pm t_{(0.025,n-1)}\sqrt{\frac{N(N-n)s^2}{n}} \, ,$$

Where:

s^2 = sample variance, and is calculated as shown above;
O = total number of fish during 100% enumeration period; and
t = the t-statistic for n-1 degrees of freedom and $\alpha/2$.

In the past, the total number of fish collected at the Swift FSC were classified as “fry”, “parr”, “smolt” and “adult” life-stages. Going forward, the total number of fish collected will also be estimated by size class (age class) to assign fish to cohorts (brood years) to align with Objective 1 (ODS). To determine the size class distribution of focal species (i.e., spring Chinook, coho, late winter steelhead, and cutthroat trout), all natural origin salmonids captured in the adult tank, sample tank, and fry tank will be measured to fork length when the Swift FSC is being operated to meet the sample size goals for Objectives 1, 2, 6, 7, and 13. During periods of high fish numbers and when subsampling is occurring, length frequencies of fish in the subsample tank will be expanded based on the subsample rate of the smolt tank to provide a representative distribution of fish lengths in relation to entire day’s catch. Length frequency distribution data will be pooled monthly so that cohort tracking can occur over time. The monthly length frequency distribution of fish collected at the Swift FSC will be determined by estimating the total number of fish captured at the Swift FSC by species for each fork length increment bin selected during analysis following the equation above used to estimate “T”. Size/age classes will be determined as described in Section 2.1.1.1 above.

2.6.1.2 Frequency and Duration

Daily counts of the number of fish entering the Swift FSC will continue for as long as the facility is operational. Typically, the Swift FSC is operated seasonally from about mid-October to mid-July.

2.6.1.3 Assumptions

The major assumptions inherent in the methodology are that the subsampled fish are representative of the general population and that the subsample data are normally distributed. PacifiCorp conducted tests in 2014 and 2015 at various discrete subsample proportions from 1 to 5 of every 10 minutes (i.e., 10%, 15%, 25%, 30%, 40%, and 50%). During each day of operation at a specific subsample rate, fish were enumerated in the sample tanks, as well as the total number of fish captured in the Swift FSC. Several days were assessed at each discrete subsample rate. T-tests showed no significant difference between measured and expected mean subsample proportions at each discrete subsample rate ($\alpha = 0.05$). This suggests that the subsample strategy of continually subsampling fish from 1 to 5 minutes of every 10 minutes (throughout the entire day) is representative of the total number of fish captured in the Swift FSC over an extended period.

The equations described above are standard equations for calculating the total and sample variance assuming a random sample is taken and that data are normally distributed (e.g., see Thompson 2002). In this case, the samples are systematic, but we are assuming there is no ordering/cyclic variation introduced by the subsample approach. One advantage of systematic sampling is that it may be more logistically feasible than random sampling, because it involves a regular sampling interval and may be automated. It also maximizes the dispersion of sampling effort. One limitation of systematic sampling is that it can introduce bias if the sampling interval corresponds to periodic variation in the sampling frame. For example, if samples are collected every 12 hours or 24 hours, they will be taken at the same time each day, which may bias the sample if fish are more likely to be present (or absent) at certain times. Selecting a sampling interval that ensures sampling occurs frequently and throughout the day at a fine temporal scale (e.g., 1 in 10 minute interval at the 10% sample rate; 1 in 4 minute interval at the 25% sample rate, etc., throughout the entire 24 hour day) minimizes this potential bias.

Consideration was given to using a stairstep approach of subsampling at the beginning and tail ends of the migration season. Actual Swift FSC smolt tank capture data was used to assess the stairstep approach using 2019 data (highest number of fish captured in a year to date) and 2021 data (average number of fish capture in a year) to determine if a stairstep subsampling approach would result in substantially more fish to measure and/or tag compared to a more constant subsample rate approach. A stairstep approach involves decreasing subsample rates in a stepwise manner, for example from 50% to 10% as migration increases, and increasing to 100% at the tail end of the migration season. For the stairstep approach assessment, as total smolts entering the Swift FSC ramped up at the beginning of the migration season, the subsample rate was decreased after each day when the smolt tank fish count was greater than 500 fish. The total numbers of “smolt-sized” fish estimated to have been captured at the Swift FSC each day in 2019 and 2021 were used as the potential number of fish that could have been captured; the assessment then applied a constant or stairstep subsample rate approach to these daily totals. For both the 2019 and 2021 examples under both the constant and stairstep sample rate approaches, the sample rate was set at 100% (i.e., total census) for most of the season, with subsampling only occurring in May and June when more than 500 smolt-sized fish generally entered the Swift FSC each day. Subsampling was employed once the smolt tank capture exceeded 500 fish, and the same number of subsampling days occurred under both the constant and stairstep approach examples. The 2019 data example (e.g., high coho abundance with much lower Chinook and steelhead abundance) suggests no benefit to coho with ample numbers of coho to sample during all months under both strategies (Table 2.6.1). Although more Chinook and steelhead were available to sample using the stairstep approach in May 2019 (Table 2.6.1), this comes at a cost as the number of days that the smolt tank would have captured more than 500 fish (increasing the potential for excess mortality) would have nearly doubled (7 days) compared to the constant subsampling rate approach (4 days).

Table 2.6.2 illustrates the challenges in implementing a cautious stairstep subsampling approach to switch from a total census (100% smolt sampling) to subsampling when total daily smolts captured at the Swift FSC can vary widely from day to day; results are based on the 2019 Swift FSC daily data example. Over this time period in May 2019, only two days exceeded 500 total smolts in the sample tank using the constant subsampling strategy; whereas the cautious stairstep approach exceeded 500 smolts in the sample tank on five days. The 2021 Swift FSC data example suggests no clear benefit for Chinook or steelhead, where a similar number of fish were captured in the smolt tank for these species for all months and ample coho were available for sampling in all months (Table 2.6.1). Due to the inability to predict the number of fish that may enter the Swift FSC each day and fish mortality concerns, a constant subsampling rate will be used, but the subsampling rate selected may vary each year based on actual fish capture abundance (i.e., lower subsampling rate in years with high total Swift FSC fish capture abundance, but a higher subsampling rate in years with lower total Swift FSC fish capture abundance). The constant rate will be determined each year based on the expected fish run size and as daily fish collection numbers begin to increase. Caution should be exercised when switching from total census to subsampling to ensure that the subsampling rate is not set too low initially, but also not set too high so as to avoid unnecessary fish mortality. Based on the available data, it appears that when initially switching from a total census to subsampling, a sample rate of 25% is sufficiently high to maximize captures and minimize overwhelming the smolt tank in an average year (similar to the 2021 data example), but may need to be dropped in season to 10% for example as soon as the smolt tank captures exceed 500 fish and remain at this rate until the end of the season when a total census can resume. However, future years with even higher catches (than experienced thus far) may require even lower subsample rates so as not to exceed the smolt sample tank capacity. It is important to maintain a single constant sample rate over the season as much as possible and to avoid adjusting the sample rate once it is established between census periods.

Table 2.6.1. Example coho, Chinook, and steelhead smolt sample tank catch rates comparing a constant subsampling rate to stairstep sampling rate for Swift FSC smolt tank operation.

	Coho		Chinook		Steelhead	
Month	**Constant Sample rate**	**Stairstep Sample Rate**	**Constant Sample rate**	**Stairstep Sample Rate**	**Constant Sample rate**	**Stairstep Sample Rate**
2019 Swift FSC Smolt Tank Captures Example						
January[a]	306	306	13	13	2	2
February[a]	78	78	50	50	1	1
March[a]	101	101	106	106	4	4
April[a]	3,131	3,131	519	519	176	176
May[b]	5,616	9,053	460	775	401	750
June[c]	9,123	9,123	510	510	66	66
July[a]	1,199	1,199	392	392	10	10
Total	19,553	22,991	2,050	2,365	660	1,009
% of total Smolt Captures	15%	18%	46%	53%	26%	39%
2021 Swift FSC Smolt Tank Captures Example						
January[a]	741	741	171	171	34	34
February[a]	382	382	135	135	19	19
March[a]	611	611	368	368	21	21
April[a]	1,012	1,012	773	773	588	588
May[d]	2,647	3,358	84	98	978	1,260
June[e]	3,751	3,751	82	82	69	69
July[a]	673	673	43	43	5	5
Total	9,817	10,528	1,656	1,670	1,714	1,996
% of total Smolt Captures	37%	39%	84%	85%	51%	59%

[a]Note: Sample rate in January, February, March, April and June was set at 100% (i.e., total census) for both the constant and stairstep approach in both 2019 and 2021 examples.

[b]Note: Sample rate in the May 2019 example was set at 10% under the constant sample rate approach, but set at 50% then gradually reduced to 10% under the stairstep sample rate approach (reduced each day the smolt sample tank exceeded 500 fish).

[c]Note: Sample rate in June 2019 was set at 10% then transitioned to 100% for both the constant and stairstep sample rate examples on the same days.

[d]Note: Sample rate in the May 2021 example was set at 25% under the constant sample rate approach, but set at 50% then gradually reduced to 25% under the stairstep sample rate approach (reduced each day the smolt sample tank exceeded 500 fish).

[e]Note: Sample rate in June 2021 was set at 25% then transitioned to 100% for both the constant and stairstep sample rate examples on the same days.

Table 2.6.2. Swift FSC smolt catch daily example for May using actual 2019 Swift FSC smolt catch data for coho, Chinook and steelhead combined.

Day	Smolts Tank Count	Expanded total Swift FSC Smolts	Constant Sample rate	Constant Sample Rate (# fish in Smolt Tank)	Stairstep Sample Rate	Stairstep Sample Rate (# fish in Smolt Tank)
5/1/2019	64	256	100%	256	100%	256
5/2/2019	826	826	100%	826	100%	826
5/3/2019	121	484	10%	49	50%	242
5/4/2019	80	320	10%	32	50%	160
5/5/2019	170	680	10%	68	50%	340
5/6/2019	137	548	10%	55	50%	274
5/7/2019	31	124	10%	12	50%	62
5/8/2019	182	728	10%	72	50%	364
5/9/2019	383	1,532	10%	153	50%	766
5/10/2019	81	810	10%	81	25%	203
5/11/2019	146	1,460	10%	146	25%	365
5/12/2019	327	3,270	10%	327	25%	818
5/13/2019	134	1,340	10%	134	20%	268
5/14/2019	161	1,610	10%	161	20%	322
5/15/2019	43	430	10%	43	20%	86
5/16/2019	79	790	10%	79	20%	158
5/17/2019	101	1,010	10%	101	20%	202
5/18/2019	392	392	10%	39	20%	78
5/19/2019	73	730	10%	73	20%	146
5/20/2019	509	5,090	10%	509	20%	1,018
5/21/2019	108	1,080	10%	108	15%	162
5/22/2019	191	1,910	10%	191	15%	287
5/23/2019	430	4,300	10%	430	15%	645
5/24/2019	395	3,950	10%	395	10%	395
5/25/2019	196	1,960	10%	196	10%	196
5/26/2019	336	3,360	10%	336	10%	336

A formal simulation will be conducted to evaluate potential Swift FSC smolt tank capture scenarios for different species and times of year. The purpose of the simulation will be to identify what sample rate(s) should be used to generate balanced estimates as well as to minimize mortality in the smolt tank. The simulation will include various out-migration scenarios, and will sample out-migrating fish by applying different subsampling rates, summarize the sampling results, and evaluate the precision and bias of the resulting estimates of the total number of out-migrating smolts by species/cohort. These results will be used to adjust the subsampling rate at the Swift FSC smolt tanks in future years.

2.6.1.4 Estimator Testing and Verification

Further validation testing should be conducted (see Appendix B for further discussion). Based on validation testing in 2014 and 2015, the mean fish sampling rate was 14.7% when the temporal sampling rate was set at 10%. However, prior validation testing of the 10% temporal sampling rate only occurred on 11 sample days, which were also clumped within two separate weeks during 2015. In addition, the upper limit of fish sampling rate values observed at the 10% temporal sampling rate may be biased due to low sample size and/or switching gate malfunction during validation testing. In 2015, the automated switching gate failed and was removed and is no longer available for validation testing. Future validation testing will be completed annually by comparing the proportion of PIT tagged fish that enter the top smolt flume that are subsequently detected in the smolt sample tank by the sample rate and stratified by species and week (as possible based on actual captures of previously PIT-tagged fish).

2.6.1.5 Results and Reporting

The total estimated number of fish collections by species age/size class will continue to be summarized for each transport species by month. Results will also include sample rate used and proportion of fish PIT tagged. The results of the analysis will be presented in tabular format and included in the Aquatic M&E Annual Report.

2.7 OBJECTIVE 7: ESTIMATE THE MIGRATION TIMING AND NUMBER OF JUVENILES ENTERING SWIFT RESERVOIR

Estimating the timing and total number of juvenile focal fish species (i.e., spring Chinook, coho, late winter steelhead and sea-run cutthroat trout) entering Swift Reservoir is required under Section 9.2.1 of the Settlement Agreement. Historically, the migration timing and number of juveniles entering Swift Reservoir has been determined by operating a screw trap seasonally (generally early March through June) at Eagle Cliff Park where the North Fork Lewis River enters Swift Reservoir. The existing methodology is effective at estimating the number of salmonids ≥60 mm in length that enter the reservoir from the upper North Fork Lewis River basin during the monitoring season. However, it is suspected that the timing of screw trap operation does not coincide with the period when the bulk of outmigrant salmonids pass the sample site. Previous estimates of the number of fish annually collected at the Swift FSC (Objective 6) suggest that a large portion of fish may enter the reservoir during periods when the trap is not operated, and/or that a substantial proportion of juveniles are produced within the reservoir tributaries (outside the area sampled by the screw trap at Eagle Cliff Park). The screw trap at Eagle Cliff Park is also operated to supply PIT tagged fish to estimate ODS (Objective 1), which on its own has failed to meet sample size recommendations described under Section 2.1.1.1 for all species in most years except for coho in recent years. However, it is expected that sample size targets will be met for all species if supplementing screw trap captured fish (naïve fish) with Swift FSC captured fish (non-naïve) that are tagged and transported upstream and released at the head of Swift Reservoir (see description of the feasibility study outlined in Section 2.1.1.1).

As there is a need to better evaluate timing and abundance, and a need to PIT tag more fish, a multi-year feasibility study approach is recommended to assess various methods to meet these objectives and inform the development of a long-term methodology. The feasibility study will be performed over a two-year period to determine if other alternatives could lead to PIT tagging more fish, which could lead to more accurate estimates of the total number of juvenile fish entering Swift Reservoir and ODS (Section 2.1 above). Alternatives include:

1. Continuing to operate the screw trap at Eagle Cliff Park over a longer seasonal period; and
2. Tributary sampling to capture and PIT tag fish (see section 2.7.2.1 below).

At the end of the feasibility study, the alternative methods will be presented to the ATS and evaluated to determine which method or combination of methods best meets the PIT tag sample size requirements for calculating ODS, and most accurately represents the abundance of juvenile fish entering the reservoir. At that time, a long-term methodology will be developed and proposed in consultation with the ATS, and/or additional recommendations will be made to further refine a selected methodology.

2.7.1 Task 7.1– Estimate the Timing and Abundance of Juveniles Entering Swift Reservoir at Eagle Cliff Park

2.7.1.1 Methods

Screw Trapping at Eagle Cliff Park

A brief description of the methods to be used in estimating the timing of juvenile salmonids entering Swift Reservoir during the two-year feasibility study from the upper North Fork Lewis River subbasin is presented below.

- The screw trap at Eagle Cliff Park will continue to be operated at the head of Swift Reservoir, but operation will be extended from March through October (instead of through June), which is thought to generally encompass the time period when a screw trap could be logistically operated. Operation during the winter and early spring is generally not possible due to high water events and unsafe (e.g., ice/snow) working conditions.

- The trap will be operated daily during the trapping season. Daily operations and placement of the rotary screw trap will follow methods similar to those described by Volkhardt et al. (2007).

- Sample size for the entire trapping season will be based on achieving a coefficient of variation (CV) of 15% for coho and spring Chinook, and 30% for late winter steelhead (NMFS 2009). In prior years (2013-2020), total trapping season efficiency for all juvenile salmonids combined has ranged from 2 to 8%. To make total outmigrant estimates for each target salmonid species with 95% confidence intervals at the desired level of precision requires marking and releasing 1,000 to 3,000 fish based on the range of annual trap efficiency observed (Figure 1). This sample size is needed for each time block period if using a stratified estimator or for the total outmigration season if making a pooled estimate. Given the number of fish typically available for marking, such a sample size can only be met for the entire trapping season for each individual species/age class to facilitate a pooled estimate.

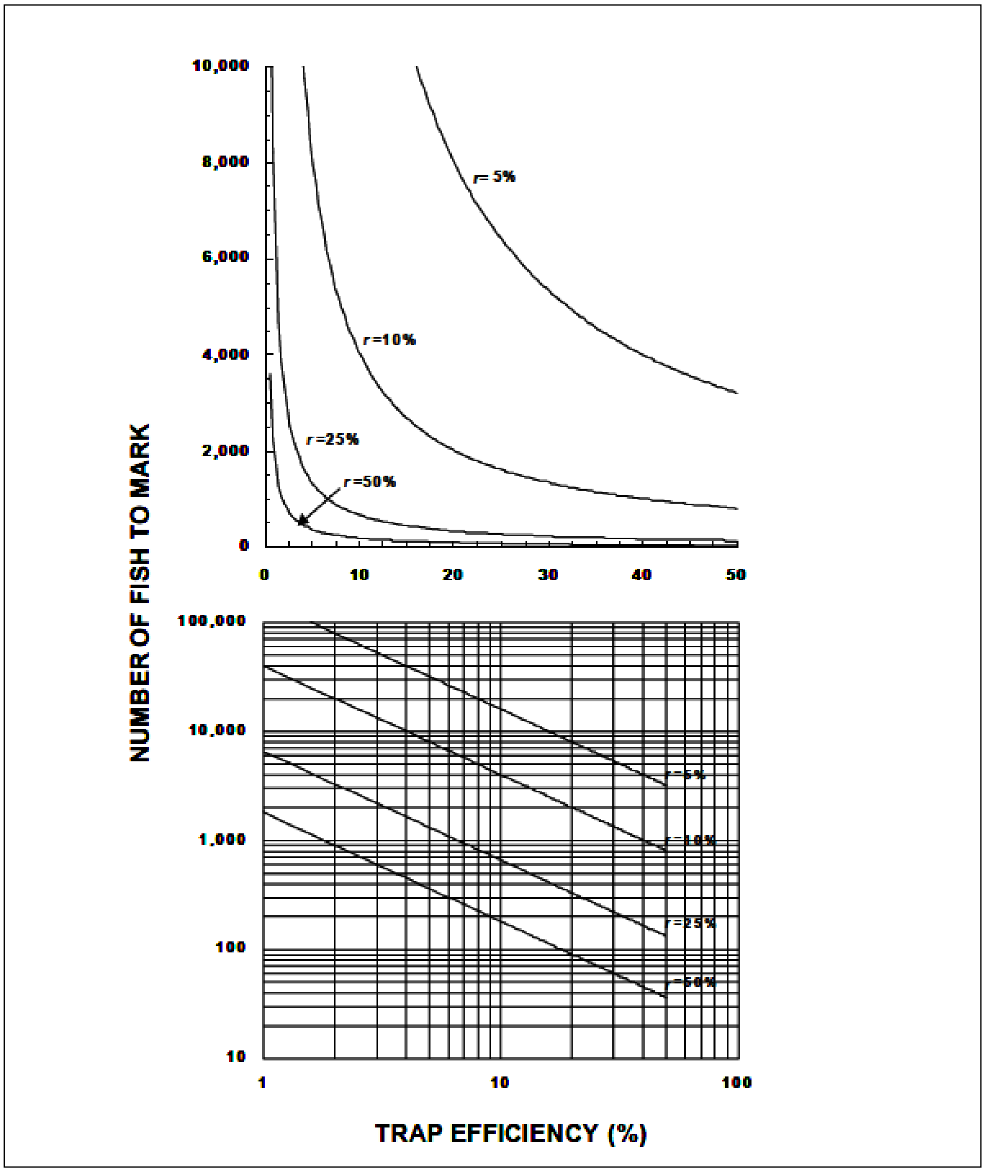


Figure 2.7.1. Relationship between trap efficiency (capture probability) and the number of salmon smolts to mark for relative error (r) of 5, 10, 25, and 50% (probability of exceeding r (α) = 5%; lower plot on logarithmic scale).

- Due to the large sample sizes needed to appropriately estimate trap efficiency, all maiden captures of juvenile focal fishes will be marked either with PIT tags (≥69 mm fork length) or an external mark (≥50-69 mm fork length) and released (daily) upstream to estimate trap efficiency. Fish less than 50 mm in length will be batch marked using Bismark Brown Y-stain. Recaptured marked fish will be recorded and released downstream of the trap. A total season trap efficiency will be calculated and used to estimate total juvenile outmigration by focal fish species and size/age class.

- Salmonids captured in the trap will be identified to species and life-stage, and measured to fork length. Fish life stage and smoltification status as indicated by physical appearance and condition will also be recorded per the most current WDFW JMS protocol methodology, which may be modified as additional Lewis River specific data becomes available. Non-salmonids will be tallied by species and life-stage.

- Total monthly juvenile outmigration by species size/age class during the trapping season will be calculated using the following formula for use of a single partial trap described in Volkhardt et al. (2007)[8], in which the estimated number of unmarked fish migrating during discrete sample period i ($\hat{U}$), weekly or monthly, is dependent on actual recapture rates observed:

$$\hat{U}_i = \frac{u_i(M_i+1)}{m_i+1} ,$$

Where:

u_i = number of unmarked fish captured during discrete period I;
M_i = number of fish marked and released during period I; and
m_i = number of marked fish recaptured during period i.

With associated variance estimator:

$$V(\hat{U}_i) = \frac{(M_i+1)(u_i+m_i+1)(M_i-m_i)u_i}{(m_i+1)^2(m_i+2)}$$

- Weekly/monthly estimates of juvenile migration will be combined to calculate the total number of juveniles migrating downstream during the monitoring period using the following formula:

$$\hat{U} = \sum_{i=1}^{n} \hat{U}_i$$

Entire monitoring period variance:

$$V(\hat{U}) = \sum_{i=1}^{n} V(\hat{U}_i)$$

95% Confidence Interval:

[8] The WDFW recommended BTSPAS model (https://github.com/cschwarz-stat-sfu-ca/BTSPAS) may also be considered for this analysis. However, we understand this model is not user friendly and is difficult to operate. Preliminary test comparisons of BTSPAS model estimates with those generated by a simple bootstrap estimator showed no significant difference in estimates or confidence intervals for total outmigration abundance estimates.

$$\hat{U} \pm 1.96\sqrt{V(\hat{U})}$$

- In addition, pooled total season estimates, variance and confidence intervals will be estimated using bootstrap methodology for each focal fish species/size class total estimate (Thedinga et al. 1994).

- As actual mark-recapture rates allow, focal fish species migration timing will be assessed by calculating total weekly/monthly outmigration abundance during the trapping season.

2.7.1.2 Frequency and Duration

Conducted each year during the two-year feasibility study, then evaluated for effectiveness at meeting sample size for ODS and determining overall juvenile entry timing.

2.7.1.3 Assumptions

Key assumptions inherent in the analysis are:

1. The population is closed;
2. All fish have an equal probability of capture in the first period;
3. Marking does not affect catchability or survival;
4. All fish (marked and unmarked) have an equal probability of being caught in the second sample;
5. The fish do not lose their marks and marks are recognizable;
6. All recovered marks are reported; and
7. Timing of outmigration of the focal fish species from the upper North Fork Lewis River basin is assumed to be representative of outmigration timing from other small independent tributaries to Swift Reservoir.

2.7.1.4 Results and Reporting

Trapping results will be summarized by species size/age class in tabular form along with a narrative in the Aquatic M&E Annual Report. Data summaries will follow WDFW's Juvenile Monitoring System (JMS) Protocol format to the extent practical.

2.7.2 Task 7.2- Estimate the Total Number of Juveniles Entering Swift Reservoir

2.7.2.1 Methods

Utilizing PIT tag records from the Swift FSC, PIT tagged fish used to estimate the efficiency of the screw trap at Eagle Cliff Park and tributary sampling (to the extent possible) will also be used to estimate the joint probability of survival through Swift Reservoir and capture at the Swift FSC (Section 2.1.1). Fish captured at the Swift FSC will also be PIT tagged and transported upstream and released at the head of Swift Reservoir as part of the two-year feasibility study to determine if there is no significant difference between recapture probability between these non-naïve test fish and those that are PIT tagged and released at the screw trap at Eagle Cliff Park (naïve fish) as discussed in Section 2.1.1.1.

Tributary sampling will be conducted to evaluate the efficacy of increasing the spatial distribution of tagged fish. Independent tributaries were not part of the prior sample design. This would also increase the overall number of PIT tagged fish. Tributary sampling will be conducted by one team of three field biologists conducting surveys in tributary reaches upstream of Swift Dam during spring and summer and any other periods deemed suitable for backpack electrofishing or other methods such as seining. The survey crew will focus sampling on the spawning survey reaches with the highest densities of redds counted in prior years for spring Chinook and coho, and late winter steelhead (including aerial radio telemetry detections of tagged steelhead upstream of Swift Reservoir) within Clear Creek, Clearwater Creek, Muddy River mainstem, North Fork Lewis River mainstem, and the independent Swift Reservoir tributaries. The crew will survey four days per week in July when stream flows are reaching summer baseflows (increasing potential capture efficiency). Surveys will be conducted in July to avoid potentially electrofishing during the onset of spring Chinook spawning in August, and to avoid steelhead spawning earlier. A variety of methods may be employed to capture fish based on the specific conditions encountered in each stream, which may include backpack electrofishing, use of block nets, stick seining, and beach seining. The feasibility of seining will be assessed and may be used to capture and tag additional fish in the fall (such as steelhead) when electrofishing is not preferred due to the presence of spawning salmon. All salmonids captured ≥69 mm in length will be anesthetized, identified to species, measured to length, PIT tagged and released in the same location as captured. Fish marked upstream of the Eagle Cliff trap will also be used to aid in estimating trap efficiency under Objective 7.1.

The estimated number of juvenile fish entering Swift Reservoir during the entire migration period will be calculated for each size/age class and each tagging location strata (i.e., tributaries, Eagle Cliff Park screw trap, and Swift FSC) using the equation under Section 2.7.1.1 above,

Where:

u_i = total estimate of unmarked fish captured during the monitoring period at the Swift FSC derived from the equation in Section 2.6.1.1;
M_i = Number of fish marked and released during the monitoring period at each marking location strata; and
m_i = Number of marked fish recaptured during the monitoring period at the Swift FSC.

Discrete sample period variance will be calculated using bootstrap methodology (Thedinga et al. 1994). The 95% confidence interval will be calculated using equation in Section 2.7.1.1. Size/age classes would be determined following the methods described in Section 2.1.1.1 for ODS.

The primary goal of the feasibility study is to determine if substantially more naïve fish can be captured and tagged, and then recaptured at the Swift FSC. Testing will be conducted to determine if there is no significant difference in recapture probability between fish tagged and released at the Eagle Cliff Park screw trap and Swift FSC as previously discussed under Objective 1. In addition, this same testing will be conducted for fish PIT tagged and released in tributaries compared to the screw trap. Any significant difference in recapture probability at the Swift FSC found between tributary and screw trap tagged fish can be attributed to the difference in the joint probability in survival/mortality of tributary capture and tagging methods and migration to the reservoir. A correction factor could then potentially be applied to the tributary tagged fish to account for any differential in survival (before they reach the reservoir) compared to screw trap tagged fish.

At the end of the feasibility study, the alternative methods will be presented to the ATS and evaluated to determine which method or combination of methods best meets the PIT tag sample size requirements for calculating the total number of fish entering the reservoir each year, and most accurately represents the abundance of juvenile fish entering the reservoir. At that time, a long-term methodology will be developed and proposed in consultation with the ATS, and/or additional recommendations will be made to further refine a selected methodology

In addition to the methods described above, the development of an IPM (see Section 2.20 below) and its associated outputs will also be eventually used to independently estimate the number of juvenile spring Chinook, coho and late winter steelhead entering the reservoir each year, which will be compared to estimates generated under this Objective. If estimates differ significantly between these two approaches, then analysis will be conducted to assess what may be driving any difference. Methods may be revised in the future when warranted based on this comparative assessment in consultation with the ATS. Reference Section 2.20 below for more information on the development of the IPM, timelines and intended outputs.

2.7.2.2 Frequency and Duration

The juvenile tributary sampling will occur during the two-year feasibility study, after which the efficacy at increasing the PIT tag sample size of naïve fish entering the reservoir will be evaluated. Annual monitoring to determine total juvenile focal fish species abundance entering Swift Reservoir (following the methods described above) will be evaluated every five years to determine if this monitoring needs to continue. Thereafter estimates will occur as needed to re-evaluate or re-verify ODS.

2.7.2.3 Assumptions

Key assumptions inherent in the analysis are:

1. The population is closed;
2. Marking does not affect catchability or survival;
3. All fish (marked and unmarked) have an equal probability of being caught at the Swift FSC;
4. Tributary capture and tagging does not increase mortality compared to capture and tagging at the screw trap or Swift FSC, or the difference in mortality can be quantified.

5. Fish do not lose their marks and marks are recognizable, or mark loss can be accounted for;
6. All recovered marks are reported; PIT tag detection probability at the Swift FSC is assumed to be 100% or can be measured;
7. Reservoir survival and residence time of juvenile fish migrating into Swift Reservoir during the “trap outages” (late-July – September) is similar to fish migrating during the trap season (October – mid-July).

2.7.2.4 Results and Reporting

Mark-recapture results by species age/size class will be summarized in tabular form along with narrative in the Aquatic M&E Annual Report. Catch per unit effort will be reported by species size class, gear type and location in tabular form along with narrative. Recapture rates of tributary marked fish at the Eagle Cliff screw trap and Swift FSC will also be reported.

2.8 OBJECTIVE 8: DEVELOP INDEX OF JUVENILE MIGRATION TIMING

The ACC has determined that, although this was specifically called for in the Settlement Agreement, this metric is covered under section 2.6 and does not need to be duplicated.

2.9 OBJECTIVE 9: QUANTIFY ADULT UPSTREAM PASSAGE SURVIVAL

The adult upstream passage survival (UPS) performance standard is defined in the Settlement Agreement as:

> *Percentage of adult fish of each species designated in Section 4.1.7 that are collected that survive the upstream trapping-and-transport process. For sea-run cutthroat and bull trout, “adult” means fish greater than 13 inches in length.*

The Settlement Agreement requires the Utilities to achieve a UPS rate for all species of 99.5%. Given the UPS definition, it is assumed survival is measured from the point of collection to the point of release

2.9.1 Task 9.1- Quantify Upstream Passage Survival

Methods proposed for measuring UPS for adult fish captured at Merwin Dam are presented below.

2.9.1.1 Methods

A variety of species and origins (NOR and HOR) are captured at the MFCF, but only a subset of those are designated for upstream transport each year. All MFCF adult mortalities will be recorded and reported; however, only the adults destined for upstream transport will be used to calculated UPS.

The UPS will be measured through the direct enumeration of adult fish at the MFCF and at transport release sites (Table 2.9.1). Any dead fish recovered at trapping or release sites will be identified to species and examined for signs of physical injury, to the extent possible.

Table 2.9.1. Current transport release sites in the upper Lewis Drainage.

Release Site	Description
Upper Swift Reservoir	Swift Camp Boat Ramp
Eagle Cliff Park	Adult Release Structure

Note: sites may be added or deleted upon ACC approval

UPS will be calculated as follows:

$$\text{UPS} = 1 - \left(\frac{AD_{TRAP} + AD_{REL}}{Fish_{REL}}\right),$$

Where:

$Fish_{REL}$ = Number of total adults collected (by category destined for upstream transport each year);
AD_{TRAP} = Number of dead adults in the trap, which includes the conveyance system, presort pond, sorting area, and holding tanks for transport (by category destined for upstream transport each year); and
AD_{REL} = Number of dead adults in the truck or at release site at the time of each release.

UPS will be calculated for each day fish are collected and/or transported from the MFCF. Daily values of UPS will be combined to produce a single per species estimate of UPS for the year by upstream transport species/origin category. In addition to tracking UPS for all fish transported upstream, all projected related mortality of ESA-listed fish species by life stage is also reported in the Lewis River Annual Report in Section 3.2.44 for incidental take as defined in the NOAA Fisheries Biological Opinion for the Lewis River Hydro Project (NMFS 2007).

In order to determine possible causes of any adult mortality observed in the collection and transport process, the following data will also be collected:

Temperature- Water temperatures at the MFCF, in the transport truck and release site will be collected each day. Transport truck water temperature will be collected and recorded during fish loading and at the time of release. Stream temperature will be recorded for each release group. Stream temperature difference between transport and receiving water will not exceed 10°F. If the difference is greater than 10°F then truck water will be tempered with stream water before releasing adults all according to the Upstream Transport Plan (PacifiCorp 2009).

Dissolved Oxygen- Measurements of dissolved oxygen will be collected and recorded, and monitored in the transport truck from initial loading to release.

Transport Time and Distance- Transport time and distance will be recorded for each load of fish.

Species Mix- The number of fish by species and origin (NOR or HOR) will be recorded for each load of fish.

Loading Density - The number of fish per gallon will be recorded.

Holding Time - Duration of time fish are held after capture until transport and release upstream of Swift Dam[9].

These data will be reviewed throughout the transport season to determine possible cause and effect relationships between transport conditions and fish loss.

2.9.1.2 Frequency and Duration

UPS will be calculated for each day fish are collected and/or transported from the MFCF and mortalities and total counts will be summed to provide a seasonal estimate of UPS.

2.9.1.3 Assumptions

A major assumption in the proposed method is that staff operating the adult trapping facility, and transporting and releasing adult fish to the river, will be able to accurately count the number of dead and live adults.

2.9.1.4 Results and Reporting

Results will be presented in tabular format by species in the Aquatic M&E Annual Report that includes total number of fish captured, total mortality by species/origin and destination category, number transported by destination category, number of upstream transport release mortalities and a calculation of percent survival for adults transported upstream (UPS). Detailed records of daily loading, water conditions in the truck, etc. will be kept and stored at the MFCF.

2.10 OBJECTIVE 10: QUANTIFY ADULT TRAP EFFICIENCY AT EACH UPSTREAM FISH TRANSPORT FACILITY (EMPHASIZES ANALYSIS OF THE MFCF UNTIL UPSTREAM PASSAGE IS EXPANDED TO YALE AND SWIFT)

Adult trap efficiency (ATE) is defined in Table 4.1.4 of the Settlement Agreement as:

> *The percentage of adult Chinook, coho, steelhead, bull trout and sea-run cutthroat that are actively migrating to a location above the trap and that are collected by the trap.*

The Settlement Agreement calls for the licensees to consult with the resource agencies and the ACC to develop such a standard as soon as practicable. This effort was completed in 2008 and the ACC selected 98% as the target ATE value for each species. However, there is an oversight in the Settlement Agreement. During settlement discussions, there was a great

[9] NOR adults are transported upstream within 24 hours after capture per the Settlement Agreement. Hatchery fish taken by WDFW for surplus broodstock may potentially be transported upstream after being held for some duration at the hatchery as part of the recolonization phase of the reintroduction program.

deal of focus on the Merwin Trap and its pivotal importance to the success of the reintroduction program. Thus, the need for high ATE. The oversight is that PacifiCorp invested a significant amount of time and money upgrading the adult trap at the Lewis River Hatchery and a large percentage of the adults captured there are transported upstream of Swift Dam. There needs to be some discussion in the ACC about this issue and how we can incorporate the Lewis River Hatchery into the monitoring of adult capture and transport as it is not intended for this monitoring effort to be used to assess passage into Lewis River Hatchery.

In review of the past five years (2013 to 2019) of ATE evaluations (summarized in Caldwell et al. 2020), two fundamental changes were recommended for evaluating adult collection efficiency. These were:

1. Test fish captured downstream of Merwin Dam, tagged and released to continue their upstream migration (trap-naïve) should be used over adults captured at the MFCF, tagged, and then returned downstream (trap non-naïve). The use of trap-naïve fish results in a non-biased estimate of collection efficiency, and is better suited for evaluating metrics associated with passage behavior (e.g., passage attempts, total time to complete passage, milling time and location, and rejection rates).

2. Use of NOR Test Fish: NOR fish presumably derived from the upper basin are to be used as test fish. HOR fish derived from Merwin Hatchery or Speelyai Hatchery may be used as surrogates for NOR fish as it is expected those fishes are driven to return to their respective hatcheries, both of which are supplied with water derived from above Merwin Dam. However, the use of these HORs as test fish is not preferred. Fish derived from and expected to return to Lewis River Hatchery and other areas downstream or out-of-basin are not to be used.

2.10.1 Task 10.1- Develop Estimate of ATE for Adult Fish Originating Above Swift No. 1 Dam.

2.10.1.1 Methods

Only trap-naïve fish captured in excellent physical condition will be use to conduct this study to the extent possible. Naïve fish will be captured by angling, tangle netting, or other methods selected in consultation with the ATS, tagged, and released in the North Fork Lewis River below Merwin Dam. Fish collection will occur from the angler deadline near Merwin Hatchery to the Interstate-5 bridge over the Lewis River.

While the use of trap non-naïve fish were previously reported to result in a biased estimates of collection efficiency, the use of these fish in the future may be possible if a consistent estimate of the bias can be determined and used to offset resulting estimates. Although limited to relatively small sample sizes, the difference in PCE between the trap naïve vs. trap non-naïve steelhead was consistent (approximately 10%) for tests conducted in both 2018 and 2019. The use of an offset may be helpful during years when it is difficult to collect naïve sample fish, or as a means to bolster sample size. Behavioral data related to non-naïve fish passage such as timing of passage and specific movement patterns is not recommended to be used as these data were shown to be dramatically different between naïve and non-naïve test fish. For each yearly test, the potential incorporation of non-naïve fish into the study will be determined in consultation with the ATS.

Following capture and prior to release, all fish will undergo the same tagging procedure. Briefly, individual fish will be transferred into a sampling trough, measured to fork length, visually assessed for injury, dorsal sinus PIT tagged, and gastrically radio tagged following the methods of prior ATE studies at Merwin Dam (Caldwell et al. 2020). All fish will be allowed to recover following the tagging procedure. Fish will be released overboard immediately after the tagging procedure near the capture site. A maximum of 11 fish will be tagged and released on any given day to reduce the frequency of tag collisions at receivers within the fixed telemetry station array. All fish captured at the Merwin Trap will have radio tags removed prior to being transported upstream.

Movements of tagged fish will be monitored using an array consisting of fixed radio telemetry sites strategically positioned within three distinct study areas as has occurred during prior ATE studies at Merwin Dam (Caldwell et al. 2020), including sites downstream of Merwin Dam extending from the Columbia River confluence to the boat ramp downstream of Merwin Dam, Merwin Dam Tailrace (between the bridge and immediately outside the trap entrance), and at the entrance to the trap ladder system extending to the trap holding area. Methods to estimate performance metrics are described below.

<u>Objective 1a: Estimate core passage metrics</u>

Adult trap efficiency (*ATE*) for Merwin Dam is the percentage of actively migrating adults that are caught in the Merwin fish trap. *ATE* is one of two metrics that have been developed in order to evaluate trap efficacy (the other being P_{EE}; see below). Observations of *ATE* among samples of study fish are essentially data points that are used to estimate *ATE* for the parent population and test whether these local populations meet ATE_{target}. Consequently, these estimates of *ATE* are referred to as ATE_{test}. ATE_{test} is calculated as the proportion of fish entering the Merwin Dam tailrace (*M*) that were ultimately captured at the trap (*C*):

$$ATE_{test} = \frac{C}{M},$$

Where:

M = number of actively migrating fish that enter the Merwin Dam tailrace, determined by unique detections from the tailrace detection sites at or above the access bridge; and
C = number of fish successfully captured, determined by unique detections from the trap and any manually collected tags from the collection facility or during fish sorting minus dead or mortally wounded fish or those collected after a specified time period.

An additional metric, trap entrance efficiency (P_{EE}), quantifies the proportion of fish entering Merwin Dam tailrace (M) that successfully pass the trap entrance (*T*), which includes fish detected at the trap entrance or any receivers upstream of the trap entrance. P_{EE} is then calculated as follows:

$$P_{EE} = \frac{T}{M},$$

Where:

T = number of fish that enter the trap, as determined by detections at any of the trap entrance, pool, or hopper receivers, and
M = same as defined for ATE_{test} (above).

A large relative difference between P_{EE} and ATE_{test} would reveal ineffective trapping and suggest an operational or infrastructural "weak link" in upstream passage at the trapping device. Here, we define an additional metric (T_i) to quantify trap ineffectiveness. T_i is calculated as the relative proportion of fish that entered the trap but were not trapped:

$$T_i = \frac{T-C}{T} \,,$$

Where:
T = same as defined for P_{EE} (above), and C is as defined for T_i (above).

Note that greater T_i values correspond with lower trap effectiveness. All core metrics (ATE_{test}, P_{EE} and T_i) will be estimated separately for each release group (i.e., if both naïve and non-naïve fish are used).

2.10.1.2 Frequency and Duration

Until ATE performance standards are achieved, the Merwin Trap will be adjusted or modified per Settlement Agreement Section 4.1.6. As long as ATE performance standards are achieved, no further adjustments or modifications to the Merwin upstream passage facility will be required in accordance with the Settlement Agreement. The timeline for study will be determined by the ATS with ACC approval, and the determination will be based on run forecasting of NOR transport species derived from upstream of Merwin Dam.

2.10.1.3 Assumptions

Key assumptions inherent in the analysis include:

1. Naïve test fish captured at some point downstream of the tailrace will not stray from the Lewis River and will return to the MFCF or the Lewis River Hatchery ladder vicinity.
2. The tailrace, defined as the entire area of river upstream of the powerhouse access bridge, is the main location for fish that are migrating upstream to congregate (or in other words, fish that enter this location are actually actively migrating to a location above the trap).
3. Naïve fish captured for tagging downstream of the project area have not previously encountered the trap at Merwin Dam.

2.10.1.4 Results and Reporting

Monitoring results that list the number of adults marked, number of adults detected in the Merwin tailrace, and the number of adults captured in the MFCF by species will be provided in the Aquatic M&E Annual Report.

2.11 OBJECTIVE 11: QUANTIFY THE NUMBER, BY SPECIES, OF ADULT FISH COLLECTED AT THE PROJECTS (EMPHASIZES MERWIN DAM UNTIL UPSTREAM PASSAGE IS EXPANDED TO YALE AND SWIFT)

The accurate enumeration of adults arriving at Merwin Dam is important not only to determine the success of the anadromous reintroduction program, but is also needed to partially provide escapement numbers that will help calculate the Ocean Recruit metric (Objective 12) as defined in the Settlement Agreement.

2.11.1 Task 11.1- Quantify the Number, by Species, of Adult Fish Collected at Merwin Dam

The methods proposed for determining the number of adult fish being collected at Merwin Dam each year are presented below.

2.11.1.1 Methods

The MFCF is operated seven days per week every day of the year. All fish arriving at the MFCF will be anesthetized using electronarcosis and sorted into a series of large capacity holding tanks prior to transport. All salmonids (adults, juveniles and jacks) will be enumerated and identified to species and sex, and examined for marks. In compliance with WDFW standards, all salmonids will also be identified to species and sorted based on the following characteristics: missing adipose fin with no coded wire tag detection *(AD CLIP ONLY or HATCHERY ORIGIN - HOR),* adipose fin absent and present with a coded wire tag detection *(CWT),* adipose fin intact with no coded wire tag detection *(WILD or NATURAL ORIGIN - NOR),* and adipose fin intact with blank wire tag present *(WILD + BWT).* The definition of adult for each transport species will be based on WDFW determination standards based on size (fork length). Additional biological sampling of scales and tissue samples as well as various forms of marking fish (e.g., PIT tagging, radio tagging), may also occur to fulfill various monitoring and evaluation needs. All sampling and tagging methodologies are provided in this Lewis River M&E Plan and H&S Plan. See the H&S Plan for greater detail on daily MFCF operations and fish handling methods (PacifiCorp and Cowlitz PUD 2020).

All fish will be sorted into tanks for transport offsite. Fish will be transported to one of three destinations including: 1) upstream of Swift Dam as part of upstream supplementation; 2) Lewis River Hatchery Complex for brood stock collection or surplus, or 3) downstream of Merwin Dam. The number of all live and dead fish captured at Merwin Dam will be summarized on a daily basis. Daily fish passage and other operational information regarding the MFCF will be provided to WDFW. The daily counts will be combined to quantify total adults, jacks and juveniles captured by species for the year by origin type and transport destination.

2.11.1.2 Frequency and Duration

The total number of fish entering the facility will be summarized each day the facility is operated.

2.11.1.3 Assumptions

The primary assumption of this analysis is that biologists working the adult trap will be able to accurately count and identify to species all captured fish. In addition, it is assumed that biologists can accurately identify the sex of adult salmon and steelhead, as well as accurately detect all external (fin clips, Floy tags, etc.) and internal (PIT tags, CWT, etc.) marks and tags.

2.11.1.4 Results and Reporting

Counts will be reported in tabular format that includes the daily number of each species by origin captured at the MFCF plus an annual total. Merwin count data will also be tracked by run year for upstream transport species such as coho and late winter steelhead where run timing overlaps more than one calendar year. This information will be provided in the Aquatic M&E Annual Report.

2.12 OBJECTIVE 12: DEVELOP ESTIMATES OF OCEAN RECRUITS

According to the Settlement Agreement, hatchery production will be reduced when the natural adult production targets identified in Table 2.12.1 are achieved.

Table 2.12.1. Hatchery and naturally produced adult threshold levels (ocean recruits) for spring Chinook, late winter steelhead and coho.

	Spring Chinook	Steelhead	Coho (Type S and Type N)	Total
Hatchery	12,800	13,200	60,000	86,000
Natural Production Threshold	2,977	3,070	13,953	20,000
Grand Total	**15,777**	**16,270**	**73,953**	**106,000**

These targets are referred to in the Settlement Agreement as Ocean Recruits[10], defined in Section 8.1 of the Settlement Agreement as:

> *"… total escapement (fish that naturally spawned above Merwin and hatchery fish) plus harvest (including ocean, Columbia River, and Lewis River Harvest)."*

Ocean recruit targets for natural production apply to fish spawning upstream of Merwin Dam. Hatchery recruits will be estimated until the natural ocean recruit goal is met and hatchery production has been reduced to the Hatchery Floor of 18,000 returning adults (Settlement Agreement 8.3.2.3).

[10] The ACC agreed to change the ocean recruits definition so that jacks are not counted as part of the ocean recruits analysis (March 9, 2005 ACC meeting).

The purpose of this objective is to inform decisions about the size of the hatchery program in the future as natural production of spring Chinook, coho and late winter steelhead increases. In the following discussion, we recommend an approach for estimating recruitment.

2.12.1 Task 1.1- Estimate Ocean Recruits

Recruitment can be estimated in at least three different ways:

1. Return year recruitment. Adults that spawned or were harvested in a given year. Returns may come from different brood years and different migration years.
2. Migration year recruitment. Adults produced from a given outmigration year that spawned or were harvested over all subsequent years.
3. Brood year recruitment. Adults from a given brood year that spawned or were harvested over all subsequent years.

For coho adults (i.e., excluding jacks) definitions 1, 2, and 3 above are the same, because returning adults come from the same brood year and migration year.

Spring Chinook and late winter steelhead have more diverse life histories, and the three estimates will generally be different. Return year recruitment tends to reflect variation in exploitation rates during a given return year. Migration year recruitment tends to be correlated with early marine survival, because mortality is high during the transition from freshwater to the marine environment and varies considerably depending on ocean conditions. Brood year recruitment is used to estimate recruits per spawner (R/S) and the smolt-to-adult survival rate (SAR) and thus provides information about productivity, especially when recruitment estimates are available for a range of spawning escapements over 10-15 years.

For the purpose of estimating ocean recruits for fish spawning upstream of Merwin Dam, **brood year recruitment** will be used. Information from this analysis will also be used to calculate the performance measures discussed in Section 2.13 below.

2.12.1.1 Methods

Brood year recruitment estimates are obtained through run reconstruction using the following steps:

- Estimate natural origin spawning escapement by age, excluding jacks. Total escapement would be obtained from Merwin Dam counts, and the proportion of natural origin adults will be estimated from CWT mark ratios at the dam. Age composition of unmarked natural origin adults will be estimated from scale samples.

- Estimate fishery exploitation rates by brood year:

    1. Estimate fishery related mortality rates in the Lewis River for adults by brood year based on CWT analysis (if creel surveys are initiated) or harvest rates on surrogate Lower Columbia River populations.

2. Estimate Columbia River mainstem exploitation rates on Lewis River adults by brood year based on CWT analysis.
3. Estimate ocean exploitation rates on Lewis River adults by brood year based on CWT analysis and/or Pacific Fishery Management Council (PFMC) reports.

- Estimate the total exploitation rate by brood year and use this to expand the brood year escapement estimates to obtain total recruitment (ocean recruits) for each brood year:

  Adult brood year recruitment (ocean recruits) = $\frac{ESC_{BY}}{(1-EXPLOIT_{TOT})}$

  Where:

  ESC_{BY} = brood year escapement, and
  $EXPLOIT_{TOT}$ = total exploitation rate

The methods above produce the fishery plus escapement estimate of brood year recruitment. This is an estimate of the number of fish that either escaped to Merwin Dam, were caught in a fishery, or died as a result of fishing activity, e.g., hooking mortality. This method does not make any assumptions regarding maturation rates or natural mortality. Calculations do rely on assumptions about release mortality rates in mark-selective fisheries.

The fishery plus escapement method is the approach recommended by WDFW. In addition, the ACC is in general agreement that this is the best approach, especially since it closely aligns with the definition of ocean recruits in the Settlement Agreement.

Alternatives to the fishery plus escapement estimate of recruitment are as follows:

1. Adult equivalents. An estimate of the number of adults that would have returned in the absence of any fishing. This method includes untestable assumptions such as age-specific natural mortality rates in the ocean. These assumptions are used to estimate the number of fish from each brood year that were alive at the beginning of each year and are used in ocean harvest management models (e.g., FRAM). Estimates tend to be lower than the fishery plus escapement model because they account for natural mortality before fish are recruited into fisheries.
2. Age-3 recruitment. This estimate is obtained by back-calculating abundance to an age (usually age-3) before fish are recruited into fisheries. This estimate differs from the adult equivalent estimate by the natural mortality rates between age-3 and escapement. This method also includes untestable assumptions about age-specific natural mortality rates in the ocean.

<u>Harvest Data</u>

The CWT data required to estimate brood year exploitation rates are readily available from the Regional Mark Information System (RMIS) database maintained by the PSMFC.

For Lewis River late winter steelhead there is limited impact from fisheries in the ocean and mainstem Columbia River. WDFW assumes negligible harvest of steelhead occurs in these fisheries; therefore, the fishery plus escapement method would utilize only Lewis River harvest when estimating mortalities in fisheries, or would assume the harvest rate (HORs) and hooking mortality rate (NORs) for Lewis River late winter steelhead are similar to the average rate of all Lower Columbia winter steelhead. There is a recreational catch and release fishery when NORs are arriving and potentially a spring Chinook fishery that coincides at the time they are in the river.

For Lewis River spring Chinook and coho salmon, fishery impacts are expected in the ocean, mainstem Columbia River, and Lewis River. Annual exploitation rates on natural origin, unmarked spring Chinook and coho adults will be estimated from expansion of double index tag (DIT) recoveries. The mortality rate of unmarked fish in selective (catch and release) fisheries is estimated based on the encounter rate of the double-index tag (DIT) groups (one ad-clipped and one not) and assumed mortality rates for fish that are encountered but not retained in the fisheries.

DIT groups are paired releases of coded-wire tagged hatchery fish (ad-clipped fish subject to harvest, and non-marked fish subject to catch and release fishing). The difference in run reconstruction numbers between these tag groups represents mortality associated with mark-selective fisheries (MSF). For the purpose of estimating release mortality, the pairing of hatchery and natural origin fish is not recommended because of likely differences in survival based on different rearing conditions.

An MSF mortality rate should be documented as part of the M&E Plan reporting process. Using DIT groups to estimate fishery release mortalities requires that DIT groups are appropriately sized to provide accurate mortality estimates. This will require completion of a power analysis that accounts for varying ocean conditions. There is agreement that PacifiCorp and WDFW continue using the Hatchery DIT groups for the present as a surrogate for calculating natural production harvest until the next iteration of the M&E Plan (in five years).

Currently, there are adequate creel programs in place to estimate mortalities for Lewis River stocks in ocean and mainstem Columbia fisheries. There is limited to no data on fisheries occurring in the Lewis River directly. There are three possible ways to address this lack of information:

1. Do not conduct any in-river creel and assume that there is no fishery related mortality occurring in the Lewis River. This would produce an ocean recruit estimate that is biased low when Lewis River fisheries occur.
2. Conduct an in-river creel. This would provide data specific to the Lewis River that could be used to estimate ocean recruits.
3. Use harvest data from other tributaries, preferably lower Columbia River tributaries. This would assume that harvest rates in other tributaries are similar to those in the Lewis River.

In the near future, it is likely that the only impacts of a recreational fishery on NOR spring Chinook, coho, and late winter steelhead would be incidental catch and release mortality.

In addition to the methods above, the IPM outputs will also be eventually used to independently estimate the number of ocean recruits for spring Chinook, coho and late winter steelhead, which will be compared to estimates generated under this Objective. The main goal of developing the IPMs is to address Objective 12 by providing a robust, unbiased method to estimate ocean recruits. If there are differences between the two estimates, they will be reviewed to evaluate the reasons for the disparity (e.g., were any assumptions violated, etc.). If estimates differ significantly between these two approaches, then methods may be revised in the future when warranted based on this comparative assessment in consultation with the ATS. See Section 2.20 below for more information on the development of the IPM, timelines and intended outputs.

2.12.1.2 Frequency and Duration

Estimates of ocean recruits will be developed for each brood year and species throughout the term of the licenses when NOR returns to Merwin meet the triggers outlined in Table 2.12.2. The triggers are calculated using baseline total exploitation rates for each of the three species based on the harvest rate assumptions from recent analyses (Mitchell Act Final EIS and NPCC Master Plans) and assuming the only impacts of terminal harvest on NORs would be due to incidental catch and release mortality. Recent returns of natural origin spring Chinook have been far too low (<50) to meet the trigger of 1,905 adults (PacifiCorp and Cowlitz PUD 2020). Natural origin returns of coho were as high as 5,395 in 2020, but have not generally come close to meeting the trigger of 8,372 adults. Similarly, natural origin returns of late winter steelhead have been as high as 456 in 2020, but have not met the threshold of 2,210 adults.

Table 2.12.2. Natural return thresholds to Merwin Dam required to trigger completion of Ocean Recruits Analysis.

	Spring Chinook	**Late Winter Steelhead**	**Coho (Type S and Type N)**
1. Natural Production Threshold (Ocean Recruits)	2,977	3,070	13,953
2. Baseline Total Exploitation Rate – NORs (est. range)*	15-20%	5-10%	20-25%
3. Natural origin returns to Merwin Dam required to meet Natural Production Threshold	2,381-2,530	2,763-2,917	10,465-11,162
4. Natural origin returns to Merwin Dam required to trigger Ocean Recruits Analysis (80% of low threshold in 3.)	1,905	2,210	8,372

Note: Conservative (high range) estimates based on harvest rate data used in recent analyses (Mitchell Act Final EIS and NPCC Master Plans).

2.12.1.3 Assumptions

Key assumptions inherent in completing the analysis include:

1. Sample sizes provide sufficient precision for making management decisions.
2. Tagged fish can be readily and reliably identified in ocean and freshwater fisheries, on the spawning grounds and at trapping facilities.
3. Recovered CWT data will be reported to RMIS in a timely manner.
4. Reliable in-river harvest estimates are available.
5. Brood year may be reliably assigned based on tagging and scale data.
6. Hatchery-origin fish that stray to other watersheds will be reported to RMIS in a timely manner. Straying of natural-origin adults to other watersheds is minimal.

2.12.1.4 Results and Reporting

The results of the ocean recruits analysis will be documented in the Aquatic M&E Annual Report. The data will be presented in tabular format similar to the following (note this example is for purposes of illustration and does not use actual program data).

Table 2.12.3. Example of brood year recruitment calculations (not based on actual program data; for purposes of illustration only).

Brood Year	Total Exploit. Rate	NOR Returns to Merwin (by return year)	Return Year Recruitment	BY Recruitment by Age*					Total BY Adult Recruitment (Ages 3-6)
				2	3	4	5	6	
2010	0.25	1,000	1,333	11	248	900	632	32	1,812
2011	0.3	1,200	1,714	31	340	813	558	30	1,740
2012	0.27	800	1,096	20	289	717	518	29	1,553
2013	0.29	1,100	1,549	36	271	665	513	25	1,475
2014	0.25	1,500	2,000	16	237	660	438	25	1,359
2015	0.28	1,300	1,806	30	249	563	431	23	1,266
2016	0.31	1,100	1,594	15	200	554	394	0	1,149
2017	0.29	1,050	1,479						
2018	0.25	1,100	1,467						
2019	0.28	900	1,250						
2020	0.31	850	1,232						
2021	0.29	800	1,127						

Note: Applying age composition data for each return year.

2.13 OBJECTIVE 13: DEVELOP PERFORMANCE MEASURES FOR INDEX STOCKS

The H&S Plan (PacifiCorp and Cowlitz PUD 2020) recommends that other Lower Columbia River stocks be used as index groups to determine whether the success or failure of the North Fork Lewis River reintroduction program upstream of Swift Dam is the result of in-basin or out-of-basin factors. This would be determined by comparing the performance of naturally spawning fish in other basins (such as the Upper Cowlitz River) with the performance of naturally spawning spring Chinook, coho and late winter steelhead reintroduced in the North

Fork Lewis River upstream of Swift Dam. The two performance measures to be evaluated are recruits per spawner (R/S) and smolt-to-adult survival rates (SARs). This section presents the methods used for calculating these metrics.

2.13.1 Task 13.1- Develop Estimates of Survival for Lower Columbia River Fish Stocks

2.13.1.1 Methods

Natural production performance is typically defined and measured in terms of the four viable salmon population (VSP) parameters: abundance, productivity, diversity and population structure (McElhany et al. 2000). For the purpose of comparing performance of the Lewis River populations upstream of Merwin Dam, the first two parameters, abundance and productivity, are the most tractable and most directly related to management actions.

Abundance is simply defined as adult brood-year recruitment as described in Section 2.12. Productivity, when measured over the entire life cycle, is estimated by the recruits per spawner (R/S) ratio, i.e., the number of adult offspring produced per adult spawner.

Estimating R/S requires the number of brood year recruits[11] (Section 2.12) and the total number of spawners. Spawners include the combined number of natural and hatchery origin adults that spawn naturally in a given year above Swift Dam. The number of spawners is calculated as the number of adults transported above Swift Dam adjusted for estimated pre-spawning mortality and the proportion of fish that may spawn within the drawdown zone of Swift Reservoir (as detailed in Section 2.15 below).

Therefore, R/S includes the following components:

R = number of adult natural-origin brood-year recruits, as defined and determined in Section 2.12

S = Adults transported above Swift Dam * 1 - (pre-spawn mortality rate + proportion fish that spawn in the drawdown zone)

In order to adjust for variation in hatchery and natural origin composition of spawners, it is customary (but optional) to apply a correction factor to obtain an estimate of the number of natural origin equivalent spawners (HSRG 2014). Typically, the correction factor (also called relative reproductive success) is 80% for hatchery-origin Chinook and coho. In other words, the reproductive success of hatchery-origin fish is assumed to be 80% of that of natural-origin fish. Steelhead correction factors can vary and are often lower than 80% (HSRG 2014). Applying this correction factor makes comparisons of R/S between populations as well as comparisons over time (trends) more informative because it accounts for different ratios of natural and hatchery-origin fish in different populations.

Estimating the SAR requires monitoring out-migrant juveniles and assigning them to brood years. This can be challenging when a diverse mixture of fish sizes and ages is transported downstream of the dam each year. Methods are outlined in Section 2.1 above to assign juveniles to ages and brood years. SAR may be estimated in two ways. Using the total

[11] Recruitment calculated as return year catch plus escapement will NOT provide estimates of SAR or R/S.

number of brood-year recruits (R) as the numerator in the SAR estimate produces the pre-harvest SAR. Using The total number of natural-origin adult returns to Merwin Dam produces the post-harvest SAR. The pre-harvest SAR provides a measure of program performance independent of changes in fishery management policies over time. However, many programs only calculate the post-harvest SAR for natural-origin fish, and this estimate allows comparison to other populations.

$SAR_{pre-harvest} = \frac{R}{Smolts}$ where R is defined above, and

Smolts = number of out-migrating smolt equivalents from above Swift Dam in a given brood year.

$SAR_{post-harvest} = \frac{Adult\ Returns}{Smolts}$ where adult returns include natural-origin fish captured at Merwin Dam.

Productivity may also be partitioned into life history segments. If the abundance of smolt migrants is available, productivity may be estimated as the product of spawner-to-smolt survival, measured as smolts per spawner (Smolt/S) and pre-harvest smolt-to-adult survival ($SAR_{pre-harvest}$):

$R/S = (Smolts/S) * SAR_{pre-harvest}$

These methods for estimating recruits per spawner and smolt-to-adult survival rates are used extensively in the region. As always, the sample size required to achieve a precise estimate is an issue. For estimates of SARs, the standard for precision is typically a maximum coefficient of variation (CV) of 15% for Chinook and coho and 25% for steelhead (Crawford and Rumsey 2011). Any potential sources of bias should also be reported when preparing estimates of R/S and SARs.

In addition to the methods above, the IPM outputs will also be eventually used to independently estimate R/S and SARs for spring Chinook, coho and late winter steelhead each year, which will be compared to estimates generated in Section 2.13.). As discussed in Section 2.20, the purpose of developing the IPMs is to produce robust, unbiased estimates of key indicators of program performance, including the number of ocean recruits (Section 2.12) as well as R/S and SARs (Section 2.13). If the estimates of R/S and SARs produced by the IPM differ from the estimates developed using the methods outlined above, the differences will be evaluated to determine the reason for the disparities. If estimates differ significantly between these two approaches, then methods may be revised in the future when warranted based on this comparative assessment in consultation with the ATS. See Section 2.20 for more information on the development of the IPM, timelines and intended outputs.

Choosing Indicator Stocks

Indicator stocks should be chosen from neighboring watersheds in the Lower Columbia region. The table below lists the candidate populations that are suitable indicators for the Lewis River populations. Several of these stocks report spawning escapement and have CWT marked groups in the RMIS database.

Since the exploitation rate (ER) used to estimate brood year recruitment is derived from the same CWT groups as the index stocks of interest, R/S and SAR for the Lewis River populations may be compared with neighboring indicator stocks.

Table 2.13.1. Candidate index stocks: Wild stocks and hatchery stocks.

Spring Chinook	Coho	Late Winter Steelhead
Upper Cowlitz wild spring Chinook	Lower Cowlitz hatchery coho	Coweeman wild steelhead
Sandy wild spring Chinook	Kalama hatchery coho	Kalama wild steelhead
Cowlitz hatchery spring Chinook	Sandy hatchery coho	Upper Cowlitz LW hatchery steelhead
	Upper Clackamas wild coho	Upper Cowlitz LW hatchery steelhead
	Upper Cowlitz wild coho	Lower Cowlitz LW hatchery steelhead
	Upper Cowlitz hatchery coho	Kalama LW Hatchery steelhead

Tagging Methods

Juvenile salmonids captured at the Swift FSC that are ≥69 mm fork length will be PIT tagged and released directly downstream to answer questions about:

- Percent NORs returning to Merwin Dam that consist of strays from other watersheds (including recruits from the lower Lewis Basin).
- SARs of NORs originating from the upper Lewis River

Outmigrants transported downstream from the Swift FSC that already contain PIT tags to facilitate studies of ODS and capture efficiency at the Swift FSC may also be used to answer these questions. SARs calculated based on PIT tag data may be used to validate SARs calculated based on adult returns and annual estimates of the number of smolt equivalents of each species transported below Merwin Dam.

The required number of PIT tags for each species depends on the expected SAR and the desired level of precision (Table 2.13.2). Based on regional guidance, the target level of precision for SARs is a CV of 15% for coho and Chinook and 25% for steelhead (Crawford and Rumsey 2011). Achieving this level of precision would require a sample size of approximately 800 for coho, which had an SAR of 6% based on adult returns in 2020 (BY 2017; PacifiCorp and Cowlitz PUD 2020). The late winter steelhead SAR was 5.8% based on 2020 adult returns (BY 2016); approximately 300 steelhead juveniles need to be PIT tagged to achieve the desired level of precision (25% CV). Both of these sample sizes are achievable at the Swift FSC based on recent years' capture results. For spring Chinook, the expected SAR is likely less than 1%, and the number of PIT tags required to meet the desired level of precision is 4,000-8,000, which would require PIT tagging the majority of spring Chinook juveniles entering the Swift FSC each year (based on recent years' capture results).

Table 2.13.2. Number of PIT tagged juveniles transported downstream from the Swift FSC to estimate SAR with alternative levels of precision (ε = margin of error; CV = coefficient of variation, and $1 - \alpha = 0.95$).

SAR	***ε***	***N***	***SE***	***CV***
5.0%	0.025	292	0.013	0.255
	0.02	456	0.010	0.204
	0.015	**811**	**0.008**	**0.153**
	0.01	1825	0.005	0.102
2.0%	0.01	753	0.005	0.255
	0.008	1176	0.004	0.204
	0.006	**2092**	**0.003**	**0.153**
	0.004	4706	0.002	0.102
1.0%	0.008	594	0.004	0.408
	0.006	1056	0.003	0.306
	0.004	2377	0.002	0.204
	0.003	**4226**	**0.002**	**0.153**
0.5%	0.004	1194	0.002	0.408
	0.003	2124	0.002	0.306
	0.002	4778	0.001	0.204
	0.0015	**8494**	**0.001**	**0.153**

2.13.1.2 Frequency and Duration

Analysis will be conducted on the same schedule as the Objective 12 analysis (see Section 2.12.1.2) based on adult thresholds identified in Table 2.12.2.

2.13.1.3 Assumptions

In addition to the assumptions listed Section 2.7 and 2.12, this analysis depends on the following assumptions:

1. The numbers of out-migrating juvenile Chinook, coho and steelhead smolt equivalents are estimated accurately.
2. The correction factors (relative reproductive success) applied to hatchery-origin adults transported upstream of Swift Dam are an accurate reflection of actual spawning success relative to that of natural-origin fish.
3. Sample sizes of PIT tagged juveniles are adequate to estimate SARs.

2.13.1.4 Results and Reporting

The results of the index stock comparison will be documented in the Aquatic M&E Annual Report. The data will be presented in tabular format and will compare R/S and SARs.

2.14 OBJECTIVE 14: DOCUMENT UPSTREAM AND DOWNSTREAM PASSAGE FACILITY COMPLIANCE WITH HYDRAULIC DESIGN CRITERIA

As new fish passage facilities are implemented, they will be tested to determine if they are operating as designed. For the Swift FSC, the key design variables are total attraction flow and water velocities passing through and past the screens. At the MFCF, adult attraction flows, water drop in elevation over weirs, and uniformity of flow across attraction flow diffusers are the indicators of facility performance to be tested.

2.14.1 Task 14.1- Confirm Swift FSC System Compliance with Hydraulic Design Criteria

The method used for determining the hydraulic performance of the Swift FSC is discussed below.

2.14.1.1 Methods

Both acoustic Doppler and hand-held water velocity meters will be used to determine the hydraulic performance of the Swift FSC. The two systems will collect data on flow velocity and direction at the following locations:

- Collection entrance
- Collection enhancement structure
- Primary and secondary dewatering screens (including floor screens)

Water velocity and directional measurements will be collected over the full range of Swift FSC operational conditions. The results will be compared to the Swift FSC design criteria to document system compliance.

2.14.1.2 Frequency and Duration

This monitoring was completed for both the Swift FSC (2013) and MFCF (2014) in their respective first years of operation, and both were found to be compliant with design criteria with NOAA Fisheries approval (Alden and R2 Resources 2013; MWH 2014, respectively). Compliance testing will be conducted in the future if flow amounts or elevations are changed over the course of the license period or if a major component in a facility is replaced. In addition, if features are added to the facility such as additional pumps or additional trap entrances at the Merwin Facility, then those new features will be validated.

2.14.1.3 Assumptions

Key assumptions inherent in completing the analysis include:

- Measurement points are readily accessible to staff.

2.14.1.4 Results and Reporting

Any future compliance testing will be provided in the Aquatic M&E Annual Report.

2.15 OBJECTIVE 15: DETERMINE SPAWNER ABUNDANCE, TIMING AND DISTRIBUTION OF TRANSPORTED ANADROMOUS ADULTS

Article 9.2.2 of the Settlement Agreement requires the licensees to identify the spawn timing, distribution, and abundance for transported anadromous species that are passed upstream of Merwin Dam. This is to be achieved by monitoring a statistically valid sample of each stock. According to the Settlement Agreement, the primary objective of this task per the Settlement Agreement is to identify preferred spawning areas in order to: (1) inform revisions to the H&S Plan and the Upstream Transport Plan; and, (2) guide the ACC in determining how to direct restoration efforts with the Aquatics Fund. To fulfill this requirement, the licensees conducted comprehensive spawning ground surveys for adult coho in the accessible river and stream reaches upstream of Swift Dam from 2012 through 2021. Since 2012, Spawning surveys specifically for adult spring Chinook were conducted in 2013, 2017, 2018, and 2021 when sufficient adults (more than 100 adult females) were transported upstream. Developing a sampling design to determine late winter steelhead spawn timing, distribution and abundance upstream of Swift Dam has historically been challenging due to several factors including the large area, remoteness, seasonally poor access due to snow accumulation and/or high stream flows, and high turbidity from snow melt during the spawning season. Given these challenges, the licensees have conducted a combination of targeted redd surveys and aerial monitoring of radio tagged fish, but with limited success (see Appendix B for further information).

Through discussions within the ATS during the development of this current M&E Plan, it was determined that spawning ground surveys for adult coho over the past nine years provided sufficient information regarding the distribution and timing of coho spawning. While the adult steelhead spawning survey data is less rich than coho surveys, the information gathered to date suggests that adult steelhead distribute widely throughout the watershed upstream of Swift Dam, and the targeted spawning surveys are thought to have adequately bounded steelhead spawn timing.

However, the estimates of spawner abundance via redd based surveys are likely biased due to survey conditions, time periods, and violations of assumptions (see Appendix B for further details). Overall, these biases likely result in an underestimate of the total number of coho redds each year, resulting in an underestimate of the proportion of transported coho that spawned. Conversely, this has likely resulted in an overestimate of the proportion of fish that did not spawn.

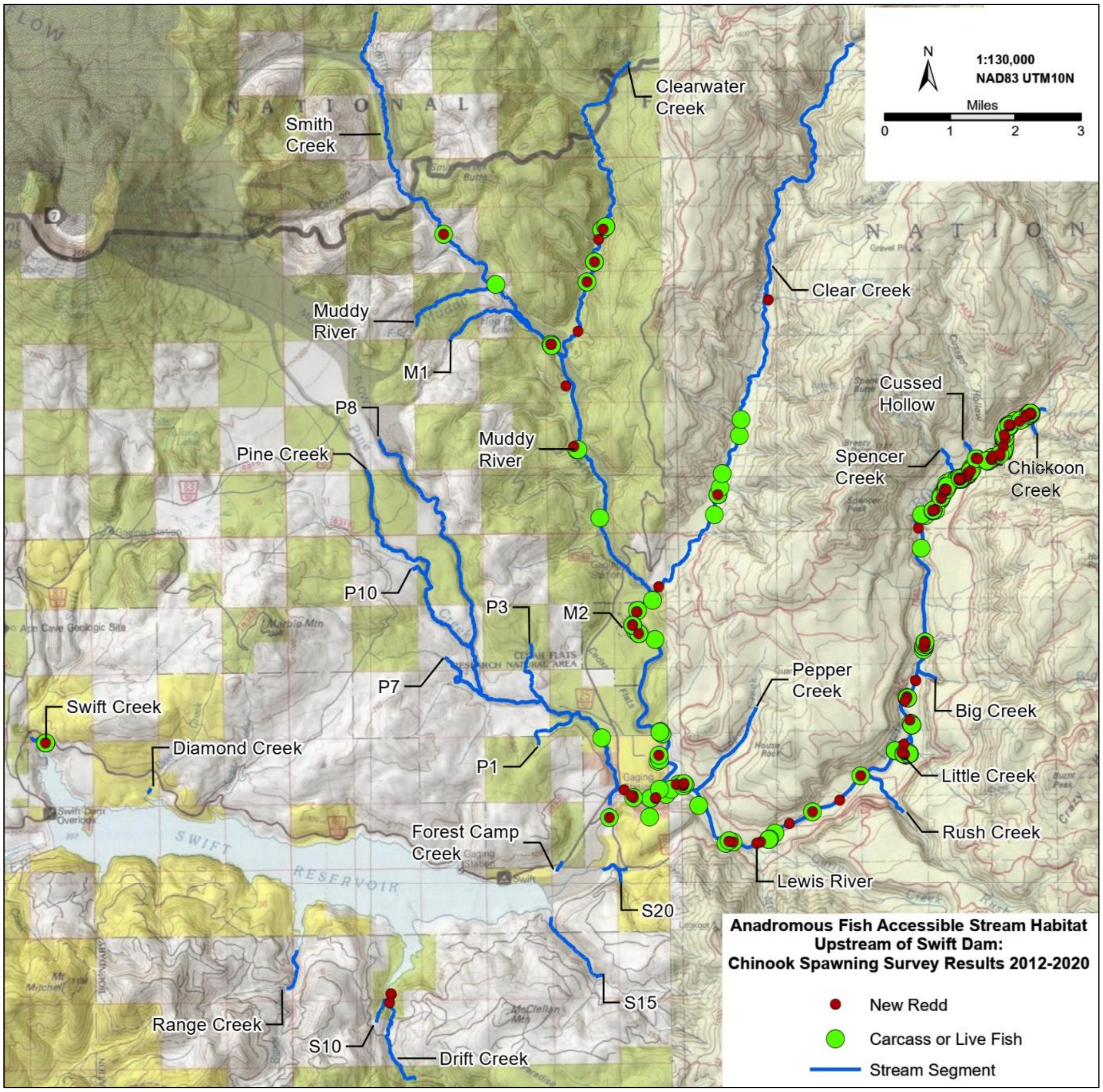
Given the logistical constraints to improving estimates of spawner abundance, combined with the fact that adults transported upstream of Swift Dam are censused (i.e., known quantity transported upstream), the ATS deemed it was appropriate in 2021 to temporarily suspend coho and winter steelhead spawning surveys and adult steelhead radio telemetry monitoring over the next five years. The ATS will reevaluate the need for this information during the next review and rewrite of the M&E Plan. Additional information pertaining to the justification for suspending these surveys for coho and late winter steelhead are provided below in Sections 2.15.2 and 2.15.3, respectively. (See Appendix B regarding the challenges of conducting coho and steelhead spawning surveys over the past nine years as part of Objective 15.) However, there continues to be a need to generate estimates of spawner abundance (i.e., the proportion of transported adults that actually spawn) primarily to feed into the coho and late winter steelhead IPMs as described in Section 2.20 of this Plan.

Due to lack of abundance of spring Chinook transported upstream of Swift Dam, spawning surveys have only been conducted in three of the last nine years. The ATS felt that surveys to determine spawn timing, distribution, and abundance of adult spring Chinook should continue over the next five years to verify the trends observed in 2017, 2018, and 2021. Similar to previous years, surveys will be conducted when sufficient adults (at least 100 female Chinook) are transported upstream to spawn using methods described below in Section 2.15.1. Generally, the number of adult female Chinook transported upstream in a given year has been very low (0 to 50 fish) or substantially more than 100 fish. Based on prior surveys, a transport abundance of at least 100 female Chinook allows for sufficient detection of redds to characterize spawner distribution (i.e., allows for detection of at least 50 redds scattered throughout the accessible stream network).

2.15.1 Spring Chinook

Monitoring of transported adult spring Chinook salmon released above Swift Reservoir from 2012 through 2021 was accomplished by conducting redd surveys of all accessible stream habitat upstream of Swift Dam (about 68 miles), excluding the drawdown zone of Swift Reservoir. The accessible stream network was divided into spatially continuous and discrete 0.3-mile-long survey reaches as part of the sample design development in 2012. These reaches were divided into three spatially balanced yearly survey panels using a Generalized Random Tessellation Stratified (GRTS) reach draw. The three survey panels have been surveyed since 2012 on a three-year rotation, where the same survey panel is surveyed once every three years. Surveys conducted to date have shown that spring Chinook spawn within the upper mainstem North Fork Lewis River and Little Creek, the Muddy River watershed, and Drift Creek (when sufficient flows are present) from late-August to early-October (Figure 2.15.1). Spawning may also occur in Swift Creek due to adequate upstream passage flows that are typically present in September. However, sufficient stream flow is generally lacking to allow adult Chinook access to all other independent Swift Reservoir tributaries. These include several small tributaries to the reservoir outside of the upper North Fork Lewis River watershed upstream of Eagle Cliff (such as S15, S20, Diamond, Range creeks, etc.). No spring Chinook have been documented spawning in the Pine Creek watershed (though two potential adult Chinook were observed in lower Pine Creek by WDFW spawning survey staff in 2013, not associated with a redd). Therefore, annual spring Chinook surveys will encompass a census of these areas only (Table 2.15.1). In years when less than 100 adult female Chinook are transported upstream, spawning ground surveys for Chinook will not be conducted.

Annually, three spawning survey passes of the streams listed in Table 2.15.1 will be conducted. All redds counted and fish observations (lives and carcasses) will be georeferenced by GPS. For consistency, the same spatially discrete 0.3 mile reach segments defined and surveyed from 2012 through 2021 will be referenced during the spawning stream census surveys so that future redd counts can easily be compared in a spatially explicit way to prior year results. The first spawning survey will be conducted in early-September, the second pass will be conducted the second half of September, and the third pass will be conducted the first half of October (i.e., all the accessible stream habitat listed in Table 2.15.1 will be surveyed once every two weeks over a six week period). Actual survey timing will be determined based on flow and weather constraints encountered during each year.



Note: n = 227 new redd and 402 fish observations.

Figure 2.15.1. Spring Chinook redd distribution and fish (live and carcass) observations (2012-2020) upstream of Swift Dam.

Table 2.15.1. Length of habitat accessible to spring Chinook in potential spawning streams.

Stream Name	Accessible to Anadromous Fish Length (miles)	Surveyable[1] Length (miles)
Mainstem NF Lewis River	12.9	12.9
Little Creek	0.3	0.3
Mainstem Muddy River	9.3	9.2
Clear Creek	11.1	7.5
Clearwater Creek	5.8	3.3
Smith Creek	5.7	5.0
Swift Creek	0.3	0.3
Drift Creek	1.5	1.5
Total Miles	**46.9**	**40.0**

[1]Note: Some areas are not accessible to surveyors due to steep canyon slopes and/or are not logistically feasible to access in one day.

The following survey methods will be employed. Surveyors will be trained in field survey methods and fish identification prior to the start of data collection each year. Project leaders will conduct periodic field assessments of survey crews to ensure proper data collection during the survey season. The start and end points of each sample reach will be located by GPS and clearly marked in the field during the first survey of each year.

Biologists will walk in an upstream direction. If flows are sufficient, surveys may also be conducted in a downstream direction using kayaks in the mainstem Muddy River and North Fork Lewis River, though side channels will be walked. Note that due to narrow passages through several rapids, larger craft such as rafts and catarafts cannot be used to conduct float surveys. It is anticipated that crews will be able to survey at least four miles per day; however, some of the more remote sites, such as Clear Creek, may require more time to survey due to difficult access conditions. Surveys will be conducted following recommendations provided by WDFW for salmon spawning survey protocols to the extent possible and applicable each year.

At a minimum, the following data will be recorded during each survey.

1. Surveyor names
2. Survey sample reach identification code
3. Survey date
4. Stream visibility
5. All salmon carcasses will be counted by species and sexed (if possible), measured for fork length and examined to determine egg retention for females. External marks will be noted. The location will be documented by GPS. After examination, tails will be excised to prevent recounting.
6. All live Chinook observed will be counted and location documented by GPS.

7. Surveyors will count all unflagged redds or groups of redds, and flag such after counting. Number of Chinook on the redd will be recorded. Redd locations will be documented by GPS.
8. Each redd or aggregation counted will be marked with a flag hung on the most permanent feature on the stream bank as close to the redd as possible. Each flag will be marked following established redd naming nomenclature with the date, sample reach identification code, redd number for the survey, location (i.e., distance and direction from flag), and indication of redd type (single or redd cluster, and note the number of redds in the cluster).
9. Redd visibility of previously identified and flagged redds will be recorded during each subsequent survey by recording the reach and redd number and visibility. Redds will be scored as either still visible or not visible on subsequent surveys. After a redd is scored as "not visible" on subsequent surveys, the redd flag will be left in place, but "NV" and the date when the redd was determined to be not visible will be written on the flag to aid in documenting redd superimposition and redd life over the entire spawn timing. If a new redd is superimposed on an old redd (either still visible or not visible) then the old redd flag will be pulled and a new redd flag will be established with a new name.
10. Any relevant notes regarding survey attributes or difficulties.

At the end of the season, all new redds will be summed to produce a census count. The census count of spring Chinook redds will be adjusted for imperfect detection probabilities. In prior years, the detection probability for Chinook redds was approximated as 0.8 based on a detailed evaluation of Chinook redd visibility conducted during the 2017 survey season and a range of 0.75 to 0.85 was used to account for some uncertainty in the estimate (Meridian Environmental 2018). This Chinook redd detection probability will be applied in a bootstrap application to calculate an estimate of the number of redds to account for imperfect detection and to obtain a 95% confidence interval based on the bootstrap of 1,000 iterations. The detection probability for each bootstrap iteration will be randomly selected from a uniform distribution within the 0.75 to 0.85 detection probability range.

The proportion of spawning females will be calculated as the estimated number of redds (census count after accounting for imperfect redd detection) divided by the total number of transported females released alive upstream of Swift Dam. This calculation is based on an assumption that each redd represents a single spawning female. Therefore, the estimated number of redds is equivalent to the estimated number of female spring Chinook spawners, and the 95% confidence interval is also the same. The proportion of transported females estimated to not have spawned within the accessible habitat upstream of the full pool of Swift Reservoir would then be estimated as the inverse of the proportion of transported females estimated to have spawned. The proportion of female spring Chinook transported upstream that did not successfully spawn is thought to be comprised of pre-spawn mortality plus any Chinook that spawn in the stream channels within the drawdown zone of Swift Reservoir. It is assumed that drawdown zone spawning results in little if any juvenile production if redds are inundated by the reservoir before eggs hatch and alevins emerge, primarily due to siltation (Reiser et al. 2016, BC Hydro 2019, Barnett et al. 2013). The proportion of Chinook spawning in the drawdown zone will be estimated following the same methods as described for coho in Section 2.15.2. Pre-spawn mortality will be assumed to fall within the range generally observed within the region by WDFW (range to be provided by WDFW).

Female spawner abundance (SA_F) will be calculated as:
$SA_F = FA_{LIVE} (1-(FP_{DS} + R_{PM}))$

Where:
FA_{LIVE} = total female spring Chinook transported and released alive upstream of Swift Dam;
FP_{DS} = proportion of female spring Chinook estimated to have spawned within the drawdown zone; and
R_{PM} = proportion of spring Chinook pre-spawn mortality based on a regionally observed range of values.

Female Chinook pre-spawn mortality (PM_F) can also be estimated as:
$PM_F = 1 – (FP_{SS} + FP_{DS})$

Where:
FP_{SS} = proportion of female Chinook estimated to have spawned upstream of the Swift Reservoir full pool; and
FP_{DS} = proportion of female Chinook estimated to have spawned within the drawdown zone.

The female Chinook pre-spawn mortality regionally observed value range (to be provided by WDFW) will be applied in a bootstrap application to calculate SA_F to obtain a 95% confidence interval based on the bootstrap of 1,000 iterations. The assumed female Chinook pre-spawn mortality value for each bootstrap iteration will be randomly selected from a uniform distribution within regionally observed value range.

The proportion of female spawners will be applied to the total number of males transported and released alive upstream of Swift Dam to determine male Chinook spawner abundance (SA_M). Therefore total spawner abundance (TSA) is calculated as:

$TSA = SA_F + SA_M$

Where:
$SA_M = MA_{LIVE} (SA_F / FA_{LIVE})$; and
MA_{LIVE} = total males transported and released alive upstream of Swift Dam

The following assumptions apply to the spring Chinook redd survey census count and spawner abundance estimate methodology:

1. The vast majority of potential spawning habitat is within the sampled streams.
2. Spawning occurs from late-August to early-October.
3. Surveyors are able to accurately detect and enumerate the number of Chinook redds.
4. Surveyors are able to discriminate redds between species (i.e., differentiate spring Chinook redds from potentially early spawning coho).
5. the number of redds per female is valid and remains constant over time.
6. Redds remain visible for at least 14 days

7. Actual redd detection probability is within the assumed range.
8. Pre-spawn mortality rates are the same for males and females.
9. The proportion of males that spawn upstream of the drawdown zone is the same as females.

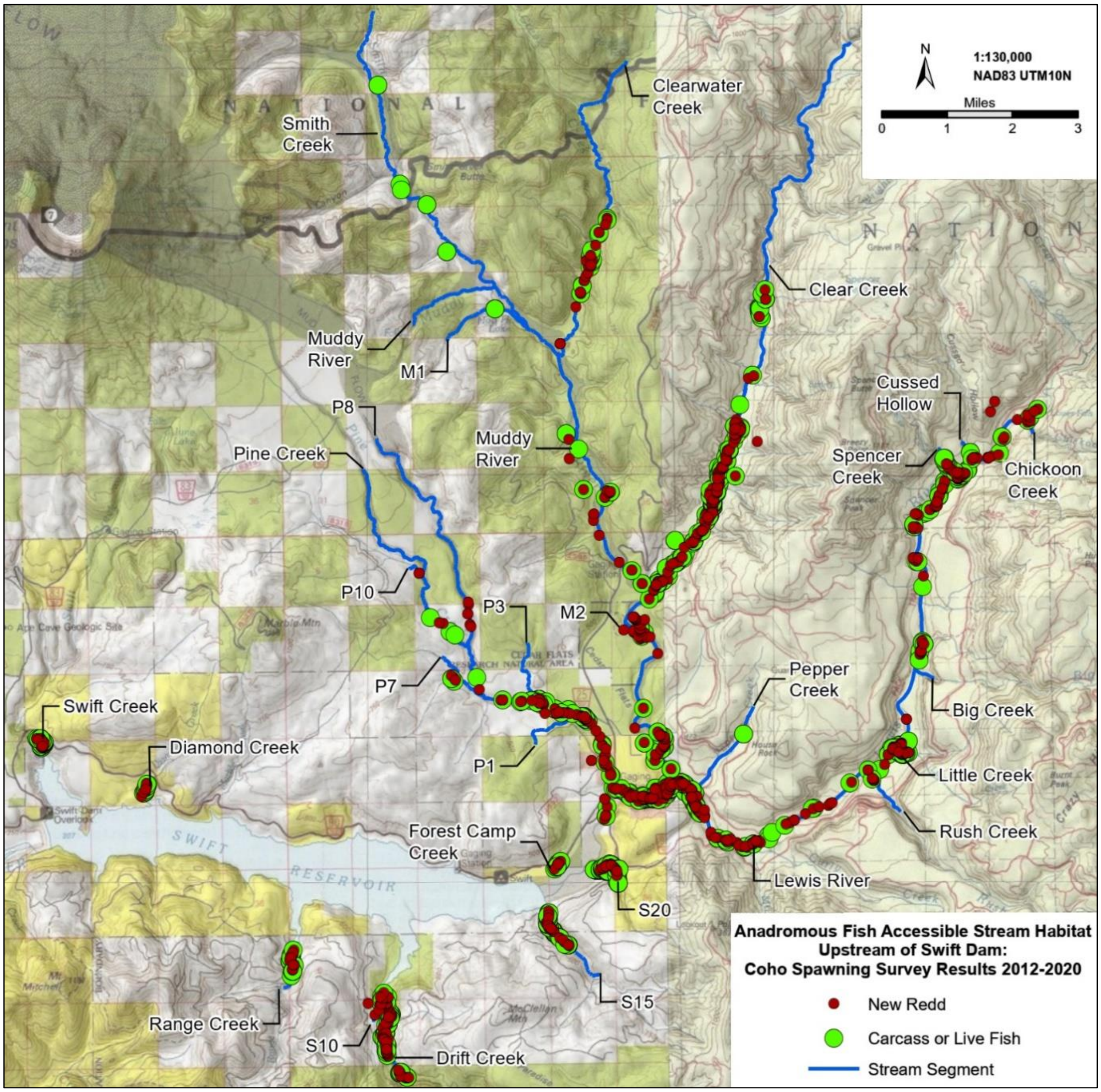
Results will be presented in tabular and graphic format in the Aquatic M&E Annual Report. At a minimum, the number of live spring Chinook observed and carcasses recovered, and total new redds by reach will be reported. In addition, the spawn timing will be reported (number of total new redds counted per survey week). The proportion of transported females estimated to have spawned upstream of the Swift Reservoir pool and within the drawdown zone of the reservoir will be reported. The assumed regional pre-spawn mortality rate will be compared to the estimated pre-spawn mortality to gauge the efficacy of this survey design and/or the applicability of the regional pre-spawn mortality rate.

In addition to the methods above, the spring Chinook IPM outputs will also be eventually used to independently estimate the number of spring Chinook spawners, which will be compared to estimates generated under this Objective. If there are differences between the two estimates, they will be reviewed to evaluate the reasons for the disparity (e.g., were any assumptions violated, etc.). If estimates differ significantly between these two approaches, then methods may be revised in the future when warranted based on this comparative assessment in consultation with the ATS. See Section 2.20 within this Plan for more information on the development of the IPM, timelines and intended outputs.

2.15.2 Coho

The overall distribution pattern of coho spawning upstream of the Swift Reservoir full pool elevation is well understood based on the surveys conducted annually since 2012. Coho primarily spawn throughout the accessible length of the mainstem North Fork Lewis River, Little Creek and the Muddy River watershed (Figure 2.15.2). In years when sufficient stream flow is present, coho also spawn throughout the accessible length of the independent reservoir tributaries and in smaller tributaries to the Muddy River and mainstem North Fork Lewis River. Some coho also spawn in the Pine Creek basin annually, but to a much lesser degree.

The available data suggests that in most prior survey years since 2012, approximately 30 to 50% of adult coho transported upstream did not spawn within the accessible stream habitat upstream of the full pool elevation of Swift Reservoir (see Appendix B). The proportion of coho transported upstream that did not successfully spawn is thought to be comprised of pre-spawn mortality plus any coho that spawn in the stream channels within the drawdown zone of Swift Reservoir. A preliminary analysis evaluating pre-spawn mortality of coho adults in tributaries throughout the lower Columbia River basin suggests that rates are generally less than 10% for natural-origin spawners, but potentially much higher for hatchery-origin adults (*WDFW unpublished data*). During coho spawning surveys conducted since 2012, there has been no indication of abnormally high pre-spawn mortality. It is thought that the proportion of coho estimated to not successfully spawn is the result of coho spawning in the drawdown zone of Swift Reservoir, in addition to potentially underestimating successful spawners as previously discussed. The drawdown zone is the only known area that coho could potentially spawn outside the spawning survey sample frame. In addition, coho spawning in the drawdown zone has been anecdotally observed while conducting annual spawning surveys of independent reservoir tributaries. Some very limited qualitative surveys of the North Fork Lewis River drawdown zone channel have documented coho spawning in certain years. However, to date, drawdown zone spawning has not been quantitatively assessed.



Note: n = 1,907 new redd and 2,278 fish observations.

Figure 2.15.2. Coho redd distribution and fish (live and carcass) observations (2012-2020) upstream of Swift Dam.

The number of female coho spawners (SA_F) upstream of Swift Dam will be determined each year by quantifying the proportion of female coho that spawn in the Swift Reservoir drawdown zone, and applying this proportion and the range of regional coho values for pre-spawn mortality (to be provided by WDFW) to the number of female coho transported and released alive upstream of Swift Dam, and calculated as:

$$SA_F = FA_{LIVE}\ (1-(FP_{DS} + R_{PM}))$$

Where:
FA_{LIVE} = total female coho transported and released alive upstream of Swift Dam;
FP_{DS} = proportion of female coho estimated to have spawned within the drawdown zone; and
R_{PM} = proportion of coho pre-spawn mortality based on a regionally observed range of values.

The coho pre-spawn mortality regionally observed value range will be applied in a bootstrap application to calculate SA_F to obtain a 95% confidence interval based on the bootstrap of 1,000 iterations. The assumed female coho pre-spawn mortality value for each bootstrap iteration will be randomly selected from a uniform distribution within regionally observed value range.

The proportion of female spawners will be applied to the total number of males transported and released alive upstream of Swift Dam to determine male coho spawner abundance (SA_M). Therefore total spawner abundance (TSA) is calculated as:

$$TSA = SA_F + SA_M$$

Where:
$SA_M = MA_{LIVE} (SA_F / FA_{LIVE})$; and
MA_{LIVE} = total males transported and released alive upstream of Swift Dam

The number of female coho estimated to spawn in the Swift Reservoir drawdown zone will be estimated annually through a census count of the drawdown zone stream channels once every two weeks during the coho spawning season (i.e., late-September through January and dependent on when adult coho are transported upstream) when the reservoir is below 980 feet-msl and the functional drawdown zone has been established. Unlike coho redd surveys within the larger watershed upstream of Swift Reservoir, it is anticipated that surveyors can access the reservoir drawdown zone throughout the entire coho spawning season. Redd counts will follow the methods as outlined above for spring Chinook (Section 2.15.1). Detection probability will be assessed using methods developed in consultation with the ATS. The redd detection probability will be applied in a bootstrap application to calculate an estimate of the number of redds to account for imperfect detection and to obtain a 95% confidence interval based on the bootstrap (based on 1,000 iterations). The detection probability for each bootstrap iteration will be randomly selected from a uniform distribution within the estimated detection probability range.

The proportion of spawning females within the drawdown zone will be calculated as the estimated number of redds (census count after accounting for imperfect redd detection) divided by the total number of transported females released alive upstream of Swift Dam. This calculation is based on the assumption that each redd represents a single spawning female. Therefore, the estimated number of redds is equivalent to the estimated number of spawning coho females within the drawdown zone, and the 95% confidence interval is also the same. The following assumptions apply to the coho redd survey census count and spawner abundance estimate methodology:

1. Surveyors are able to accurately detect and enumerate the number of coho redds in the drawdown zone.

2. Surveyors are able to discriminate redds between species (i.e., differentiate spring Chinook redds from potentially early spawning coho).
3. The number of redds per female is valid and remains constant over time.
4. Redds remain visible for at least 14 days.
5. Actual redd detection probability is within the assumed range, which is as yet to be identified.
6. Pre-spawn mortality rates are the same for males and females.
7. The proportion of males that spawn upstream of the drawdown zone is the same as females.

Results will be presented in tabular and graphic format in the Aquatic M&E Annual Report. At a minimum, results will include the number of live coho observed and carcasses recovered, and total new redds for each streams' drawdown zone. The proportion of transported females estimated to have spawned upstream of the Swift Reservoir pool and within the drawdown zone will be reported.

In addition to the methods above, the coho IPM outputs will also be eventually used to independently estimate the number of coho spawners, which will be compared to estimates generated under this Objective. If there are differences between the two estimates, they will be reviewed to evaluate the reasons for the disparity (e.g., were any assumptions violated, etc.). If estimates differ significantly between these two approaches, then methods may be revised in the future when warranted based on this comparative assessment in consultation with the ATS. See Section 2.20 within this Plan for more information on the development of the IPM, timelines and intended outputs.

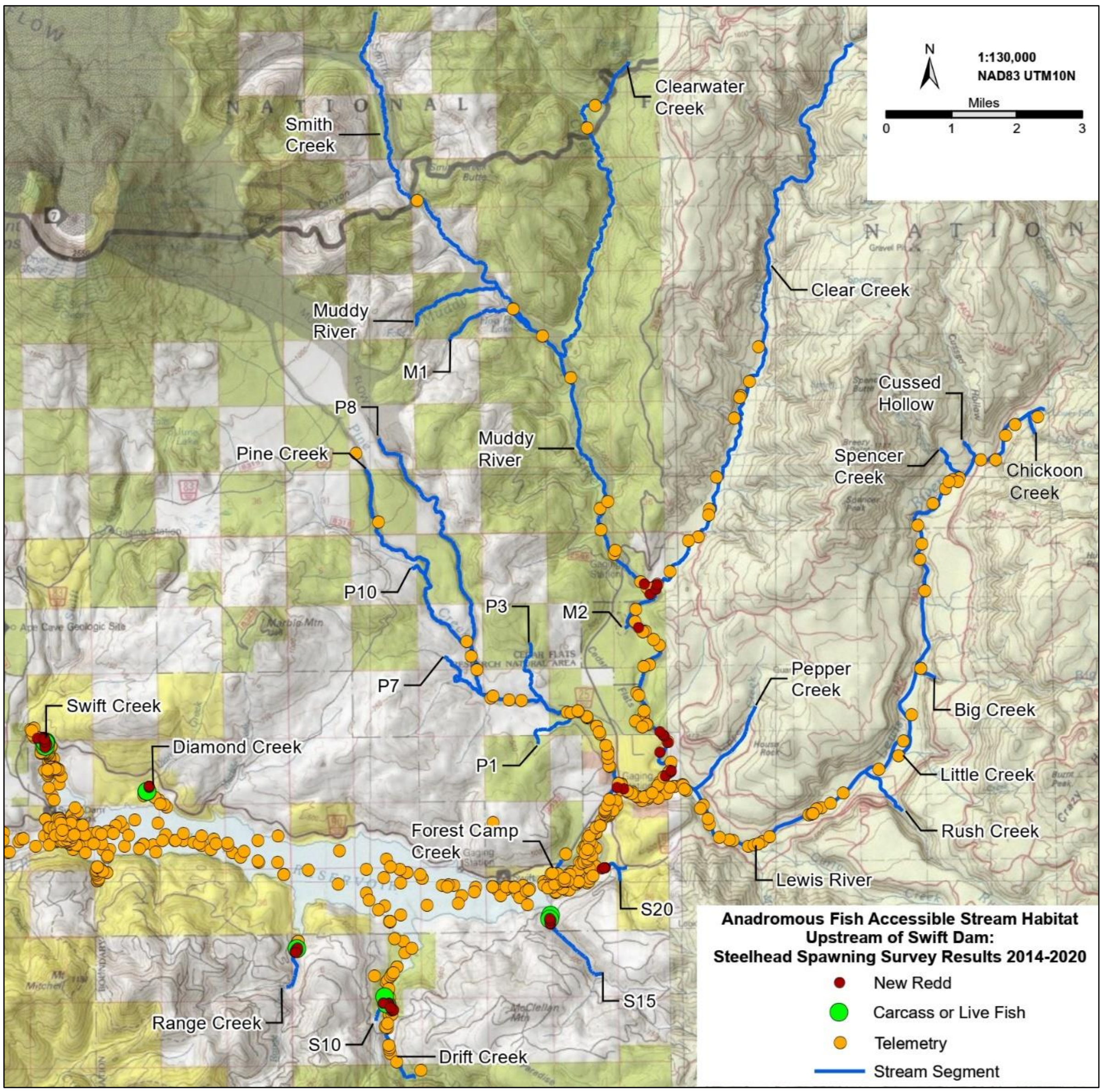
2.15.3 Late Winter Steelhead

Late winter steelhead spawn timing and distribution (see Figure 2.15.3) has been determined by a combination of on-the-ground spawning surveys of reservoir tributary index reaches, and radio tracking using both fixed stations and aerial surveys in select years since 2014. While the adult steelhead spawning survey data is less robust than the coho survey data set, the information gathered to date demonstrates that steelhead adults distribute throughout the potential available spawning habitat, and established methodology indicates that pre-spawn mortality is likely not a limiting factor to recovery. Therefore, adult steelhead spawning surveys and radio telemetry monitoring will also be suspended unless an additional need is identified as the reintroduction program progresses over time.

Annual spawner abundance will be estimated by applying the regionally observed range of pre-spawn winter steelhead mortality rates (to be provided by WDFW) to the total number of late winter steelhead transported and released alive upstream of Swift Dam. Drawdown zone spawning is not suspected for steelhead and has not been observed during reservoir tributary surveys conducted over the last few years; and therefore, will not be assessed.

The steelhead pre-spawn mortality regionally observed value range will be applied in a bootstrap application to calculate spawner abundance to obtain a 95% confidence interval based on the bootstrap of 1,000 iterations. The assumed steelhead pre-spawn mortality value for each bootstrap iteration will be randomly selected from a uniform distribution within regionally observed value range.

In addition to the methods above, the late winter steelhead IPM outputs will also be eventually used to independently estimate the number of steelhead spawners, which will be compared to estimates generated under this Objective. If there are differences between the two estimates, they will be reviewed to evaluate the reasons for the disparity (e.g., were any assumptions violated, etc.). If estimates differ significantly between these two approaches, then methods may be revised in the future when warranted based on this comparative assessment in consultation with the ATS. See Section 2.20 within this Plan for more information on the development of the IPM, timelines and intended outputs.



Note: n = new redd 88, 31 fish , and 637 telemetry observations.

Figure 2.15.3. Steelhead redd distribution, fish (live and carcass) observations, and adult radio telemetry detections (2014 to 2020) upstream of Swift Dam.

2.16 OBJECTIVE 16: EVALUATE LOWER LEWIS RIVER WILD FALL CHINOOK AND CHUM POPULATIONS NOTE: THIS OBJECTIVE, BECAUSE IT IS A LOWER LEWIS RIVER MONITORING ACTIVITY, HAS BEEN MOVED TO BECOME MONITORING OBJECTIVE 1 OF THE HATCHERY AND SUPPLEMENTATION PLAN

The ACC made a decision to separate tasks originally identified in the Settlement Agreement into monitoring upstream of Merwin dam (M&E Plan Tasks) and monitoring downstream of Merwin dam (H&S Plan Tasks). Because of that distinction, this section, which is a downstream activity, has been transferred to the H&S Plan (PacifiCorp and Cowlitz PUD 2020) and is now covered under Objectives 5 and 6 of that Plan.

2.17 OBJECTIVE 17: MONITOR BULL TROUT POPULATIONS

These bull trout objectives represent the mutual obligations of PacifiCorp and Cowlitz PUD. Methods to achieve these objectives will be provided in the Utility's Lewis River Bull Trout Annual Operating Plan.

Bull trout populations affected by the Lewis River Hydroelectric Project are monitored to 1) inform Project management decisions and 2) provide information to assist in gauging whether recovery goals and objectives are being met. Bull trout recovery goals and objectives are identified in the Recovery Plan for the Coterminous United States Population of Bull Trout (USFWS 2015a) and the associated Coastal Recovery Unit Implementation Plan for Bull Trout (RUIP; USFWS 2015b). Both plans seek to reverse declining trends and to ensure long-term persistence of bull trout and their habitats.

The Recovery Plan describes recovery criteria and lists five key points as the general range-wide strategy for recovery of bull trout: "(1) conserve bull trout so that they are geographically widespread across representative habitats and demographically stable in six recovery units; (2) effectively manage and ameliorate the primary threats in each of six recovery units at the core area scale such that bull trout are not likely to become endangered in the foreseeable future; (3) build upon the numerous and ongoing conservation actions implemented on behalf of bull trout since their listing in 1999, and improve our understanding of how various threat factors potentially affect the species; (4) use that information to work cooperatively with our partners to design, fund, prioritize, and implement effective conservation actions in those areas that offer the greatest long-term benefit to sustain bull trout and where recovery can be achieved; and (5) apply adaptive management principles to implementing the bull trout recovery program to account for new information."

Recovery unit implementation plans were developed for each of the six bull trout recovery units in the Unites States by individuals familiar with the populations within the recovery unit. The RUIPs describe threats to population persistence, recommend actions necessary to promote recovery, and identify research, monitoring and evaluation needs. The specific actions necessary to achieve recovery are identified at the Core Area spatial scale (e.g. Lewis River basin) and are included in their respective RUIP. The Lewis River Bull Trout Recovery Team (LRBTRT), comprised of federal, state, and non-governmental biologists and scientists, provided the aforementioned information for the Lewis River Core Area, which was subsequently included in the Coastal RUIP.

The LRBTRT took the RUIP one step further with the additional development of a Lewis River Bull Trout Recovery Monitoring Plan, which details specific methods and direction for population monitoring of bull trout in the Lewis River basin.

Bull Trout Objectives:

The bull trout objectives were developed by the Utilities in collaboration with the LRBTRT and are consistent with the: 1) Bull Trout Recovery Plan, 2) the Coastal RUIP, and 3) the Lewis River Bull Trout Recovery Monitoring Plan. The monitoring objectives are intentionally broad in scope to allow for flexibility in specific actions as monitoring needs evolve. At a minimum, elements of the following objectives will be monitored annually: demographic characteristics, vital rates, spatial distribution, movement patterns, and genetic diversity. Achieving these monitoring objectives annually will provide information necessary to evaluate population response to recovery measures implemented and to assess the recovery progress of bull trout in the Lewis River Core Area. Additional monitoring and evaluation objectives may be included over time, in accordance with the Lewis River Bull Trout Recovery Monitoring Plan, and identified in the Lewis River Bull Trout Annual Operating Plan.

The Lewis River Bull Trout Annual Operating Plan will identify the specific monitoring actions that will be implemented by the Utilities each year to achieve the monitoring objectives. Each year, the Plan will be developed in consultation with the USFWS and the LRBTRT. The Plan may change through time as new scientific information becomes available or as monitoring needs change. The results of the monitoring actions identified in the Plan will be provided in the annual Aquatic M&E report.

2.18 OBJECTIVE 18: DETERMINE INTERACTIONS BETWEEN REINTRODUCED ANADROMOUS SALMONIDS AND RESIDENT FISH (UPSTREAM OF MERWIN DAM)

In 2013 through March 2016, USGS-Bozeman, along with University of Washington, performed several tasks to inform the future fish passage decision in February 2017 regarding the quality of habitat in Merwin and Yale reservoirs and their tributaries. One of the required tasks was to assess anadromous fish interactions with resident fish as it relates to Objective 18. Specific objectives of this prior work included:

1. Utilize existing data (e.g., pre-introduction isotope data from Swift Reservoir) and empirical field data to identify the structure of the food webs in Swift Reservoir, Yale Lake, and Lake Merwin.
2. Estimate predation potential and consumption of juvenile salmonids by resident native and non-native species across different seasons in each system.
3. Estimate potential competition among different resident species and anadromous salmonids for resources.
4. Quantify spatial overlap within Pine Creek (Swift Reservoir) and habitat use by anadromous smolts and resident fishes.
5. Estimate predation and competition among species in Pine Creek using stable isotope methods.

This work was conducted over a period of three years from 2012 to 2015. A final report was provided to the ACC (Al-Chokhachy et al. 2018).

Next Steps

The M&E subgroup has suggested that this effort be repeated to some degree to assess resident/anadromous interactions once the reintroduction program is fully operational and full complements of the reintroduced species are present. The LRBTRT is developing information needs and proposed work regarding this objective, which will be provided when available.

2.19 OBJECTIVE 19: DOCUMENT PROJECT COMPLIANCE WITH FLOW, RAMPING RATE AND FLOW PLATEAU REQUIREMENTS

PacifiCorp has agreed to document project flow, ramping rate, flow plateau, and flood storage requirements of the new Licenses for the Project. Pending approval of the High Run-Off Procedures, PacifiCorp has also agreed to document flood storage. The monitoring locations for stream flow-related requirements will be at the Ariel Gage located in the lower Lewis River, and at two sites in the Lewis River bypass reach below Swift No. 1 Dam. Flood storage requirements will be monitored at each of the project dams.

2.19.1 Task 19.1 – Monitor River Flow, Ramping Rate and Flow Plateau for the Lewis River Projects

2.19.1.1 Monitoring Locations

Minimum stream flow values for the Lewis River are measured in real-time at the USGS Gage No. 14220500 (Ariel Gage) located downstream of the Merwin Dam. This gage is the official compliance point for minimum stream flow releases, ramping rates and plateau operations downstream of Merwin Dam.

Flow into the Swift bypass reach will be measured in two locations in accordance with Section 6.1 of the Settlement Agreement. These locations are the “Upper Release Point” in the upper end of the bypass reach, and at the “Canal Drain”, located approximately one-third the length of the canal downstream of the Swift No. 1 tailrace[12].

The methods used for determining Project compliance with all flow and ramping rate license requirements at these monitoring locations are presented below.

2.19.1.2 Rating Tables and Gage Station Maintenance

Where used, rating tables will be maintained by PacifiCorp or a qualified contractor. Maintenance of relevant monitoring instrumentation will meet PacifiCorp’s need for real time access to flow data. Instruments will be maintained by PacifiCorp or other qualified contractors.

[12] PacifiCorp will pay for the maintenance, operation and replacement, if necessary, of both gages.

2.19.1.3 Data Management and Publication

Data will be managed by PacifiCorp. Any data deficiencies discovered during the review and publication process (e.g., rating table shifts, stage offsets) will be edited to produce an accurate record.

Ariel Gage

Real-time 15-minute provisional data from the Ariel gage will be logged by PacifiCorp to monitor hourly average flow and hourly ramping rates downstream of Merwin Dam. Minimum stream flow, ramp rate and plateau operations reporting will occur on an excursion basis only as provided in Section 2.19.1.4.

Swift Bypass Reach: Upper Release Point

Real-time 15-minute data from the Swift bypass reach and Upper Release Point will be logged by PacifiCorp and/or a qualified contractor to monitor hourly average flow. Minimum flow at these locations will be reported on an excursion only basis in the annual report. All reviewed records will be stored by PacifiCorp in a permanent repository.

In the event of an extended unplanned interruption to flow from the upper release point, PacifiCorp will provide flow via the spill gates (or other means) to allow at least the required minimum flow into the upper bypass reach. During this particular scenario, flow will be calibrated by PacifiCorp at the most suitable point downstream of the spillway to verify that the temporary flow release is equal to the flow required by the 401 Certification. The spill gates will be adjusted until such time as the appropriate minimum flow is achieved and the spill gates fixed to this opening. In addition, PacifiCorp will send a notice by electronic mail (email) to the ACC members within 48 hours after each adjustment or change to the flows in the bypass reach (unless the Parties agree upon an alternate method of notification). In the case of planned interruptions (e.g., for canal maintenance) flow will be provided to the Upper Release channel using a pump or siphon until the flows can be restored.

Swift Bypass Reach: Canal Drain

Flow into the lower Swift bypass reach from the canal drain will be monitored by logging 15-minute stage data in the Swift canal. This data will be used to calculate hourly average flow into the lower Swift bypass reach. Since the required flow release from the canal drain remains constant throughout the year (14 cfs), the canal drain opening will be fixed to release required flows at the lowest possible stage in the canal. Most of the time, flow from this release point will likely exceed the required minimum since the stage in the canal generally is operated higher than this minimum elevation, thereby increasing the head at the release point. Mean hourly stream flow values measured at the canal drain will be published in the Aquatic M&E Annual Report. All reviewed records will be stored by PacifiCorp in a permanent repository.

In the event of a planned or unplanned interruption of flow release from the canal drain, PacifiCorp will place a pump siphon or use other means to allow at least the minimum flow into the bypass reach from this location. During this particular scenario, flow will be calibrated by PacifiCorp or a qualified contractor at the most suitable point downstream of the canal drain to verify that the temporary flow release is equal to the flow required by the 401 Certification. Flow will be adjusted until such time as the appropriate minimum flow is achieved and set at this level. As is the case for the Upper Release Point, PacifiCorp will send a notice by email to the ACC members and WDOE within 48 hours after each adjustment or change to the flows in the bypass reach via the canal drain (unless the Parties agree upon an alternate method of notification).

2.19.1.4 Flow and Ramp Rate Monitoring and Excursion Reporting

<u>Flow Monitoring and Excursion Reporting</u>

If flows at gage sites are discovered to be less than the required minimum flows, or ramping occurs that exceeds the compliance limits, PacifiCorp will correct these conditions as rapidly and prudently as possible. Any excursions from the flow requirements will be clearly documented by date, time and duration and reported as discussed below.

<u>Ariel Gage</u>

PacifiCorp will review hourly average flow data for compliance with the minimum stream flow requirements in the new license (Table 2.19.1). Excursions from hourly minimum stream flow requirements will be reported to FERC, WDOE, and the ACC within 24 hours of verifying the excursion. Notification will include a detailed explanation of why the event occurred and corrective actions implemented.

These initial notifications will be distributed via email, and will describe the location, time, duration, magnitude, and cause of the event; what immediate corrective actions were taken; and any long-term plans to prevent repetition. Comprehensive reports may be requested by the agencies for individual circumstances. Minimum flow excursions measured at the Ariel Gage site will be described in the Aquatic M&E Annual Report.

<u>Swift Bypass Reach Upper Release</u>

PacifiCorp will review hourly average flow data for compliance with the minimum stream flow requirements in the new license (Table 2.19.1). Excursions from minimum stream flow requirements will be reported to FERC, WDOE, and the ACC within 24 hours of verifying the excursion. Notification will include a detailed explanation of why the event occurred and corrective actions implemented.

These initial notifications will be distributed via email, and will describe the location, time, duration, magnitude, and cause of the event; what immediate corrective actions were taken; and any long-term plans to prevent repetition. Comprehensive reports may be requested by the agencies for individual circumstances. Minimum flow excursions measured at the Upper Release site will be described in the Aquatic M&E Annual Report.

<u>Swift Bypass Reach Canal Drain</u>

Flow in the lower Swift bypass reach from the canal drain will be monitored by logging 15-minute stage data in the Swift canal. PacifiCorp will review mean hourly average stage data for compliance with the minimum stream flow requirements in the new license (Table

2.19.1). Excursions from minimum (stage) stream flow requirements will be reported to FERC, WDOE and the ACC within 24 hours of verifying the excursion. Notification will include a detailed explanation of why the event occurred and corrective actions implemented. These initial notifications will be distributed via email, and will describe the location, time, duration, magnitude, and cause of the event; what immediate corrective actions were taken; and any long-term plans to prevent repetition. Comprehensive reports may be requested by the agencies for individual circumstances. Minimum flow excursions measured at the canal drain will be described in the Aquatic M&E Annual Report.

Table 2.19.1. Minimum flow releases in the Lewis River from Merwin Dam and the Swift bypass reach from the Swift canal as required by the FERC licenses and Section 401 Certifications.

Lewis River Downstream of Merwin Dam	
Date	**Minimum Flow (cfs)**
October 16 through October 31	2,500
November 1 through December 15	4,200
December 16 through March 1	2,000
March 2 through March 15	2,200
March 16 through March 30	2,500
March 31 through June 30	2,700
July 1 through July 10	2,300
July 11, through July 20	1,900
July 21 through July 30	1,500
July 31 through October 15	1,200
Swift Bypass Reach*	
Date	**Minimum Flow (cfs)**
January	65
February	89**
March	90
April	90
May	90
June	68
July	68
August	68
September 1-23	68
September 24-30	69
October	75
November 1-15	90
November 16-30	70
December	65

* Flow levels were taken from the WDOE 401 Certification for the Swift No. 1 Hydroelectric Project (WDOE 2006) and are the “Combined Flow Schedule” for the required stream flow releases from the “Upper Release Point” and the “Canal Drain.”
** During leap years, 88 cfs shall be released for the first 7 days in February and 89 cfs for the rest of the month.

Ariel Gage Ramp Rate and Plateau Operations Monitoring and Excursion Reporting

When ramping occurs that exceeds compliance limits, PacifiCorp will correct these conditions as rapidly and prudently as possible. If plateau operations are violated, PacifiCorp will not attempt to correct the action by returning to the flow level preceding the event since plateau operations seek to limit flow changes.

PacifiCorp will review hourly Ariel gage stage data to ensure compliance with Project ramping rate restrictions and plateau changes downstream of Merwin Dam[13]. Stage will be measured in tenths of feet per hour, and will be calculated using available 15-minute Ariel gage flow data to calculate an hourly average. The ramping rates will then be compared with the Settlement Agreement required ramping rate and flow plateau requirements on an hourly basis. The requirements are as follows:

1. PacifiCorp will limit the up-ramping rate as observed at the Ariel gage (downstream of Merwin Dam) to 1.5 feet per hour for all periods when flows below Merwin Dam are at or less than the hydraulic capacity of the Merwin Project turbines (currently 11,400 cfs).
2. PacifiCorp will limit the down-ramping rate to 0.17 feet per hour for all periods when flows are at or less than 8,000 cfs. From February 16 through June 15, no down-ramping shall occur (1) commencing one hour before sunrise until one hour after sunrise and (2) commencing one hour before sunset until one hour after sunset.
3. PacifiCorp will further restrict daily flow fluctuation from February 16 through August 15 of each year by maintaining flow plateaus (periods of near-steady discharge) as described in Section 6.2.2 of the Settlement Agreement.

Excursions from hourly ramp rate requirements or plateau changes will be reported to FERC, WDOE, and the ACC within 24 hours of verifying the excursion. Notification will include a detailed explanation for why the event occurred and corrective actions implemented.

These initial reports will be distributed via email, and will describe the location, time, duration, magnitude, and cause of the event; what immediate corrective actions were taken; and any long-term plans to prevent repetition. Comprehensive reports may be requested by the agencies for individual circumstances.

PacifiCorp will describe ramping rate and plateau operation excursions as measured at the Ariel gage in the Aquatic M&E Annual Report.

High Run-Off Procedure Monitoring and Reporting

The reporting requirements described here are pending approval of PacifiCorp's Lewis River High Run-Off Procedures by FERC and the U.S. Army Corps of Engineers (USACE)). However, neither FERC nor FEMA are willing to sign off on the HRP so PacifiCorp is

[13] "Ramping" means those Project-induced increases ("up-ramping") and decreases ("down-ramping") in river discharge and associated changes in river surface elevation over time below Merwin Dam caused by Project operations or maintenance (Section 6.2.1 of the Settlement).

defaulting to the historic protocols. Documentation of compliance with the historic protocols will be reported directly to FERC at the end of each flood season.

The High Run-Off Procedures define vacant storage requirements for flood control purposes throughout the flood control season extending from September 20 through April 30 or April 15 in years of low snowpack (Table 2.19.2). Generally, vacant storage[14] is a function of reservoir elevation relative to the normal full operating level in the reservoir. PacifiCorp will report daily average vacant storage to the nearest tenth of a foot for the flood control season to the FERC by July 31, annually. In the event that the average daily storage requirement is encroached upon for flood control purposes or other reasons, this will be reported to the FERC within 24 hours of verifying the reservoir storage encroachment. Notification will be provided via email and will include an explanation for the need/use of the vacant storage. Notification will occur when the vacant storage requirement (as measured to the nearest tenth of a foot) is encroached upon by more than 0.2 feet for 6 hours or more. PacifiCorp will report daily average reservoir elevation for each project, to the nearest tenth of a foot for the flood control season to the FERC by July 31, annually.

Table 2.19.2. Vacant storage requirements for the Lewis River Project reservoirs (Merwin, Yale and Swift reservoirs)

Date	Vacant Storage (feet)
Normal Vacant Storage	
Sept. 20	0
Oct. 10	8.5
Nov. 1 thru Apr. 1	17.0
Apr. 15	8.5
Apr. 30	0
Vacant Storage in Low Snowpack Years	
Sept. 20	0
Oct. 10	8.5
Nov. 1 thru Mar. 15	17.0
Apr. 1	8.5
Apr. 15	0

The high runoff procedure also defines elevations at which the reservoirs are considered "full" under normal operating conditions. However, during some high flow events, it may be necessary to surcharge the reservoirs beyond these normal operating limits. When this occurs in any of the three project reservoirs, PacifiCorp will notify the FERC of this occurrence within 24 hours of verifying the reservoir surcharge. Notification will be provided via email and will include an explanation for the need to surcharge. Notification will occur when the normal maximum elevation in each reservoir is exceeded by more than 0.2 feet (measured to the nearest tenth of a foot) for 6 hours or more. Reservoir elevation monitoring devices are located at the Project dams and are operated and maintained by PacifiCorp. Data from these devices will be archived in PacifiCorp's operations databases.

[14] Vacant storage is measured in feet of depth between the current reservoir water levels and elevation 1,000 feet-msl at Swift, elevation 490 feet-msl at Yale, and elevation 239.6 feet-msl at Merwin. Because the average storage space in the top foot of the three Lewis River reservoirs is approximately the same, depth can be summed over multiple reservoirs.

2.20 OBJECTIVE 20: DETERMINE WHEN REINTRODUCTION OUTCOME GOALS ARE ACHIEVED

Section 3.1.1 of The Settlement Agreement notes:

> *…the Services, after discussion with the ACC, shall determine how they will assess whether Reintroduction Outcome Goals have been met, e.g., metric, model, qualitative factors ("Evaluation Methodology"). The determination shall take into account the variability of the factors influencing the success of the comprehensive aquatics program over time such as cycles of ocean conditions and will include an appropriate temporal component in developing and applying the Evaluation Methodology.*

Although the responsibility of the Services, the Utilities are interested in playing a significant role in putting forth viable approaches for the Services to consider in establishing the reintroduction Evaluation Methodology. The H&S Plan (PacifiCorp Energy and Cowlitz PUD 2020) provides some ideas as to what type of information should be considered in determining program success. In general, the H&S Plan suggests:

1. Using other lower Columbia River spring Chinook, coho and steelhead as index stocks to track out-of-basin effects on the success of the Lewis River program.

2. Tracking similar reintroduction efforts on the Cowlitz River and other lower Columbia River tributaries.

3. Calculating annual harvest rates, smolt-to-adult survival rates, juvenile production, etc., to estimate when runs are self-sustaining.

<u>Methods</u>

Methods for conducting each of the three analyses are presented in different sections of this M&E Plan. Yet to be defined is a numeric adult goal that dictates when run-size is sufficient for achieving both recovery and harvest goals. Until the Services develop numeric goals per Section 3.1.1 of the Settlement Agreement, the natural adult abundance targets presented under Objective 12 (Ocean Recruits; Section 2.12) will be used as the benchmarks for determining the success of the reintroduction effort.

In addition to these suggested analyses, IPMs will be developed and used to independently estimate adult and juvenile productivity and capacity, adult brood-year recruitment (ocean recruits), R/S and SARs for coho, spring Chinook, and late winter steelhead upstream of Swift Dam. The IPMs are described below.

<u>Integrated Population Models</u>

The North Fork Lewis River reintroduction program for spring Chinook, coho and late winter steelhead upstream of Swift Dam has been in place for nearly 10 years, and the monitoring and evaluation program has collected data on these populations since the program was initiated. However, the various data sets associated with population metrics of the target species have not been incorporated into a model to help understand the factors influencing the dynamics of these populations.

IPMs are a type of life-cycle model that may be used to evaluate the potential effects of management activities and environmental variability on salmonid populations (Buhle et al. 2018). Such models integrate all available data into a joint likelihood function that accounts for all (known) sources of uncertainty in the data (Schaub and Abadi 2011), resulting in more accurate and precise estimates of model outputs (Tavecchia et al. 2009, Johnson et al. 2010).

IPMs will be developed for the North Fork Lewis River spring Chinook, coho, and late winter steelhead populations with the primary goal of estimating production and survival during two life stages: (1) juvenile production and survival, and (2) adult production and survival, based on production of adults transported upstream of Swift Dam. The models will be used to estimate specific M&E Plan objectives including juvenile production and survival (Objectives 1, 4, & 6), ocean recruits (Objective 12), and smolt-to-adult survival rates and recruits per spawner (Objective 13), as well as other metrics (e.g., productivity and capacity, pHOS). In addition, the IPMs may be used to evaluate the effects of potential management activities on program objectives. For example, scenario analysis may be used to assess the cost of improving adult fish collection facilities versus the potential returns in terms of the number of juveniles captured and released downstream.

IPMs are currently in development for the Lower Columbia River chum population (Buhle et al. 2021) and the Upper Cowlitz River coho population (Plumb and Perry 2020). The Lower Columbia River chum IPM is being developed to identify the life-stages limiting population recovery, evaluate the need for ongoing supplementation, and prioritize habitat restoration efforts. The Upper Cowlitz coho IPM was developed to help evaluate how juvenile collection efficiency, spill, and other factors influence fish production upstream of Cowlitz Falls Dam, and has many features that are applicable to the North Fork Lewis River populations reintroduced above Swift Dam. A key finding of the Upper Cowlitz coho IPM analysis was that juvenile collection efficiency is the most important factor influencing productivity of the population. Juvenile to adult survival rates during the time-period studied were relatively high and have the potential to support a self-sustaining population if enough juveniles are captured and released downstream. These existing IPMs can serve as a foundation for developing the North Fork Lewis River IPMs.

Model Application

The North Fork Lewis River spring Chinook, coho, and late winter steelhead IPMs will use a Bayesian state-space framework with two components: 1) a process model to account for underlying population dynamics (e.g., Beverton-Holt or Ricker spawner-recruit function), and 2) an observation model that incorporates empirical data from the North Fork Lewis River spring Chinook, coho, and late winter steelhead populations. The state-space modeling approach allows for missing data (e.g., discontinuity in the current M&E data sets), accounts for uncertainty in model inputs, and produces estimates of uncertainty for model outputs. The two-stage IPMs will allow estimation of separate parameters for the spawner-to-smolt and smolt-to-adult life stages (Moussalli and Hilborn 1986). The models will incorporate juvenile and adult data collected by the M&E program as well as assumptions about harvest rates in the ocean, Columbia River, and North Fork Lewis River fisheries. Juvenile parameters are based on marking, trapping and transport data collected by the M&E program (Table 2.20.1). Adult parameters will include the number of adults transported upstream, data on the age, sex ratio, and origin of adults, estimates of pre-spawn survival and fecundity, and estimates of harvest rates (Table 2.20.2). Model outputs include smolt productivity and capacity, juvenile survival and abundance (outmigrants), adult ocean recruits, the smolt-to-adult survival rate (SAR), and recruits per spawner (Table 2.20.3). All outputs will include an estimate of uncertainty.

The IPMs may potentially build on the work of the previously developed IPMs discussed above. For example, the R package salmonIPM (Buhle et al. 2018) was used to develop the Lower Columbia chum IPM. The models could also use the framework developed by Plumb and Perry (2020) on the Upper Cowlitz coho IPM, which shares many of the parameters that apply to the North Fork Lewis River populations above Swift Dam. The North Fork Lewis River model framework also needs to include information on the spring Chinook, coho and late winter steelhead hatchery programs (broodstock removal, number of juvenile releases, etc.). Also, the models should incorporate environmental stochasticity (e.g., Pacific Decadal Oscillation).

Some of the model outputs listed in Table 2.20.3 will only be estimated by the IPMs (e.g., productivity and capacity). Others will also be estimated independently using the methods outlined in the M&E plan for each respective objective. For example, the total number of juveniles transported downstream and overall downstream survival will also be estimated using the methods outlined in Objectives 1, 4 and 6. Ocean recruits will also be estimated using the catch plus escapement method described under Objective 12 (Section 2.12). Similarly, smolt-to-adult survival and recruits per spawner will be estimated independently using the methods outlined in Section 2.13 for Objective 13. These estimates may be compared to the IPM outputs. If there are substantial differences between the independent and IPM estimates, the calculations will be reviewed to assess the reasons for the disparity, including whether any of the assumptions were violated.

The IPMs would be developed with the goal of producing estimates of the outputs in Table 2.20.3 prior to the next 5-year review of the M&E plan. The IPMs will be developed in coordination with the ATS.

Model Development Timing

The IPMs will be developed over the next 5-year M&E Plan implementation period. Model development will begin in 2022 with the goal to have modeling of Phase 1 of the Reintroduction Program completed by the 5th year of this M&E Plan implementation (2026) or sooner, prior to when downstream passage facilities are required to be operational at Yale Dam. It is acknowledged that these models will be refined over time as additional passage facilities are added.

Table 2.20.1. Juvenile parameters available for use in the North Fork Lewis River Integrated Population Models.

Potential IPM model parameter	Current M&E Plan Objective	Data Source
Number of juveniles entering Swift Reservoir	Objective 7	•2016-present (PacifiCorp); prior to 2016 (WDFW) •Estimated based on screw trap operations; index of abundance based on sample period. •Generally good estimates for coho and steelhead; poor estimates for Chinook due to low sample size.
Juvenile survival in Swift Reservoir through capture at the Swift FSC	Objective 1, embedded in S1 parameter joint probability of survival through reservoir (S_{RES}) and collection at the Swift FSC (P_{COL})	•2016-present; reservoir survival not specifically estimated, but is embedded within the S1 parameter estimate
Proportion of juveniles that enter the reservoir and are collected at the Swift FSC	Objective 1, embedded in S1 parameter = joint probability of survival through reservoir (SRES) and collection at the Swift FSC (P_{COL})	•2016-present; not specifically estimated, but is embedded within the S1 parameter estimate
Juvenile migrant collection efficiency of those entering the Zone of Influence (i.e., those that are “available” for collection)	Objective 2, Collection Efficiency	•2013-present •Generally good estimates for coho, Chinook, and steelhead active migrants
Number of juveniles collected at Swift FSC	Objective 6	•2012-present •Good estimates for coho, Chinook and steelhead
Survival of juveniles through the downstream collection and transport system	Objective 1 and 4, Overall Downstream Survival	•2013-present •Estimates good for all species/sizes at Swift FSC •Good transport estimates only for fish large enough to PIT tag
Number of juveniles that exit the Woodland Release Ponds alive to NF Lewis River	Objective 1 and 4, Overall Downstream Survival	•2019-present •Good estimates only for fish large enough to PIT tag
Number of juveniles released to NF Lewis River at Pekin Ferry alive (apply transport survival estimate from WRP to these fish)	Objective 1 and 4, Overall Downstream Survival	•Not specifically estimated •Juveniles released at Pekin Ferry when release ponds are not available due to outage or transporting steelhead kelts downstream

Table 2.20.2. Adult parameters available for use in the North Fork Lewis River Integrated Population Models.

Potential IPM model parameter	Current M&E Plan Objective	Data Source
Ocean harvest rate	Objective 12, Develop Estimates of Ocean Recruits	•Coded-wire tag data; PFMC harvest reports
Columbia River harvest rate	Objective 12, Develop Estimates of Ocean Recruits	•Coded-wire tag data; PFMC harvest reports
Adult returns to NF Lewis River	Objective 12, Develop Estimates of Ocean Recruits	•Not estimated by PacifiCorp
NF Lewis River harvest rate	Objective 12, Develop Estimates of Ocean Recruits	•Not estimated by PacifiCorp; potentially use surrogate data from nearby populations
Adult trap efficiency at Merwin Trap	Objective 10	•2016-2019 steelhead; estimates are considered good •2017-2018 coho (limited information); estimates have larger CI than steelhead •No estimates for spring Chinook
Number of adults collected at Merwin Trap	Objective 11	•Census count, 2012-continuing annually
Number of adults trapped at Lewis River Hatchery	NA	•Census count, collected by WFDW each year
Number of adults removed for broodstock	NA	•Merwin Hatchery
Number of adults transported upstream of Swift Dam that are released alive	Objective 9, Upstream Passage Survival	•Census count, 2012-continuing annually
Age, sex ratio, and origin (hatchery or natural-origin) of adults transported upstream of Swift Dam	NA	
Number of adults that survive to spawn (conversely pre-spawn mortality)	Objective 15, Determine Spawner Abundance (the proportion of the transported fish that spawned)	•Currently based on spawning surveys, but estimates have CIs that are relatively large •No real estimate for steelhead, though radio telemetry has provided some information
Fecundity	NA	•Not estimated by PacifiCorp for upstream spawners. Data available from Merwin Hatchery.

Table 2.20.3. North Fork Lewis River Integrated Population Model outputs based on production of adults transported upstream of Swift Dam.

Potential IPM output	Current M&E Plan Objective
Smolt Productivity and Capacity	NA
pHOS	NA
Overall Downstream Survival	Objective 1 and 4, Overall Downstream Survival
Juvenile Outmigrant Abundance and Timing	Objective 1 and 4, Overall Downstream Survival; Objective 6, Number of Juveniles Collected at Swift FSC
Ocean Recruits	Objective 12, Develop Estimates of Ocean Recruits
Smolt to Adult Ratio	Objective 13, Develop Performance Measures
Adult Recruits per Spawner	Objective 13, Develop Performance Measures

2.21 OBJECTIVE 21: DEVELOP A HATCHERY AND SUPPLEMENTATION PLAN (H&S) TO SUPPORT AND PROTECT LEWIS RIVER NATIVE ANADROMOUS FISH POPULATIONS AND PROVIDE HARVEST OPPORTUNITY

A plan has been established and is revised and updated on a 5-year cycle by the ACC. The most recent update was in 2020 (PacifiCorp and Cowlitz PUD 2020). A major component of the H&S Plan is an Annual Operating Plan (AOP) that is generated by the H&S Plan subgroup of the ACC. The steps and timeline for developing the AOP are described in the H&S Plan.

2.22 OBJECTIVE 22: DEVELOP A COORDINATION TABLE THAT CROSS-REFERENCES OBJECTIVES OF THE HATCHERY AND SUPPLEMENTATION PLAN AND THE MONITORING AND EVALUATION PLAN

2.22.1 Introduction

The purpose of this objective is to show what data is collected by the M&E and H&S plans and how these data can be used to provide information about Viable Salmonid Population (VSP) metrics such as population abundance and productivity. Reporting from this objective will include information that identifies VSP or other metrics being measured, methodology used to collect data, statistical methodology used to analyze data, and if point estimates with precision will be produced for each metric, as per NOAA Fisheries monitoring recommendations.

NOAA Fisheries recommends a specific regimen designed to monitor the Columbia River ESA listed salmon and steelhead and to demonstrate viability of each Evolutionarily Significant Unit (ESU) and each Distinct Population Segment (DPS). Those recommendations and guidelines are included in a document titled: *Guidance for Monitoring Recovery of Pacific Northwest Salmon & Steelhead listed under the Federal Endangered Species Act.* This document was prepared for the National Marine Fisheries Service by Crawford and Rumsey (2011) and was published one year after completion of the first version of this M&E Plan. In that document, the authors state, “It is our intention that these recommendations will be considered as the desired level of monitoring to be conducted and will provide consistency across recovery domains. The relative importance of each recommendation is left to the reader to determine based on their own circumstances and biological and physical conditions.” They go on to state, “This document is not intended to establish new requirements or modify any existing requirements set by a currently approved biological opinion or habitat conservation plan.”

In light of this document, PacifiCorp and Cowlitz PUD, in the spirit of cooperation, are willing to provide any desired information that relates to the NOAA Fisheries document to the extent that information is included in the required M&E Objectives as part of the Lewis River Settlement Agreement.

An example report framework by species is shown in Appendix C that addresses the parameters in Crawford and Rumsey (2011) and how these parameters are aligned with metrics measured as part of the M&E and H&S Plan objectives. Those metrics that do not align or are not required by either the M&E Plan Objectives or the H&S Plan Objectives are not included or noted as not applicable (NA)

Methodology necessary to combine data from both the M&E and H&S plans to develop annual point estimates with precision estimates for these metrics at the population scale has not been developed. Combining data to estimate these metrics at the population scale is necessary to fully evaluate the success of PacifiCorp funded reintroduction and hatchery production programs.

The specific detailed methodology for developing metric estimates at the population scale and summary table format will be developed by WDFW and PacifiCorp and will be included as part of annual reporting for Objective 22. The threshold for developing population scale metric summaries will be the same as identified under Objective 12 for developing ocean recruit analysis under Section 2.12.1.2.

2.22.2 Frequency and Duration

Data will be collected daily or weekly during each applicable fish run. Annual summaries will be prepared for the Aquatic M&E Annual Report.

2.22.3 Results and Reporting

At a minimum, the tables given in Appendix C (Tables 2.22.1 through 2.22.6) will show numbers associated with each metric for above Merwin dam (M&E Objectives) and below Merwin dam (H&S Objectives).

Results will be provided in the Aquatic M&E Annual Report. Results reported will include point estimates with precision estimates for each metric addressed by an M&E or H&S Plan objective. Additionally, individual estimates for the lower and upper North Fork Lewis basin will be combined to provide a single estimate for the entire North Fork Lewis basin. For populations that also include the East Fork Lewis (Tule Fall Chinook and Chum) WDFW will combine estimates for the North Fork Lewis with estimates for the East Fork Lewis to produce a single population estimate. WDFW will be responsible for reporting results at the population level, provided that WDFW determines that estimates are unbiased and include precision estimates consistent with NMFS guidance and WDFW standards. WDFW will provide information regarding the status of each population to the NMFS annually via WDFW's SCoRE web page.

2.22.4 Future Actions Summary

Detailed methodology for Objectives 1-22 are presented this M&E Plan. Implementation of these objectives will require adaptive management to achieve the goals of each objective; therefore, changes to methodology presented in this plan may occur on an annual basis. These changes will be captured in the annual report for each Objective. Table 2.22.7 will present and summarize these changes.

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Appendix A

PacifiCorp Response to Draft M&E Plan Comments
(ACC and Services Formal Review Combined)

Aquatics Monitoring and Evalaution Plan (AMEP) - Comment Matrix (ACC review and Services review combined)

Commenter	Agency	Reference (page no./line no. of CLEAN Version)	Comment	Response
Kale Bentley	WDFW	page 18 (lines 7 to 11) and page 19 (lines 1 through 5)	The pooled estimator to calculate SWIFT FSC collection efficiency should be modified to ensure that estimates are unbiased. A time stratified estimator should be used to generate a weighted estimate of collection efficiency. WDFW would like to see a formal commitment in the updated M&E Plan to update the collection efficiency estimator when collection efficiency reaches a certain threshold based on current methods or at the next M&E Plan re-write, whichever comes first.	Noted. The following paragraph was added to Section 2.2.1.3 of the M&E Plan: *The pooled estimator used to calculate PCE above may potentially be biased if all of the assumptions cannot be reliably met. A stratified estimator will also be used to calculate PCE when the estimate's upper confidence interval approaches the performance goal to give further confidence that the performance goal is actually being attained, or at the next M&E Plan update interval, whichever is sooner.*
Bonnie Shorin	NOAA Fisheries	page 3 (lines 22 and 23)	I believe the Merwin passage decision was presented in late December. Reference to that on lines 27/28 could also be updated.	We have updated the section you noted below regarding the in-lieu decision and potential amendments to the Plan (Pg. 3). This section now reads: *Section 7.6 of the Settlement Agreement directs PacifiCorp to establish an In-Lieu fund if the Services determine that anadromous fish passage into Yale or Merwin Reservoirs is not required. The Services determined on October 27, 2021 that reintroduction of anadromous fish into Yale Reservoir is warranted and that downstream fish passage facilities at Yale Dam are to be completed by June 26, 2026. On December 23, 2021 the Services informed parties of their determination on appropriateness of anadromous fish passage into Merwin Reservoir.* *Presently, this plan only describes M&E efforts upstream of Swift Dam and at the MFCF at the base of Merwin Dam. Additional anadromous fish reintroduction M&E efforts will be developed and incorporated into this M&E plan prior to the completion of any future fish passage facilities.*
Bonnie Shorin	NOAA Fisheries	pages 16, 17, and 22 (no specific lines referenced)	Will any of the M&E plan help inform the Swift Stranding issue? I am trying to infer from pages 16/17 and 22 - but the few fish entering the FSC is one issue, and while it may be related to the Swift stranding I cannot discern that this monitoring helps develop more information on that issue. Can information on that be inferred going forward from the data gathered under section 7.2. and section 2.6?	Regarding the "Swift Stranding Issue", any mortality associated with this issue would actually be captured in our estimate of Overall Downstream Survival (ODS), along with all other sources of mortality as fish move through the Project. ODS is outlined in Objective 1 (Pg. 10) of the Plan, and currently has a performance measure of 80% survival.
Jeffrey Garnett	USFWS	page 3 (lines 22 and 23)	"At the time of this Plan, a decision regarding downstream fish passage at Merwin Dam has not been determined." This can now be updated to reflect the Services' December 2021 decision. RESOLVED WITH LANGUAGE BELOW (thanks) [resolved with the language provided in response to NOAA Fisheries related comment]	Same response as for NOAA Fisheries page 3 comment regarding the In-Lieu Decision.
Jeffrey Garnett	USFWS	no specific page number referenced	When do studies related to each objective commence? For example, would the Objective 1 feasibility study begin in October 2022 when the FSC is first operational? I realize this may be a difficult question to answer with 22 objectives, but for many of them I'm unclear as to when data collection will begin (if it hasn't already begun).	In general, the vast majority of the actions outlined in the revised Plan occur every year as they are associated with deriving annual population metrics or assessing facility performance. The intent here is to conduct these "studies" annually for the life of the License, or until the specified performance standard has been met. As for some of the more long-term objectives associated outcome goal achievement (e.g., Objectives 12 and 20), specific language was added in the revised Plan to better define when those actions would be taken (as an example, see Section 2.12.1.2, Pg 52). In direct response to the Objective 1 feasibility study, the specified intent was to begin that effort upon approval of the revised Plan, so we are planning to begin that evaluation this spring.
Jeffrey Garnett	USFWS	page 23 (lines 15 and 16)	"The PIT tag data collected…can be used to estimate CS…" Based on the methods stated for Objective 4, it seems there is no PIT tag interrogation; therefore, I'm confused by this statement.	This statement is referring to the fish being PIT tagged and released as part of Objective 1 (Overall Downstream Survival) also being used to help determine Collection Survival (CS) – by way of adding more tagged fish in the system for S_{TRANS} - as they will also be passing through and being detected at various interrogation sites throughout the project. There are fixed station PIT tag interrogation sites at all the fish passage facilities throughout the project. Detection data from these sites are uploaded hourly to PITAGIS. For more information on PTAGIS see: https://www.ptagis.org/About/Introduction).
Jeffrey Garnett	USFWS	page 27 (lines 2 through 5)	"Estimates of PCINJ will be determined by closely examining a minimum of 10% of the total juvenile population collected each day. Sample fish will be diverted (through the use of automatic gates on the Swift FSC) into small holding tanks where they will be anesthetized and examined for injury." The methods for Objective 5 only refers to juvenile fish. Is the methodology the same for adult fish?	Because of the facility's design, all adult sized fish pass over the separator bars and are not diverted along with juvenile fish. All adult sized fish that enter the Swift FSC are handled separately, and therefore all are inspected for injury. Additional language was added to note the difference. Good catch!
Jeffrey Garnett	USFWS	page 44 (lines 37 and 38)	"Naïve fish will be captured by angling, tangle netting, or other methods selected in consultation with the ATS, tagged, at the Eagle Cliff Park screw trap and released in the North Fork Lewis River below Merwin Dam." I'm not following how fish collected in the Eagle Cliff Park screw trap would be appropriate for determining the upstream collection efficiency MFCF. Is the idea that PIT tagged juveniles will be recorded as they ascend the Lewis River in later years (although this seems to be a purely radio tag study)?	Statement highlighted above was removed as it was a typo. Again, good catch!!
Jeffrey Garnett	USFWS	page 45 (lines 11-13)	"Briefly, individual fish will be transferred into a sampling trough, measured to fork length, visually assessed for injury, dorsal sinus PIT tagged, and gastrically radio tagged following the methods of prior ATE studies at Merwin Dam (Caldwell et al. 2020)." Does this occur for bull trout (and steelhead)? I don't have immediate access to the Caldwell reference, but I'm assumed only semelparous salmonids receive gastric tags.	Bull trout are not a species identified as part of the Merwin Adult Trap Efficiency (ATE) Study protocols. (As a side note, to date no bull trout have been collected at the Merwin Adult Trap since it was commissioned in 2013.) Gastric tagging protocols have been previously used on adult steelhead because of the high rate of return (>90%). Radio tags are removed at the Merwin Trap before being transported upstream. Additional language was added to note this.

Appendix B

Lewis River M&E Plan Review Technical Memorandum of First Revision (Dated 02/28/2017)

2021 LEWIS RIVER MONITORING AND EVALUATION (M&E) PLAN REVIEW

TECHNICAL MEMORANDUM

FERC PROJECT NOS. 935, 2071, 2111 AND 2213

June 28, 2021

PREPARED FOR:

PacifiCorp and Cowlitz PUD

PREPARED BY:

Meridian Environmental, Inc.

and

Cramer Fish Sciences

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1.0 INTRODUCTION

This technical memorandum provides initial recommendations for updating the current Lewis River Monitoring and Evaluation (M&E) Plan (PacifiCorp and Cowlitz PUD 2017) based on a review of the objectives, methodologies, and data collected from current M&E Plan work in 2016 through 2020 (PacifiCorp and Cowlitz PUD 2017). The current M&E Plan addresses 22 objectives, most of which are identified in the Project's Federal Energy Regulatory Commission (FERC) License and/or the Lewis River Settlement Agreement. Based on relatedness of objectives, the M&E objectives were grouped into five elements for this review: 1) timing and number of juveniles entering Swift Reservoir, 2) overall downstream fish passage collection and survival, 3) adult passage and spawning, 4) ocean recruit estimates, and 5) all other monitoring objectives (Table 1.1).

In addition, the objectives were prioritized based on the level of effort needed to review and update the current methods. Prioritization was based on previous experience and involvement of PacifiCorp Biologists with preforming and reporting on objectives using the methodologies outlined in the current M&E Plan. Each objective was initially prioritized using three different rankings:

- High priority objectives were those that were thought to have methodologies that would require extensive review as they are not currently providing the information required to meet the intended goal of the objective. High priority objectives were thought to require extensive review of existing data, data collection, and/or data analysis practices previously outlined in the existing M&E Plan.

- Medium priority objectives where those that were thought to have methodologies that would require some additional clarification or adjustment to the current methodologies, but were generally adequate in meeting the objective goals and intent of the M&E Plan.

- Low priority objective where those that were thought to have methodologies that adequately meet the objective goals and intent of the M&E Plan, and require only minimal review. Objectives that were classified as low priority were also those that had been previously completed or are not yet applicable.

This technical memorandum is organized by the five M&E areas identified in Table 1.1. For each objective, we briefly describe the methods used in the current M&E plan, summarize recent data, and evaluate the effectiveness of the methods and resulting data in meeting each objective. In addition, initial recommendations for revising current methods or using potential alternative approaches (as needed) are provided for each objective. High and medium priority objectives are discussed in the individual group sections in detail, while the low priority objectives are reviewed in Section 7 (Evaluation Summary).

Table 1.1 Prioritization of M&E objectives for revision.

M&E Area	Objective	Priority		
		Low	Med	High
Timing/Number of Juveniles Entering Swift Reservoir	7.1 – Estimate the timing and number of juveniles entering Swift Reservoir from the Upper North Fork Lewis River Subbasin			X
	7.2 – Estimate the total number of juveniles entering Swift Reservoir			X
	8 – Develop index of juvenile migration timing	X		
Overall Downstream Collection and Survival	1 – Quantify overall juvenile fish downstream survival (ODS) which includes reservoir survival, collection survival, transport survival, and survival at the release ponds		X	
	2 – Quantify Swift Floating Surface Collector (FSC) collection efficiency	X		
	4 – Quantify juvenile and adult collection survival		X	
	6 – Quantify the number, by species, of juvenile and adult fish collected at the Swift FSC	X		
Adult Passage and Spawning	9 – Quantify adult upstream passage survival	X		
	10 – Quantify adult trap efficiency at each upstream fish transport facility (emphasizes analysis of the Merwin Adult Trapping Facility)	X		
	15.1 – Determine spawner abundance, timing and distribution of transported Chinook and coho			X
	15.1 – Determine spawner abundance, timing and distribution of transported winter steelhead			X
Ocean Recruits	12 – Develop estimates of ocean recruits			X
	13 – Develop performance measures for index stocks			X
All Other Monitoring with Low Priority for Revision	3 – Quantify the percentage of juvenile fish available for collection that are not captured by the Swift FSC and that enter the powerhouse intake	X		
	5 – Quantify juvenile injury and mortality rates during collection at the Swift FSC	X		
	11 – Quantify the number, by species, of adult fish collected at the Merwin Dam Upstream Collection Facility	X		
	14 – Document upstream and downstream passage facility compliance with hydraulic design criteria	X		
	16 – Evaluate lower Lewis River wild fall Chinook and chum populations	X		
	17 – Monitor bull trout populations	X		
	18 – Determine interactions between reintroduced anadromous salmonids and resident fish (upstream of Merwin Dam)		X	
	19 – Document Project compliance with flow, ramping rate and flow plateau requirements	X		

M&E Area	Objective	Priority		
		Low	Med	High
	20 – Determine when reintroduction outcome goals are achieved	X		
	21 – Develop a Hatchery and Supplementation Plan	X		
	22 – Develop a Coordination Table that cross-references Objectives of the Hatchery and Supplementation Plan and the Monitoring and Evaluation Plan	X		

2.0 EVALUATION OF OBJECTIVES RELATED TO TIMING AND NUMBER OF JUVENILES ENTERING SWIFT RESERVOIR

OBJECTIVE 7.1

Description

Estimate the timing and number of juvenile salmonids entering Swift Reservoir from the Upper North Fork Lewis River subbasin.

FERC License/Settlement Agreement Guidance/Specification

9.2.1 Monitoring and Evaluation of Upstream and Downstream Passage Facilities*. PacifiCorp, with respect to…Swift No. 1…, shall include in the M&E Plan the following monitoring and evaluation elements…for Chinook, steelhead, coho, bull trout, and sea-run cutthroat:*

a. Juvenile migration timing and the estimated number of juveniles entering Swift Reservoir.

2017 M&E Plan Methods

Operate a rotary screw trap located at the head of Swift Reservoir (at Eagle Cliff Park) from approximately March 1 through June 30 to estimate the total number of out-migrants entering the reservoir by estimating trap efficiency using mark-recapture. Because unsampled periods and reservoir tributaries are not accounted for in this analysis, this information serves as an estimate of outmigrants entering the reservoir during the period of trap deployment. Estimates are used as an index of total annual juvenile salmonid production that is tracked over time.

Relationship to Other Objectives

A subsample of the salmonids collected during operation of the Eagle Cliff screw trap are Passive Integrated Transponder (PIT) tagged to help meet the following M&E objectives:

- Objective 1 – Estimate reservoir survival as part of estimating the Overall Downstream Survival
- Objective 7.2 – Estimate the number of juveniles entering Swift Reservoir
- Objective 8 – Develop index of juvenile migration timing

2016 to 2020 Results Summary

Table 2.1 Eagle Cliff screw trapping results from 2016 through 2020.

Year	Trap Operation Period	Total Caught <60mm	Total Caught ≥60mm	Total PIT Taggable (>69mm)	Total PIT-tagged	Bootstrap Mean Total Estimate ≥60mm	95% CI	CV
Coho								
2016	3/24 - 6/30	116	232	228	119	7,164	4,485	32%
2017	4/20 - 7/30	1,258	1,265	714	117[a]	33,385	10,212	16%
2018	3/13 - 6/30	1,693	1,412	882	588	22,974	4,509	10%
2019	3/5 - 7/19	5,545	1,519	893	646	31,071	6,258	10%
2020	3/9 - 7/15	1,422	1,914	1,253	1,027	37,225	9,087	12%
Chinook								
2016	3/24 - 6/30	0	3	3	3	77	100	66%
2017	4/20 - 7/30	0	1	1	1	20	38	97%
2018	3/13 - 6/30	129	36	21	12	588	218	19%
2019	3/5 - 7/19	504	169	104	55	4,120	1,170	14%
2020	3/9 - 7/15	9	18	14	14	334	174	27%
Steelhead								
2016	3/24 - 6/30	3	144	143	86	3,832	1,976	26%
2017	4/20 - 7/30	16	116	113	91	2,366	615	13%
2018	3/13 - 6/30	3	196	184	159	3,195	767	12%
2019	3/5 - 7/19	361	237	225	202	4,855	1,168	12%
2020	3/9 - 7/15	296	264	259	254	4,745	1,142	12%
Cutthroat								
2016	3/24 - 6/30	0	42	42	25	1,104	623	29%
2017	4/20 - 7/30	1	52	51	39	1,057	355	17%
2018	3/13 - 6/30	1	84	68	60	1,365	385	14%
2019	3/5 - 7/19	1	54	53	51	1,050	348	17%
2020	3/9 - 7/15	0	61	60	59	1,047	357	17%

[a]Note: At this time only fish >90mm were PIT-tagged.

Methodology Effectiveness at Meeting Objective Intent

- The existing methodology is effective at estimating the number of salmonids ≥60mm in length that enter the reservoir during the monitoring season (approximately March 1 to mid-July each year) with CVs generally at or below the VSP guidelines of 15 percent for coho and 30 percent for steelhead (Crawford and Rumsey 2011), though small sample size limits the precision of estimates for juvenile Chinook and cutthroat.

- It is suspected that the timing of screw trap operation does not coincide with the period when the bulk of out-migrant salmonids pass the sample site at Eagle Cliff Park. Estimates of the number of fish annually collected at the Swift Reservoir Floating Surface Collector (Swift FSC) under Objective 6 suggest that a large portion of fish may enter the reservoir during periods when the trap is not operated, and/or that a substantial proportion of juveniles are produced within the reservoir tributaries (outside the area sampled by the Eagle Cliff Park screw trap).

- The screw trap could be operated over a longer period of time into the summer each year; however, based on average daily flow, low flow conditions may limit effective cone revolutions needed to capture and retain fish in the summer and early fall (late-July through mid-October). Frequent high flows and flood conditions, heavy debris loading, and periodic snow and ice preclude operating the trap from November through February.

- Currently, only fish approximately ≥70 mm fork length (FL) are PIT-tagged and fish ≥60 mm FL are tattoo marked. Therefore, the methodology does not estimate the number of salmonids <60mm that enter the reservoir, which annually comprise more than 50 percent of the total salmonid catch at the screw trap.

- Vollset et al. (2020) recommends a minimum size of 69 mm total length (TL) for tagging salmonids with 12-mm PIT tags. Generally, over 50 percent of Chinook, coho and steelhead captured each year at the Eagle Cliff screw trap are less than 69 mm TL, although most cutthroat and bull trout are larger. Therefore, the majority of salmonids captured at the screw trap are not possible to PIT tag for recapture at the Swift FSC to determine reservoir survival to address Objective 1.

Recommendations

Implement a two-year feasibility study to determine if other alternatives could lead to tagging more fish, and fish across a larger size/age frequency. PIT-tagging more fish would result in a more accurate estimate of the total number of juvenile fish entering Swift Reservoir (Objective 7.2) and would produce a better estimate of reservoir survival (Objective 1). See Objective 7.2 recommendations (below) for a discussion of alternative methodologies, and Objective 1 (Section 3) for an evaluation of PIT tag sample size. If alternative methods are more effective, then operation of the screw trap at Eagle Cliff Park may be discontinued.

OBJECTIVE 7.2

Description

Estimate the total number of juvenile salmonids entering Swift Reservoir.

FERC License/Settlement Agreement Guidance/Specification

Same as Objective 7.1

2017 M&E Plan Methods

The mark-recapture estimate of the total number of juveniles that enter Swift Reservoir is developed using fish PIT-tagged from the screw trap operated at Eagle Cliff Park (Task 7.1 above). Additional fish captured at the Swift FSC are tagged and returned to the head of Swift Reservoir and released. The Swift Fish are intended to supplement those released directly from the screw operations at the head of the reservoir. All fish (from screw trap and Swift FSC) are subsequently recaptured at the Swift FSC.

Relationship to Other Objectives

Recapture of marked fish at the Swift FSC is also used to meet the following objectives:

- Objective 1 – Estimate reservoir survival as part of estimating Overall Downstream Survival (ODS)
- Objective 8 – Develop index of juvenile migration timing

2016 to 2020 Results Summary

Table 2.2 Estimated number of fish captured at the Swift FSC from 2016 through 2020.

Year	# unmarked fish collected at Swift FSC	# fish PIT-tagged at Swift FSC and released upstream	# fish PIT-tagged at Eagle Cliff Screw Trap	Total # of PIT-tagged fish recaptured at Swift FSC	Bootstrap Mean Total Estimate ≥60mm	95% CI	CV
Coho							
2016	59,461	594	119	227	189,999	22,316	6%
2017	24,505	282	117	71	140,366	30,577	11%
2018	40,433	484	588	290	150,266	14,876	5%
2019	96,254	413	646	481	213,531	14,472	4%
2020	31,421	425	1,027	300	148,552	15,508	5%
Chinook							
2016	3,787	NR	3	0	NR	NR	NR
2017	5,797	110	1	64	57,948	14,003	12%
2018	4,552	396	12	97	19,290	3,501	9%
2019	10,887	168	55	56	44,186	10,614	12%
2020	4,310	80	14	36	84,291	25,152	15%
Steelhead							
2016	2,091	NR	86	12	14,087	8,820	32%
2017	1,797	175	91	27	17,655	6,748	20%
2018	7,690	278	159	191	17,718	1,876	5%

Year	# unmarked fish collected at Swift FSC	# fish PIT-tagged at Swift FSC and released upstream	# fish PIT-tagged at Eagle Cliff Screw Trap	Total # of PIT-tagged fish recaptured at Swift FSC	Bootstrap Mean Total Estimate ≥60mm	95% CI	CV
2019	3,013	78	202	23	36,463	16,314	23%
2020	4,208	89	254	38	38,864	12,425	16%
Cutthroat							
2016	1,049	NR	25	1	5,442	9,877	93%
2017	751	17	39	3	10,659	13,110	63%
2018	854	36	60	18	4,713	2,243	24%
2019	947	0	51	4	12,089	21,603	91%
2020	507	0	59	4	9,250	12,577	69%

Methodology Effectiveness at Meeting Objective Intent

The current methodology results in estimates of Swift FSC total captures with CVs generally at or below the VSP guidelines of 15 percent for coho and 30 percent for steelhead. However, the total estimates currently co-mingle cohort years as well as combine fish tagged at the screw trap and Swift FSC; both of which may have significantly different recapture rates. Co-mingling cohorts confounds the annual estimate of the number of fish that enter the reservoir in any given calendar year, because some fish rear in the reservoir for a year or more before being captured at the Swift FSC.

- Operating the screw trap provides relatively few fish large enough to PIT-tag for recapture at the Swift FSC. This sample size is further reduced when parsing by size (year class) to account for extended reservoir rearing (i.e., migrants rearing in the reservoir then captured at the Swift FSC the following year). As a result, sample sizes are smaller than those suggested in the M&E Plan, and why Swift FSC fish have been used.

- Fish captured at the Swift FSC, PIT-tagged, then released at the head of the reservoir are typically larger than fish tagged at the Eagle Cliff screw trap, and may have different recapture rates (i.e., the Swift FSC-tagged fish used to meet this objective may not be representative of fish that first enter the reservoir).

- As no fish are marked within the independent reservoir tributaries, the methodology does not specifically estimate collection efficiency of fish entering the reservoir from streams outside the upper North Fork Lewis River watershed, which spawning surveys have shown are regularly used by coho and steelhead. Some of the independent reservoir tributaries are much closer to the Swift FSC and may have higher contribution of fish that are subsequently collected at the Swift FSC compared to those from the upper NF Lewis River.

- The methodology does not estimate the number of salmonids <60mm that enter the reservoir, which annually comprise more than 50 percent of the total salmonid catch at the screw trap operated at Eagle Cliff Park.

Recommendations

- Assess and revise the methodology used to calculate the total number of juveniles that enter Swift Reservoir to account for reservoir hold-over rearing, so that the total number of each cohort entering the reservoir each year can be calculated. Use PIT tag mark-recapture data to assess age at length and length frequency analysis to determine age class length bins. Make annual estimates of the number of fish collected at the FSC by cohort (based on the age at length analysis and size class specific mark-recapture data). Update the individual cohort estimates annually as older fish from the same cohort are captured at the FSC. The actual estimation equations would remain the same, but would be applied to the individual cohort estimates.

- Conduct testing to determine if there is a significant difference in recapture probability between fish (of a similar size) marked and released at the Eagle Cliff screw trap (naïve fish) at the head of Swift Reservoir compared to fish marked at the Swift FSC then released at the head of Swift Reservoir (non-naïve fish). If no significant difference, use only Swift FSC PIT-tagged fish to measure reservoir survival. Initial review of mark-recapture data of both groups shows that there is little overlap in the size class distributions for coho, steelhead and Chinook between the locations from 2018 through 2020. Preliminary assessment of this data suggests that most fish enter the reservoir at a much smaller size than when they are captured at the FSC as outmigrants.

- If Swift FSC PIT-tagged fish are not representative of the reservoir survival of naïve fish entering the reservoir, assess potential effectiveness of combining tributary PIT-tagging of juvenile fish. Evaluate catch per unit effort of USGS Clear Creek electrofishing conducted in 2013, 2014 and 2015 to PIT tag salmonids (see Table 2.3). Design a two-year feasibility study to determine if electrofishing and seining in tributary reaches could be used to PIT tag substantially more fish for use in estimating the total number of fish that enter Swift Reservoir compared to screw trapping at Eagle Cliff.

- During the two-year feasibility study, operate the Eagle Cliff screw trap from approximately March 1 through October 31 each year to assess efficacy of screw trapping versus tributary sampling to PIT tag juvenile salmonids, and assess the Swift FSC recapture rates of each methodology. Assess if operating the screw trap longer also better informs the timing of when fish enter the reservoir.

- During the two-year feasibility study, focus on PIT tagging juvenile salmonids at the Swift FSC within the same size range as typically captured at the Eagle Cliff screw trap (to the extent available) in order to make a statistically valid comparison of the reservoir survival between the two marking locations (i.e., to compare reservoir survival between naïve and naïve fish of the same species/size class).

- Make sure that the length of all PIT-tagged fish recaptured at the Swift FSC subsample tanks are measured to length to aid in assessing length frequency age structure at the Swift FSC.

- During the two-year feasibility study, design a monthly index survey of reservoir transects using split beam hydroacoustics (or similar technology) to assess the timing, size distribution and density of fish within the reservoir. Determine if these parameters are related to screw trap and/or FSC captures. This information would be used to determine if index hydroacoustic surveys could be used to determine timing and relative abundance of juvenile salmonids entering the reservoir (parsed by species and size class distributions of fish observed at the FSC).

- If after the two-year feasibility study, tributary sampling proves ineffective, evaluate options to increase the number of trapping sites to increase the number of PIT-tagged fish.

Table 2.3 USGS Clear Creek electrofishing results to PIT tag juvenile salmonids and recaptures at the Swift FSC.

Year	Total Captured and PIT-Tagged by Electrofishing				Total Recaptured at the Swift FSC		
	# Marking Days	Coho	Cutthroat	Steelhead	Coho	Cutthroat	Steelhead
2013	16	355	26	51	1	0	0
2014	8	881	68	0	25	0	0
2015	8	746	25	3	65	0	0
2016	0	0	0	0	164	3	0
2017	0	0	0	0	4	1	0
Total	32	1982	119	54	259	4	0

Note: USGS electrofishing was comprised of one (three person) backpack electrofishing crew.

OBJECTIVE 8.0

Description

Develop index of juvenile migration timing.

FERC License/Settlement Agreement Guidance/Specification

9.2.1 Monitoring and Evaluation of Upstream and Downstream Passage Facilities. *PacifiCorp, with respect to…Swift No. 1…, shall include in the M&E Plan the following monitoring and evaluation elements…for Chinook, steelhead, coho, bull trout, and sea-run cutthroat:*

a. Juvenile migration timing and the estimated number of juveniles entering Swift Reservoir.

2017 M&E Plan Methods

In the 2017 M&E Plan, the ACC determined that although this was specifically called for in the Settlement Agreement, this metric is covered under Objective 6 and does not need to be duplicated.

Relationship to Other Objectives

An index of juvenile migration timing is also related to:

- Objective 7.1 – Estimate the timing and number of juvenile salmonids entering Swift Reservoir from the Upper North Fork Lewis River subbasin.

2016 to 2020 Results Summary

See table 2.1 under Objective 7.1.

Methodology Effectiveness at Meeting Objective Intent

While the FERC license and Settlement Agreement stipulate determining the juvenile migration timing, there is no mention of an "index" of juvenile migration timing. Migration timing is determined annually based on captures at the Eagle Cliff screw trap at the upstream end of Swift Reservoir and at the Swift FSC. The issues with determining timing of fish entering the reservoir are the same as described under Objectives 7.1 and 7.2.

Recommendations

- Determine timing of fish entering Swift Reservoir as recommended under Objective 7.2

3.0 Evaluation of Objectives Related to Overall Downstream Collection and Survival

Objective 1

Description

Estimate Overall Downstream Survival (ODS) for coho, spring Chinook, steelhead and sea-run cutthroat (currently for fish that originate upstream of Swift Dam).

FERC License/Settlement Agreement Guidance/Specification

ODS is defined as the percentage of juvenile anadromous fish of each transport species that enter the reservoirs from natal streams and that survive to enter the Lewis River downstream of Merwin Dam by collection, transport, and release via the juvenile fish passage system, passage via turbines, or some combination thereof, calculated as provided in Schedule 4.1.4 of the Settlement Agreement.

2017 M&E Plan Methods

ODS for juvenile coho, spring Chinook, steelhead and sea-run cutthroat trout is currently calculated using PIT tag mark-recapture methods over an area that extends from the head of Swift Reservoir to the exit of the Woodland Release Ponds located downstream of Merwin Dam. The parameters used to estimate ODS include S1, which is the joint probability of reservoir survival (S_{RES}) and probability of collection (P_{COL}); collection survival at the Swift FSC (S_{COL}), and transport survival (S_{TRAN}). These proportions are multiplied to estimate ODS for each species.

Relationship to Other Objectives

Determining collection survival and transport survival to make the overall ODS estimate is also related to:

- Objective 4 – Quantify juvenile and adult collection survival (which also includes quantifying transport survival)
- Objective 7.2 – Estimate the number of juveniles entering Swift Reservoir

2016 to 2020 Results Summary

Table 3.1 ODS results from 2016 through 2020.

Year	S_{RES} (%)	S_{COL} (%)	S_{TRAN} (%)	Estimated ODS (%)	95% CI	CV
Coho						
2016	NR	NR	NR	33.0	3.5	5%
2017	NR	NR	NR	18.0	3.4	10%
2018	NR	NR	NR	27.0	2.7	5%
2019	45.0	99.3	94.7	42.3	3.0	4%
2020	20.6	96.5	98.2	19.6	2.1	5%
Chinook						
2016	NR	NR	NR	0.0	0.0	NA
2017	NR	NR	NR	13.0	3.0	12%
2018	NR	NR	NR	23.3	4.1	9%
2019	25.0	99.1	98.6	24.4	5.7	12%
2020	18.5	95.5	93.7	16.6	5.5	17%
Steelhead						
2016	NR	NR	NR	15.0	7.8	27%
2017	NR	NR	NR	10.0	3.6	18%
2018	NR	NR	NR	43.5	4.6	5%
2019	8.2	99.8	100.0	8.2	3.2	20%
2020	11.1	96.7	96.3	10.3	3.3	16%
Cutthroat						
2016	NR	NR	NR	19.0	7.8	21%

Year	S_{RES} (%)	S_{COL} (%)	S_{TRAN} (%)	Estimated ODS (%)	95% CI	CV
2017	NR	NR	NR	5.4	5.9	56%
2018	NR	NR	NR	4.5	8.6	98%
2019	7.8	97.7	100.0	7.6	7.4	50%
2020	6.8	98.1	100.0	6.7	6.4	49%

Note: NR = not reported. Only ODS was reported before the release ponds were operational in 2019 (which are necessary to calculate S_{TRAN}). Therefore, the ODS value for 2016 through 2018 is more accurately defined as the joint probability of S_{RES} and S_{COL}.

Methodology Effectiveness at Meeting Objective Intent

Overall, the ODS estimation method results in CVs below the VSP guidelines of 15 percent for coho and Chinook and 30 percent for steelhead (Crawford and Rumsey 2011), though sample size limits the precision of the estimate for cutthroat. The methods for collection survival work well and need no improvement as they are based on a subsample of fish of all size classes. Transport survival is currently only estimated for fish that are PIT-tagged and does not include fish too small to PIT tag (i.e., <60mm in fork length). The S1 parameter is measured using both fish tagged at the screw trap at the head of Swift Reservoir and at the Swift FSC; as discussed above, these two tag groups may have significantly different recapture rates. In addition, all fish recaptured are combined across cohorts, and fish may hold-over and rear in the reservoir for a year or more after being release and subsequently recaptured at the Swift FSC. Therefore, the ODS calculation are currently iterative and is updated as fish from one year's release (across cohorts) are recaptured in subsequent years.

Recommendations

- See Objective 7.2 recommendations regarding the need to evaluate the difference in recapture probability between trap-naïve (screw trap fish) and trap non-naïve (Swift FSC fish) release groups and sample sizes.

- Estimate ODS by length class (age class) to the extent possible (determine length at age as described under Objective 7.2).

- Review the 95 percent confidence interval calculations for each of the components of ODS to ensure the methods are statistically valid.

OBJECTIVE 2

Description

Estimate Swift FSC collection efficiency, currently for Chinook, coho, and steelhead.

FERC License/Settlement Agreement Guidance/Specification

9.2.1 Monitoring and Evaluation of Upstream and Downstream Passage Facilities*. PacifiCorp, with respect to…Swift No. 1…, shall include in the M&E Plan*

> *the following monitoring and evaluation elements…for Chinook, steelhead, coho, bull trout, and sea-run cutthroat:*
>
> *c. Collection Efficiency and Collection Survival for each downstream fish passage facility.*
>
> *Collection efficiency is defined as the percentage of juvenile anadromous fish of each of the species designated in Section 4.1.7 that are available for collection and that are actually collected.*

2017 M&E Plan Methods

Collection efficiency at the Swift FSC is currently measured using fish tagged with biotelemetry tags (radio or acoustic) that are released at the head of Swift Reservoir. Tagged fish that subsequently enter the Zone of Influence (ZOI) near the entrance of the Swift FSC are considered “available for collection”. The proportion of those fish that are subsequently captured in the Swift FSC are then used to calculate collection efficiency and other associated passage metrics.

Relationship to Other Objectives

Determining collection survival and transport survival is also related to:

- Objective 1 – Collection efficiency is embedded within the S1 metric to calculate ODS (which combines actual survival to the Swift FSC and collection efficiency).

2016 to 2020 Results Summary

Table 3.2 Summary of results from Swift FSC collection efficiency studies (2013-2020).

Study Attributes						Detection Numbers (Total)			Detection Estimates (Total)[1]			
Year	Study Type	Capture Location	Release Location	Species	Release Numbers	Detected Forebay	Detected ZOI	Captured at FSC	P_{ZOI} Estimate	P_{ENT} Estimate	P_{RET} Estimate	P_{CE} Estimate
2013	Radio Telemetry	FSC	<3.1 miles east of FSC	Chinook Salmon	58	NA	46	0	79%	NA	NA	0%
				Coho Salmon	82	NA	44	6	54%	NA	NA	6%
				Steelhead	NA	NA	NA	NA	NA	NA	NA	NA
2014	Radio Telemetry	FSC	2 miles east of FSC	Chinook Salmon	20	NA	3	0	15%	NA	NA	0%
				Coho Salmon	157	NA	31	9	20%	NA	NA	29%
				Steelhead	16	NA	4	1	25%	NA	NA	25%
2015	Dual PIT/ Acoustic Telemetry	Eagle Cliff Rotary Screw Trap/Hook and Line	Swift Forest Camp Boat Launch	Chinook Salmon	14	9	6	0	28%	NA	NA	0%
				Coho Salmon	139	126	110	13	72%	NA	NA	12%
				Steelhead	47	43	43	8	84%	NA	NA	19%
2016	Dual PIT/ Acoustic Telemetry	FSC and Eagle Cliff Rotary Screw Trap	Swift Forest Camp Boat Launch	Chinook Salmon	3	1	1	0	11%	NA	NA	0%
				Coho Salmon	156	140	98	30	56%	NA	NA	31%
				Steelhead	40	28	17	4	30%	NA	NA	24%
2017	Dual PIT/ Acoustic Telemetry	FSC	Swift Forest Camp Boat Launch	Chinook Salmon	108	75	62	7	57%	47%	24 %	11%
				Coho Salmon	232	184	164	46	74%	65%	41%	27%
				Steelhead	180	117	107	21	59%	48.6	40%	20%
2018	PIT	FSC	Swift Forest Camp Boat Launch	Chinook Salmon	396	--	--	94	--	NA	NA	24%[2]
				Coho Salmon	484	--	--	191	--	NA	NA	40%[2]
				Steelhead	278	--	--	136	--	NA	NA	49%[2]
2019	Dual PIT/Acoustic Telemetry	FSC	Swift Forest Camp Boat Launch	Chinook Salmon	155	88	75	42	54%	78%	65%	51%
				Coho Salmon	300	175	167	156	82%	98%	65%	64%
				Steelhead	70	40	37	11	58%	97%	28%	27%
2020	Dual PIT/Acoustic Telemetry	FSC	Swift Forest Camp Boat Launch	Chinook Salmon	183	--	104	47	58%	95%	47%	44%
				Coho Salmon	185	--	112	45	62%	95%	42%	39%
				Steelhead	153	--	110	47	73%	99%	42%	42%

Notes:
Source: Courter et al. 2013; Stroud et al. 2014; Reynolds et al. 2015; Caldwell et al. 2017; Anchor QEA 2018; PacifiCorp and Cowlitz County PUD 2019; Four Peaks 2020
1. For 2013 through 2017, seasonal performance metrics have been corrected for array detection efficiency.
2. In 2018, survival probability through reservoir (SRES) was used as a surrogate for collection efficiency.
-- = not calculated
NA = not applicable

Methodology Effectiveness at Meeting Objective Intent

The methods accurately estimate collection efficiency, and CVs for Chinook, coho, and steelhead are generally below 15 percent. However, previous studies have used fish captured at the Swift FSC as test fish that are then tagged and released upstream. Similar to the recommendation for Objective 7, there may be differences in collection efficiency for trap-naïve versus trap non-naïve test fish. Earlier attempts to capture enough fish of each species large enough to tag that are actively migrating have failed.

Recommendations

- Review sample size requirement assumptions.
- Assess the naïve vs non-naïve testing of PIT-tagged fish under Objective 1 to assess potential for bias.

OBJECTIVE 4

Description

Quantify juvenile and adult collection survival (estimate fish collection and transport survival rates for fish migrating downstream).

FERC License/Settlement Agreement Guidance/Specification

Collection survival is defined as the percentage of juvenile anadromous fish of each of the species to be transported that enter the reservoirs from natal streams and that survive to enter the Lewis River downstream of Merwin Dam by collection, transport, and release via the juvenile fish passage system, passage via turbines, or some combination thereof. ,

2017 M&E Plan Methods

Collection survival is based on physically enumerating and evaluating a subsample of fish of all size classes collected at the Swift FSC. Transport survival is currently assessed using PIT-tagged fish for coho, spring Chinook, steelhead and sea-run cutthroat trout.

Relationship to Other Objectives

Determining collection survival and transport survival is also related to:

- Objective 1 – Estimate ODS for anadromous fish species.

2016 to 2020 Results Summary

Collection survival rates for out-migrants collected at the Swift FSC have varied annually since the facility was brought online in 2013. In the years immediately following commissioning, annual estimates of collection survival were consistently lower than the performance goal, which was attributed largely to heavy debris accumulation on the sorting bars and in fish holding tanks. Over the years, collection survival has improved in large measure to the number of modifications designed to improve debris management and reduce mortality of out-migrants. Transport survival has only been calculated since the release ponds became operational in 2019. Therefore, no retrospective data summary of transport survival is available. Estimates of S_{COL} and S_{TRANS} of juvenile salmonids transported downstream since 2016 is provided in Table 3.1.

Methodology Effectiveness at Meeting Objective Intent

The methods for evaluating collection survival work well and need no improvement as they are based on a subsample of fish of all size classes. Transport survival is currently only estimated for fish that are PIT-tagged and does not include fish too small to PIT tag (i.e., <60mm in length). However, fry were originally intended to be returned to the reservoir and not transported downstream.

Recommendations

- Estimate survival by size class (age class) to the extent possible.

OBJECTIVE 6

Description

Quantify the number of juvenile and adult fish collected at the Swift FSC by species using Swift FSC subsampling.

FERC License/Settlement Agreement Guidance/Specification

> ***9.2.1 Monitoring and Evaluation of Upstream and Downstream Passage Facilities.*** *PacifiCorp, with respect to…Swift No. 1…, shall include in the M&E Plan the following monitoring and evaluation elements…for Chinook, steelhead, coho, bull trout, and sea-run cutthroat:*
>
> *j. The number, by species, of juvenile and adult fish being collected at the Projects.*

2017 M&E Plan Methods

The total number of fish collected at the Swift FSC is determined by directing fish into subsampling tanks for physical enumeration. Subsampling rate is based on the amount of time fish are directed into subsampling tanks by automated gates and expanded based on the total amount of time the Swift FSC is operated within a discrete time interval.

Relationship to Other Objectives

Determining the number of fish that are collected at the Swift FSC is also used for the following objectives:

- Objective 7.2 – Estimate the number of juveniles entering Swift Reservoir
- Objective 8 – Develop index of juvenile migration timing

2016 to 2020 Results Summary

Table 3.3 Estimated annual totals of salmonids transported downstream from the Swift FSC (2016-2020).

Year	Coho	Chinook	Steelhead	Cutthroat	Bull Trout	Hatchery Rainbow Trout	Total
2016	60,976	3,793	2267	1,101	0	1,713	68,175
2017	28,098	5,801	1,825	804	0	444	36,972
2018	41,721	4,680	7,913	876	0	146	55,336
2019	96,817	10,886	3,059	940	0	2,992	111,702
2020	30,953	15,377	4,363	503	0	1,041	51,196

Methodology Effectiveness at Meeting Objective Intent

The methodology works well and the resulting estimates have relatively low CV values that are within VSP guidelines, except for cutthroat trout, which do not meet VSP guidelines due to small sample size. However, it is possible that the subsampling strategy may not be representative of the total number of fish that enter the FSC if the fish enter in large numbers very quickly (i.e., are not more evenly distributed within the subsampling time intervals). There is also some concern regarding how accurate the subsampling strategy is for estimating the total number of less abundant species, such as bull trout and cutthroat.

Recommendations

- The total number of fish collected at the Swift FSC is currently reported as fry, parr, smolt and adults. We recommend estimating the total number of fish collected by size class (age class) to assign fish to cohorts (brood years) to align with recommendations made for Objective 7.2.

- To better quantify the estimation error rate of the subsample methodology, we recommend conducting periodic validation testing of the assumed subsampling rate (i.e., operating in a subsampling mode, but actually enumerating all of the fish that enter the Swift FSC). Testing should be done during periods with relatively low and high numbers of fish entering the Swift FSC, and across a range of subsampling rates typically used, primarily 10 percent.

4.0 Evaluation of Objectives Related to Adult Passage and Spawning

Objective 9

Description

Quantify adult upstream passage survival (UPS).

FERC License/Settlement Agreement Guidance/Specification

4.1.4(b): …The Licensees…shall design and construct upstream fish passage facilities to achieve the UPS equal to or greater than 99.5 percent.

2017 M&E Plan Methods

UPS for adult fish being transported upstream is measured through the direct enumeration of adult fish collected at the Merwin Fish Capture and Transport Facility (MFCF) or the Lewis River Hatchery, and released upstream of Swift Dam (currently at Eagle Cliff Park or Swift Forest Camp Boat Launch). Any dead fish recovered at the trap or release site(s) are identified to species and examined for signs of physical injury, to the extent possible.

Relationship to Other Objectives

Determining the number of adult fish that are released upstream of Swift Dam alive is also related to:

- Objective 15 – Determine spawner abundance, timing and distribution of transported anadromous adults

2016 to 2020 Results Summary

Table 4.1 Merwin adult upstream passage survival from 2016 through 2020.

Species/Run	2016	2017	2018	2019	2020
Early Coho	99.6	99.6	99.8	99.7	98.8
Late Coho	99.9	99.9	99.8	99.9	99.9
Spring Chinook	Not Transported	99.2	98.4	94.5	99.8
Winter Steelhead	99.9	99.8	100	99.8	99.9
Coastal Cutthroat	100	100	100	100	100
Total	99.7	99.6	99.7	99.7	99.1

Methodology Effectiveness at Meeting Objective Intent

Overall, the methodology works well for determining upstream passage survival. Very rarely are there any transport-related issues. However, survival within the MFCF needs to be better tracked and related to survival of fish destined for transport and release upstream. Many fish captured at the MFCF are not destined for upstream transport, and any mortalities of fish that are not destined for upstream transport should not be included in the UPS calculation. However, all mortalities need to be tracked (even if they are excluded from the UPS calculation).

Recommendations

- Implement a more detailed recording of MFCF adult mortalities so that mortality of fish not destined for upstream transport is not included in the UPS calculation, though all mortalities should be recorded and reported.

OBJECTIVE 10

Description

Quantify adult trap efficiency at each upstream fish transport facility (emphasizes analysis of the Merwin adult trapping facility until upstream passage is expanded to Yale and Swift).

FERC License/Settlement Agreement Guidance/Specification

Adult trap efficiency (ATE) is defined in Table 4.1.4 of the License as:

> *The percentage of adult Chinook, coho, steelhead, bull trout and sea-run cutthroat that are actively migrating to a location above the trap and that are collected by the trap.*

The License calls for the licensees to consult with the resource agencies and the ACC to develop such a standard as soon as practicable. This effort was completed in 2008 and the ACC selected 98 percent as the target ATE value for each species.

2017 M&E Plan Methods

Currently, the ATE standard is only applicable to spring Chinook, coho and steelhead. Mark-recapture of radio tagged adults is currently used to estimate adult collection efficiency. The original methodology called for all fish to be collected and tagged at the MFCF, and then released back downstream to be assess collection efficiency and associated passage behavior. However, it was apparent from these early studies that test fish that had already passed through the collection system had altered behavior during their second attempt. Therefore, the original study methodologies were modified to also include test fish that were collected, tagged and released downstream of Merwin Dam. The results of this work indicated that there were differences in passage metrics between the two groups (trap-naïve vs. trap non-naïve fish), and that it was agreed that trap-naïve fish were the more appropriate group for evaluating adult trap efficiency.

Relationship to Other Objectives

Determining the ATE of the MFCF is not related to any other M&E objectives.

2016 to 2020 Results Summary

Table 4.2 Merwin adult trap collection efficiency from 2016 through 2019.

Species/Run	2016	2017	2018	2019
Steelhead				
Collection Efficiency (PCE)	73% (65% - 80%)	77% (70% - 84%)	93% (85-97%)	84% (76-90%)
Trap Non-Naïve			91% (83-96%)	85% (81-93%)
Trap Naïve	NA	NA	100% (84-100%)	95% (87-99%)
Coho				
Collection Efficiency (PCE)	Not Tested	63% (50%-74%)	68% (48-83%)	Not Tested
Trap Non-Naïve			70% (49-84%)	
Trap Naïve		NA	50% (NA)	

Note: Not measured in 2020

Methodology Effectiveness at Meeting Objective Intent

Overall, the methodologies originally outlined work well for NOR coho and spring Chinook. However, measuring ATE may be more problematic for winter steelhead due to their life history and migration strategy that can result in fish milling around the river system for months before eventually migrating to their spawning stream of choice. False passage attempts for winter steelhead may need to be addressed. The decision to use fish collected and tagged before entering the Merwin Dam tailrace (trap-naïve) has improved the original study design, however by going with this methodology, it may be more difficult to acquire enough test fish to meet sample size needs.

Recommendations

- Continue to use trap-naïve fish to the extent possible.
- Revisit the definition of what constitutes an “upstream bound” fish to account for the variability of fish life history and behavior of fish that may have extended natural residence times and movement variability in the North Fork Lewis River watershed downstream of Merwin Dam prior to spawning (such as steelhead).

OBJECTIVE 15.1

Description

Determine spawner abundance, timing and distribution of transported spring Chinook and coho.

FERC License/Settlement Agreement Guidance/Specification

> *The Licensees shall identify the spawning timing, distribution, and abundance for Transported Anadromous Species passed upstream by monitoring a statistically valid sample of each stock. The primary purpose is to identify preferred spawning areas in order to (i) inform revisions to the Hatchery and Supplementation Plan and the Upstream Transport Plan and (ii) inform the decisions of the ACC in determining how to expend funds from the Aquatics Fund, but such identification shall not otherwise create or increase obligations of the Licensees except as expressly set forth in this Agreement.*

2017 M&E Plan Methods

For adult coho and spring Chinook, this objective is being addressed by conducting annual spawning surveys in a random-stratified and spatially balanced set of discrete (0.3-mile-long) reaches located throughout the accessible stream network upstream of Swift Dam. Currently, coho surveys are conducted weekly from October through December each year. When a sufficient number of spring Chinook are transported upstream, their surveys are conducted in September and October. Each year approximately one third of the study reaches are surveyed. Total redds are then estimated based on the subsampling design. The number of spawning females is then estimated based on the total redd estimate assuming 1 redd per female. The estimated number of spawning females is then compared to the total number of females transported upstream to determine “spawner abundance”, or the estimated proportion of adult female salmon transported upstream that spawned.

Relationship to Other Objectives

Determining spawner abundance, timing and distribution of transported anadromous fish is not related to any other M&E objectives.

2016 to 2020 Results Summary

Spawning surveys conducted over the previous monitoring period have shown that early-coho spawn primarily from October to early November, and late-coho spawn from November into January. During years when sufficient numbers of spring Chinook have been transported upstream and surveys have been conducted, they have been found to consistently spawn throughout September into early October. Spawner abundance (the proportion of transported adult females estimated to have spawned) is recorded annually (Table 4.3). In addition to spawner abundance, the number of redds estimated by major subwatershed strata (i.e., spawning distribution) is also summarized for coho (Table 4.4).

Since 2016, spring Chinook-specific spawning surveys in September (the primary spawning time) were only conducted in 2017 and 2018. The total number of adult female spring Chinook transported upstream of Swift Dam to spawn in 2016, 2017, 2018, 2019, and 2020 was 0, 430, 177, 12, and 56 (respectively). Spring Chinook have been shown to primarily spawn in the mainstem North Fork Lewis River and Muddy River watersheds, and sporadically in Drift Creek (Swift Reservoir tributary). No Chinook have been documented in the Pine Creek watershed to date.

Table 4.3 Estimated proportion of adult female salmon transported upstream that spawned (i.e., spawner abundance).

Year	Estimated Proportion of Female Coho Transported Upstream that Spawned[b]	95% Confidence Interval	Estimated Proportion of Female Chinook Transported Upstream that Spawned[b]	95% Confidence Interval
2020	1.26	0.75 to 1.96	No survey	NA
2019	0.54	0.26 to 0.91	1.90 (survey only in October)	0.86 to 2.91
2018	0.61	0.33 to 0.98	2.17	0.29 to 4.16
2017	0.34[a]	0.20 to 0.54	1.03	0.56 to 1.50
2016	0.69	0.25 to 1.20	none transported upstream	NA

[a]Note: Likely substantially underestimated due to survey limitations in areas known to be heavily used by coho for spawning in November and December. North Fork Lewis River mainstem surveys were limited due to high flows, and Swift Reservoir tributary surveys were limited due to low reservoir conditions, which precluded boat access. Closed gates limited access to the upper Muddy River watershed. Very high flow events likely scoured redds between surveys in October and November.

[b]Note: Proportions of successful female spawners of 1.0 (or greater) suggest that all transported females spawned (assuming one redd per female). Proportions substantially greater than 1.0 indicate that actual detection probabilities are higher than assumed and/or that female salmon may build more than one redd on average. It is also possible that some salmon may residualize in Swift Reservoir to adulthood to spawn, which could also contribute to proportions greater than 1.0 (i.e., if the actual number of females spawners is greater than the number of transported anadromous females).

Table 4.4 Spawning distribution of adult coho transported upstream.

Subwatershed Strata	2020 Total Redd Estimate (% total) 95% CI	2019 Total Redd Estimate (% total) 95% CI	2018 Total Redd Estimate (% total) 95% CI	2017 Total Redd Estimate (% total) 95% CI	2016 Total Redd Estimate (% total) 95% CI
Muddy River Watershed	3,240 (53%) 1,526 to 5,45	387 (30%) 183 to 662	40 (8%) 11 to 79	336 (29%) 116 to 622	61 (6%) 39 to 83
North Fork Lewis River Watershed	2,163 (35%) 1,145 to 3,542	558 (44%) 59 to 1,180	246 (51%) 130 to 402	465 (39%) 175 to 846	316 (31%) 118 to 515
Pine Creek Watershed	29[b] (1%) 0 to 71	86 (7%) 0 to 190	55 (11%) 8 to 114	37 (3%) 6 to 72	178 (17%) 0 to 367
Swift Reservoir Watershed	696 (11%) 249 to 1,301	249 (19%) 83 to 453	138 (29%) 11 to 284	339 (29%) 190 to 534	466 (46%) 241 to 691
Grand Total	6,128 3,662 to 9,515	1,280 607 to 2,171	479 260 to 774	1,178 702 to 1,886	1,022 667 to 1,377
Total Female Coho[c]	4,865	2,368	2,452	3,281	3,311

[b]Does not include 48 Coho redds counted in Pine Creek during Bull Trout surveys (outside reaches scheduled for 2020 surveys).
[c]Total adult female Coho transported upstream of Swift Dam that could have potentially been observed during the survey period.

Methodology Effectiveness at Meeting Objective Intent

Overall, the methods in the existing M&E Plan work well for early-coho and spring Chinook. Stream flows are generally low and clear in September and October, which are very conducive for early-coho and spring Chinook redd detection. However, the methods do not work well for late-coho, which typically spawn from November through January, when stream flows can be higher and more turbid (Note - In some years, high water events occurring earlier in the fall have also impacted redd detection for early-coho spawning in October as well). In addition, snow and/or seasonally closed gates can hinder access for surveys occurring beyond October. The observed fluctuation in spawning success appears to be as much related to variability in redd detection probability from year to year (as a function of stream flow and access) as to actual issues with spawning success. Overall, spawning surveys have determined the spawn timing and distribution patterns for coho sufficiently to meet the goals of the M&E Plan. However, due to low returns, there is less information regarding spring Chinook spawn timing, distribution, and abundance upstream of Swift Dam.

Recommendations

- Assess the potential efficacy of genetic testing of juveniles collected at the FSC to determine the number of successful adult (coho and spring Chinook) spawners (i.e., the number of adults that successfully spawned to produce the progeny collected at the Swift FSC). See section 6.0 for further information.

- Assess the potential to use eDNA tributary sampling to determine the distribution and relative density of spawning and rearing in the streams accessible to coho and spring Chinook upstream of Swift Dam. See section 6.0 for further information.

- Continue to conduct annual spring Chinook spawning surveys when a sufficient number of females are transported upstream (e.g., at least 100 females) to allow for redd detection.

- Reduce the frequency of coho redd surveys to once every three years to determine any significant shifts in spawner distribution over time and to validate eDNA sampling results.

OBJECTIVE 15.2

Description

Determine spawner abundance, timing and distribution of transported winter steelhead.

FERC License/Settlement Agreement Guidance/Specification

Same as described for Objective 15.2.

2017 M&E Plan Methods

Surveys in the North Fork Lewis River upstream of Swift Reservoir have been conducted in some years through aerial radio telemetry tracking. Aerial radio tracking and redd surveys by foot in index reaches have been employed in reservoir tributaries.

Relationship to Other Objectives

Determining spawner abundance, timing and distribution of transported anadromous fish is not related to any other M&E objectives.

2016 to 2020 Results Summary

Steelhead spawning has primarily been documented in May, but has ranged from April into June.

Table 4.5 Summary of winter steelhead redd counts in select index reaches of tributaries to Swift Reservoir.

Survey Date (2020)	Swift Creek	Diamond Creek	Range Creek	Drift Creek	S10 Creek	S15 Creek	S20 Creek	Total Redds
2016	No redd surveys conducted? Not reported in annual report							
2017	Not reported in annual report							
2018	No redd surveys conducted							
2019	No redd surveys conducted							
2020	10	2	4	11	1	4	1	33

Methodology Effectiveness at Meeting Objective Intent

Radio telemetry surveys of adult winter steelhead ascending into the upper basin have had limited success. The fixed receiver station located at Eagle Cliff Park has been successful in detecting fish passage in and out of the reservoir. However, the periodic aerial surveys have been shown to only provide a snapshot of fish locations at any given time, and have limited utility in determining spawner distribution in the upper basin. Redd surveys along portions of the reservoir tributaries have provided information on general spawn timing and distribution of winter steelhead in those locations.

Recommendations

- Continue winter steelhead redd surveys in reservoir tributaries and evaluate whether the approximate 0.25 mile index reaches are representative of the accessible habitat within the reservoir tributaries as a whole, and extend or relocate as necessary.

- Establish a series of fixed monitoring stations at strategic locations in the lower portion of the upper basin to determine when radio tagged steelhead enter and exit major drainages within the North Fork Lewis River upstream of Swift Reservoir (e.g., Pine Creek, Muddy River, and upper North Fork Lewis River upstream of Muddy River) to better assess major distribution patterns.

- Discontinue aerial radio telemetry surveys due to safety concerns.

- Assess the potential efficacy of genetic testing of juveniles collected at the FSC (same as recommended for coho and Chinook under Objective 15.1) to determine spawner abundance (i.e., the number of adults that successfully spawned to produce the progeny collected at the FSC). See section 6.0 for further information.

- Assess the potential to use eDNA tributary sampling to determine the distribution and relative density of spawning and rearing in the streams accessible to steelhead upstream of Swift Dam. See section 6.0 for further information.

5.0 EVALUATION OF OBJECTIVES RELATED TO OCEAN RECRUITS

OBJECTIVE 12

Description

Determine when the hatchery- and natural-origin adult production targets identified in the Settlement Agreement are achieved. These targets are referred to as “ocean recruits”.

FERC License/Settlement Agreement Guidance/Specification

Ocean recruits are defined in Section 8.1 of the Settlement Agreement as:

"… total escapement (fish that naturally spawned above Merwin and hatchery fish) plus harvest (including ocean, Columbia River, and Lewis River Harvest)."

8.3 Anadromous Fish Hatchery Adult Ocean Recruit Target by Species. The Licensees shall develop and implement the Hatchery and Supplementation Plan to achieve hatchery adult Chinook, Steelhead, and coho ocean recruit targets ("Hatchery Targets") as described below.

8.3.1 Hatchery Targets. The following Hatchery Targets shall be in effect at the commencement of the Hatchery and Supplementation Program, Hatchery Produced Adults (Ocean Recruits):

- *Spring Chinook = 12,800*
- *Steelhead = 13,200*
- *Coho = 60,000*

8.3.2.3 Reductions in Hatchery Targets. When the number of Ocean Recruits from natural spawning grounds of any species exceeds the relevant natural production threshold(s) for that species, the Licensees shall decrease the appropriate Hatchery Targets on a 1:1 basis, Naturally Production Threshold (Ocean Recruits) for Hatchery Reduction:

- *Spring Chinook = 2,977*
- *Steelhead = 3,070*
- *Coho = 13,953*

2017 M&E Plan Methods

The plan describes two primary methods for estimating Ocean Recruits:

1. Return year recruitment – adults that were harvested or returned to Merwin Dam or the hatchery in a given year. Requires information on total adult returns (NORs and HORs); harvest rates in the ocean, mainstem Columbia River, and Lewis River; and mark-selective fishery impacts. This is the simplest method of estimating Ocean Recruits.

2. Brood year recruitment – adults produced from a given brood year. In addition to the information required for the return year method, this method requires information on age structure of adult returns (e.g., based on tagging data or scale samples from unmarked fish).

The current M&E Plan describes two approaches for estimating brood year recruitment – 1) accounting for adult equivalents (AE), an estimate of the number of adults that would have returned in the absence of fishing, or 2) the fishery plus escapement method, an estimate of the number of fish that either escaped or were harvested (including hooking mortality). The AE method requires assumptions about age-specific natural mortality rates in the ocean. WDFW recommended using the fishery plus escapement method; the M&E Plan subgroup generally agreed with this approach (PacifiCorp and Cowlitz PUD 2017). It also more closely aligns with the definition of Ocean Recruits in the Settlement Agreement (8.1).

The Plan also briefly describes the migration year recruitment method and the age-3 recruitment method. All methods rely on information provided by Double Index Tag (DIT) groups to estimate the mortality associated with mark-selective fisheries.

Relationship to Other Objectives

Developing estimates of ocean recruits is also related to:

- Objective 4 – Quantify juvenile and adult collection survival
- Objective 6 – Quantify the number, by species, of juvenile and adult fish collected at the Swift FSC
- Objective 9 – Quantify adult upstream passage survival
- Objective 11 – Quantify the number, by species, of adult fish collected at the projects
- Objective 13 – Develop performance measures for index stocks.

2016 to 2020 Results Summary

Has not been conducted to date due to low numbers of returning NOR adults originating from upstream of Swift Dam.

Methodology Effectiveness at Meeting Objective Intent

Ocean recruit analysis has not been conducted for several reasons:

- The DIT program did not work as intended because creel surveys did not consistently scan ad-present fish for the presence of coded-wire tags. DITs were intended to estimate the mortality associated with mark-selective fisheries.
- Lack of creel data for the Lewis River fisheries.
- Low returns of NORs adults from supplementation effort upstream of Swift Dam.

Recommendations

- Revise and simplify the run reconstruction methods used to estimate adult ocean recruits. Select and focus on one method.
- The return-year and brood-year recruitment methods both provide reasonable estimates to assess whether natural and hatchery production targets have been met.

The brood-year method requires age structure data (based on CWTs or scale data collected from adult returns) in addition to harvest rate data.

- Data on pre-terminal harvest rates are available (ocean and Columbia River fisheries). The program needs to determine how terminal harvest information will be collected, or if information from other populations (e.g., Cowlitz) provides a reasonable estimate.

- If the DIT program is not providing data on harvest of NORs, the program needs to determine how mark-selective harvest information will be collected or if information is available from other populations that can be used as a surrogate.

Objective 13

Description

Develop performance measures of index stocks.

FERC License/Settlement Agreement Guidance/Specification

This objective is not stipulated in the FERC license or Settlement Agreement.

2017 M&E Plan Methods

The H&S Plan recommends that other Lower Columbia River stocks be used as index groups to determine whether the success or failure of the Lewis River reintroduction program is the result of in-basin or out-of-basin factors. This would be determined by comparing the survival rates of hatchery- and natural-origin fish produced in other basins (such as the Cowlitz River) with releases made in the Lewis River. Two metrics would be calculated to compare the performance of the Lewis River populations with other Lower Columbia River index stocks: 1) Recruits per spawner (R/S), and 2) Smolt-to-adult ratio (SAR).

Recruits per spawner is calculated using adult NOR returns to Merwin Dam and Lewis River Hatchery (recruits), the number of adults transported upstream (spawners), and age data or assumptions about age structure. The SAR for NORs is calculated using brood-year recruitment of NORs and the number of smolts transported downstream of Merwin Dam. The SAR for HORs is calculated using brood-year recruitment of HORs and the number of smolts released into the Lewis River. Assumptions about harvest rates may be used to calculate pre-harvest R/S and SARs.

Relationship to Other Objectives

- Objective 4 – Quantify juvenile and adult collection survival

- Objective 6 – Quantify the number, by species, of juvenile and adult fish collected at the Swift FSC

- Objective 9 – Quantify adult upstream passage survival

- Objective 11 – Quantify the number, by species, of adult fish collected at the projects
- Objective 12 – Develop estimates of ocean recruits

2016 to 2020 Results Summary

In the draft 2020 Annual Fish Passage Report, SARs and R/S were calculated for BY 2017 coho and BY 2016 late-winter steelhead. No results were calculated for spring Chinook due to low numbers of out-migrating smolts and adult returns.

SARs were relatively high for Upper Lewis River NORs (6 percent for coho and 5.8 percent for late-winter steelhead) as compared to Lewis River Hatchery HORs (0.8 percent for coho and 1.4 percent for late-winter steelhead), but recruits per spawner values for the upstream populations were below replacement for both coho (0.79) and late-winter steelhead (0.59).

Methodology Effectiveness at Meeting Objective Intent

- The intent of this objective is to estimate Lewis River survival metrics with CVs at or below the VSP guidelines of 15 percent for coho and Chinook and 30 percent for steelhead. The outlined methodology works well if there is a sufficient number of out-migrating smolts and returning adults.
- The limitations of these methods include: 1) assuming all adults transported upstream of Swift Dam are spawners (likely overestimation of spawners), 2) not accounting for NOR strays to the Lewis River (possible overestimation of recruits, or underestimation if Lewis River NORs stray in large numbers to other basins), 3) assumptions about the number of smolts produced, particularly when different sizes and ages are transported downstream, and 4) not accounting for all out-migrating juveniles (unknown number of juvenile migrants not trapped at the Swift FSC).
- As long as similar methods are used to estimate R/S and SARs for the Cowlitz and/or other index populations, these metrics provides a valid comparison to the index populations.

Recommendations

- Revise and simplify the methods for calculating NOR SARs and R/S.
- In addition to calculating SARs for hatchery-origin fish based on adult returns to the Lewis River, use coded-wire tag data to estimate SARs that account for all recoveries, including fish recovered at other hatcheries and harvested fish.
- Collect age structure data for NOR adults (e.g., scale samples).
- Increase number of PIT tagged NOR juveniles. Use PIT tag returns to calculate SARs and validate results using total adult NOR returns and juvenile outmigrants

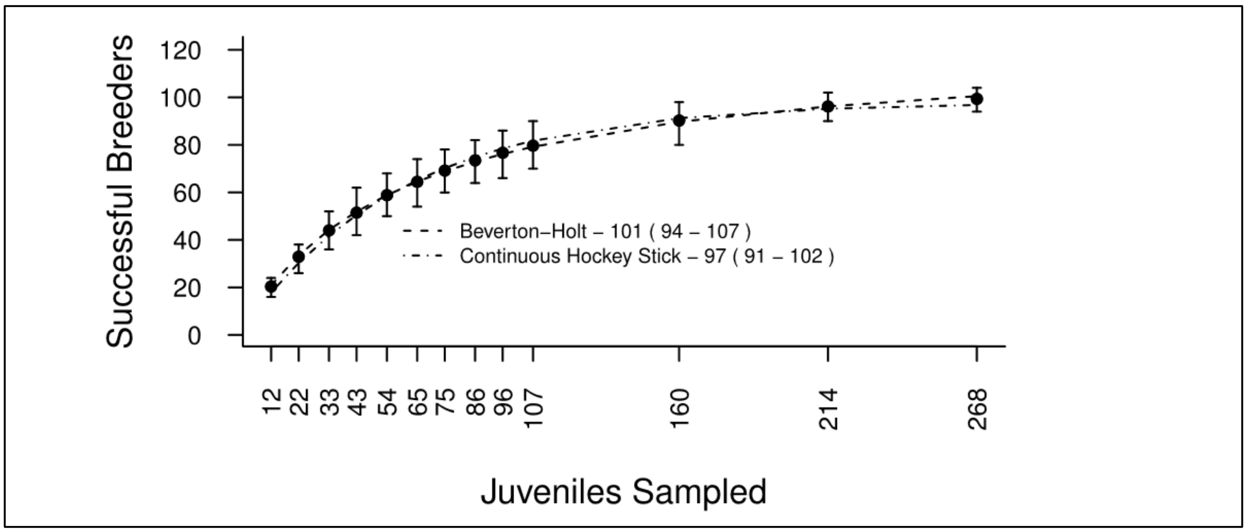
6.0 POTENTIAL EFFICACY OF GENETIC ASSESSMENT TO INFORM OBJECTIVES

The genetically effective population size (N_e) is arguably the most important eco-evolutionary metric in conservation biology, because unlike census size (N), e.g., escapement, it determines the rate at which a population evolves through natural selection (Waples 2006). Although the true ratio of N_e to N across populations varies considerably, it is conventionally assumed to be 0.20 in Pacific Salmon (Waples et al. 2004). N_e is affected by numerous factors, with variation in reproductive success playing a prominent role (Allendorf et al. 2013). Yet, ability to link indices of abundance, such as from redd counts, to actual spawner abundance and reproductive success is limited, because redds can be under- or over-counted (Dunham et al. 2001) and redd excavation rates (i.e., the number of spawners per redd) can vary widely across populations (Al-Chokhachy et al. 2005), years (Dauble and Watson 1997), and spawning densities. Redd counts provide no information on whether a particular spawner successfully produced offspring, which is necessary to determine whether a reintroduced population is genetically viable and self-sustaining (Araki et al. 2007). Understanding how reproductive success of reintroduced spawners is affected by management (e.g., handling and transport practices), ecology (e.g., spawning habitat), and spawner phenotype (e.g., HOR vs. NOR) can illuminate reintroduction practices that are more likely to achieve viability and self-sustainability.

Genetic pedigree analysis provides a powerful method for estimating the number of successful spawners, as opposed to simply indexing the number of spawners present during mating (Serbezov et al. 2010). Pedigree analysis is a well-established technique for measuring reproductive success and has been used extensively in fisheries management, including to document fitness differences between NOR and HOR salmonids (Araki et al. 2007), to estimate spawner escapement (Rawding et al. 2014), and to estimate the number of spawners that successfully produce offspring in a focal tributary (Whitlock et al. 2017). Although many different pedigree tools are available, they all apply the principles of Mendelian inheritance and specifically that each offspring contains one copy of an “allele,” or genetic variant, from each parent at all genetic markers analyzed (Manel et al. 2005). Nevertheless, samples collected from single juvenile cohorts can be used in the absence of any adult samples to estimate the number of successful spawners through a specific version of pedigree analysis called “sibship analysis” in which groups of siblings and half siblings are inferred via individual pairwise relatedness (Rawding et al. 2014). Specifically, full and half siblings are, on average, identical by descent at 50 percent and 25 percent of their genomes, respectively.

Upstream of Swift Dam, sibship analysis of juvenile samples could be used to monitor and evaluate the number of successful spawners at two key temporal and spatial scales: (1) within individual streams prior to outmigration and (2) watershed-wide during outmigration (i.e., by sampling at the Swift FSC). Inference at both scales is complementary because each provides distinct information about the overall success of reintroduction. For example, sampling within tributaries could support identification of specific tributaries or habitat units associated with reproductive success from the egg-to-fry life stage, whereas sampling at the FSC could provide a measure of the overall proportion of transported adult anadromous fish that successfully spawned and produced outmigrants.

In practice, the number of successful spawners is estimated by rarefaction using samples from young-of-the-year salmonids, or whichever cohort is of interest. This approach involves fitting the cumulative number of examined genotypes to the number of unique genotypes to estimate the asymptote of the curve, which is the population estimate of successful breeders (Rawding et al. 2014). For example, Cramer Fish Sciences demonstrated the utility of this technique to estimate the number of successful breeders that contributed to a small sample of juvenile coho salmon (n=107) collected from a section of Clear Creek in 2020, a Muddy River tributary upstream of Merwin Dam (Figure 6.1).



Note: Rarefaction-based estimate using the CKMR package in R suggests at least 97 (95% CI 91 to 102) parents are needed to explain the pattern of relatedness observed in the sample of 107 age-0 offspring from sampled in 2020 (i.e., brood year 2019).

Figure 6.1 Number of successful spawners (NS) needed to explain the number of juveniles sampled in Cedar Creek.

In addition to estimating the number of successful spawners, genetic tools can be used to describe the physical distribution of target species across the watershed through the application of environmental DNA (eDNA) surveys. eDNA is simply DNA that is isolated from environmental samples, such stream water, rather than directly from an organism. As collection of eDNA is noninvasive; biological information can be obtained without manipulating or handling organisms or disturbing their ecosystems. Well-designed eDNA surveys can be implemented with *a priori* estimates of probability of detection (PoD); are often substantially more sensitive at detecting organisms than conventional direct surveys; and can potentially be implemented faster and at a lower cost compared to direct surveys, such as snorkeling or redd counts (Schumer et al. 2019). Statistical modeling can be used to design eDNA sampling layouts that provide a 95 percent probability of detecting a single fish at 500 meters. Such statistical certainty in surveys is often challenging or impractical to estimate using direct fish observation methods, but is invaluable to sampling efforts because it allows more informed pronouncements of absence. eDNA surveys can be designed to increase likelihood that eDNA signal strength reflects specific life stages, for example, by sampling during the spawning or rearing season (Bracken et al. 2018). Cramer Fish Sciences is also currently testing the ability to determine relative distribution of biomass based on the eDNA signal strength (Bingham et al. in prep.).

7.0 EVALUATION SUMMARY

Overall, upstream and downstream passage monitoring and evaluation methods have been fairly effective at meeting M&E Plan objectives. However, there is a general need to increase the sample size of marked fish used to determine downstream fish passage and to refined assessments based on cohort representation rather than total migrants collected. It will also be important to assess whether potential trap-naïve vs. trap non-naïve test fish bias exists for downstream transport metrics and needs to be corrected in the monitoring program. In addition, the minimum size to tag salmonids with 12-mm PIT tags should be set at 69 mm TL to align with the recommendations of a recent large meta-analysis on survival conducted by Vollset et al. (2020).

To more accurately determine the total number of juvenile fish that enter the reservoir each year, we recommend 1) determine the potential efficacy of marking fish in tributaries by electrofishing compared to operating the screw trap operated at Eagle Cliff over a longer time period, 2) conduct index hydroacoustic surveys in Swift Reservoir to determine monthly changes in fish relative abundance by size class to further assess the timing and number of fish that enter the reservoir, and 3) calculate total abundance through age/cohort analyses of captures at the Swift FSC. A two-year feasibility study should be implemented to determine if substantially more juvenile salmonids can be collected and PIT-tagged using annual tributary electrofishing compared to annual screw trapping over a longer time period at the upstream end of Swift Reservoir. The hydroacoustic survey would also be conducted during the two-year feasibility study.

eDNA analyses could potentially be used to determine spawning distribution and genetic analysis could potentially be used to determine the number of transported salmonids that successfully produce offspring, which could be more effective at addressing the M&E objectives than conducting annual spawning surveys. We recommend assessing the sample size and effort necessary to conduct genetic parentage analysis (Parentage-Based Genetic Tagging) to determine the cost/benefit compared to the more traditional spawning survey approach currently employed.

A summary of the status and recommendations for each objective is summarized in Table 7.1 below.

Table 7.1 Summary of 2017 M&E Plan evaluation and recommendations by Objective.

Objective	Evaluation	Primary Recommendations
Objective 1 – Quantify overall juvenile fish downstream survival (ODS) which includes reservoir survival, collection survival, transport survival, and survival at the release ponds	• Within VSP guidelines for Chinook, coho and steelhead • Sample size limits precision for cutthroat • Collection survival method works well • Transport survival estimate does not include fish too small to PIT tag (fry and small parr) • Using non-naïve fish to estimate reservoir survival may not be the same as for naïve fish	• Evaluate the difference in recapture probability between naïve and non-naïve release groups and sample size • Estimate survival by size class (age class) to the extent possible • Review the 95 percent confidence interval calculation to ensure the method is statistically valid
Objective 2 – Quantify Swift FSC collection efficiency	• Within VSP guidelines for Chinook, coho and steelhead (cutthroat not tested) • Using non-naïve fish to estimate reservoir survival may not be the same as for naïve fish	• Revisit sample size requirements
Objective 3 – Quantify the percentage of juvenile fish available for collection that are not captured by the Swift FSC and that enter the powerhouse intake	• Not to be quantified until downstream collection systems are installed at Yale and Merwin dams	• None
Objective 4 – Quantify juvenile and adult collection survival	• Collection survival method works well • Transport survival estimate does not include fish too small to PIT tag (fry and small parr)	• Estimate survival by size class (age class) to the extent possible
Objective 5 – Quantify juvenile injury and mortality rates during collection at the Swift FSC	• On-going and methodology is adequate • Note that mortality rates are addressed under Objective 4	• Determine if injury classification system is consistent with other facilities • Review M&E plan for consistency of injury classification
Objective 6 – Quantify the number, by species, of juvenile and adult fish collected at the Swift FSC	• Within VSP guidelines for Chinook, coho and steelhead • Sample size limits precision for cutthroat • The subsampling strategy may not be representative if fish enter the Swift FSC in large numbers very quickly (i.e., are not more evenly distributed within the subsampling time intervals), or for fish with low abundance (bull trout, cutthroat)	• Estimate the total fish collected by size class (age-class) to determine the total number of fish collected by cohort (brood year) to align with recommendations made for Objective 7.2 • Conduct periodic validation testing of the assumed subsampling rate

Objective	Evaluation	Primary Recommendations
Objective 7 – Estimate the number of juveniles entering Swift Reservoir	• Within VSP guidelines for Chinook, coho and steelhead • Sample size limits precision for cutthroat • Over half the salmonids caught in the screw trap are too small to PIT tag • Screw trap captures have generally not resulted in meeting sample PIT tag size requirements • A substantial portion of fish appear to enter Swift Reservoir outside the time when the screw trap is operated • Environmental conditions limit potentially operating the screw trap during other times • Using non-naïve fish from the Swift FSC may not be the same as for naïve fish • Estimates cannot be made for fish too small to PIT tag • Does not directly account for fish entering reservoir from other independent tributaries other than the upper North Fork Lewis River	• Implement a two-year feasibility study to determine if tributary PIT tagging can result in more marked fish than operating the screw trap over a longer time period. • Conduct monthly index hydroacoustic surveys of the reservoir during the two-year feasibility study to determine if this method can effectively provide an index of the number and timing of juveniles entering Swift Reservoir in combination with FSC captures. • Assess methodology and revise to account for reservoir hold-over rearing to estimate fish entering reservoir by cohort • Determine PIT tag sample size needed to account for cohort-based estimation • Evaluate the difference in recapture probability between naïve and non-naïve release groups and sample size required, tag more fish at the Swift FSC in the smaller size class range (similar to the Eagle Cliff screw trap size distribution) to test during the two-year feasibility study • Record lengths of all recaptured PIT-tagged fish in the subsample tanks at the Swift FSC • If Swift FSC PIT-tagged fish cannot be used to estimate reservoir survival, assess effectiveness of tributary PIT-tagging of juvenile fish with PIT array detection to determine reservoir entry timing

Objective	Evaluation	Primary Recommendations
Objective 8 – Develop index of juvenile migration timing	• While the license and Settlement Agreement stipulate determining the juvenile migration timing, there is no mention of an “index” of juvenile migration timing • The issues with determining timing of fish entering the reservoir are the same as described under Objective 7	• Determine timing of fish entering Swift Reservoir as recommended under Objective 7
Objective 9 – Quantify adult upstream passage survival	• Overall, the methodology works well • Survival within the MFCF needs to be better tracked and related to survival of fish destined for transport and release upstream • All mortalities need to be tracked (even if they are excluded from the UPS calculation)	• Implement a more detailed recording of MFCF adult mortalities so that mortality of fish not destined for upstream transport are not included in the UPS calculation, though all mortalities should be recorded and reported
Objective 10 – Quantify adult trap efficiency at each upstream fish transport facility (emphasizes analysis of the Merwin Adult Trapping Facility)	• Overall, the method works well for coho and spring Chinook • Due to their life history and long run-time, measuring steelhead ATE is problematic as steelhead can mill around the river system for months before eventually migrating to their spawning stream of choice • Over-time, the decision has been made to only use naïve fish for the ATE test as there is a differential in capture efficiency between naïve and non-naïve fish	• Continue to use naïve fish to the extent possible • Revisit the definition of what constitutes an “upstream bound” steelhead
Objective 11 – Quantify the number, by species, of adult fish collected at Merwin	• On-going and methodology is adequate (simple counts)	• None

Objective	Evaluation	Primary Recommendations
Objective 12 – Develop estimates of ocean recruits	Ocean recruit analysis has not been conducted for several reasons: • The double-index tag (DIT) program did not work as intended • Lack of creel data for the Lewis River fisheries • Low returns of spring Chinook.	• Revise and simplify the run reconstruction method and choose one method to apply • Determine how terminal harvest information will be collected, or if information from other populations (e.g., Cowlitz) provides a reasonable surrogate • If the double-index tag program will not provide data on NOR harvest rates, the program needs to determine how mark-selective harvest information will be collected or if this information is available from other populations that can be used as a surrogate
Objective 13 – Develop performance measures for index stocks	• Methodology works well if there are a sufficient number of out-migrating smolts and returning adults, but returns thus far have been relatively low. • Several assumptions regarding the number of successful spawning adults, not accounting for NOR strays, assumptions about the number of smolts produced, and number of migrants not captured by the Swift FSC complicate the assessment • As long as similar methods are used to estimate R/S and SARs for the Cowlitz and other index populations, these metrics provides a valid comparison to the index populations	• Revise and simplify the methods for calculating NOR SARs and R/S • In addition to calculating SARs for hatchery-origin fish based on adult returns to the Lewis River, use coded-wire tag data to estimate SARs that account for all recoveries, including fish recovered at other hatcheries and harvested fish • Collect age structure data for NORs (e.g., scale samples) • Increase number of PIT tagged NOR juveniles. Use PIT tag returns to calculate SARs and validate results using total adult NOR returns and juvenile outmigrants
Objective 14 – Document upstream and downstream passage facility compliance with hydraulic design criteria	• Completed for both the Swift FSC and MFCF in their respective first year of operation • Both were found to be compliant with design criteria with NOAA Fisheries approval.	• None
Objective 15 – Determine spawn timing, distribution and abundance of transported anadromous adults	• Overall spawning surveys work well for spring Chinook	• Discontinue annual coho spawning surveys and assess the potential efficacy of genetic testing of juveniles collected at the FSC (see

Objective	Evaluation	Primary Recommendations
	• Spawning surveys can work well in some years for early-coho, but not for late-coho due to high flows and access limitation in the late-fall and winter • Steelhead index spawning surveys are limited in spatial area and may not be representative • Aerial telemetry surveys are dangerous and the point data is meaningful to address the intent of the objective	recommendations for Objectives 1 and 7) to determine successful spawner abundance (i.e., the number of adults that successfully spawned to produce outmigrants) • Assess the potential efficacy of eDNA surveys to assess annual distribution of transported anadromous fish • Conduct coho spawning surveys once every three years to determine any shifts in spawner distribution over time • Continue annual spring Chinook spawning surveys when a sufficient number of females are transported upstream to allow for sufficient redd detection probability • Continue steelhead redd surveys in reservoir tributaries and evaluate if index reaches are representative • Establish fixed telemetry station monitoring locations to determine when radio tagged steelhead enter and exit major drainages within the North Fork Lewis River upstream of Swift Reservoir • Discontinue aerial radio telemetry surveys due to the cost, risk, and relatively poor quality of information.
Objective 16 – Evaluate lower Lewis River wild fall Chinook and chum populations	• This objective was moved to the H&S Plan	• None
Objective 17 – Monitor bull trout populations	• Yearly monitoring methods and activities are identified by the Bull Trout Group composed of PacifiCorp and Agency representatives (described in the Lewis River Bull Trout Annual Operating Plan)	• None

Objective	Evaluation	Primary Recommendations
Objective 18 – Determine Interactions between reintroduced anadromous salmonids and resident fish (Upstream of Merwin dam)	• Studies were performed by USGS and UW from 2013 to 2016 • These reports recommended repeating a streamlined version of the studies sometime within 5 to 10 years	• The Lewis River Bull Trout Recovery Team is developing information needs and proposed work regarding this objective, which will be provided at a later date
Objective 19 – Document Project compliance with flow, ramping rate and flow plateau requirements	• On-going and reported annually	• None
Objective 20 – Determine when reintroduction outcome goals are achieved	• Until the Services develop numeric adult return goals, the natural adult abundance targets presented under Objective 12 (Ocean Recruits) will be used as the benchmarks for determining the success of the reintroduction effort	• None
Objective 21 – Develop a Hatchery and Supplementation Plan	• Complete	• None
Objective 22 – Develop a Coordination Table that cross-references Objectives of the Hatchery and Supplementation Plan and the Monitoring and Evaluation Plan	• Reporting as outlined in the 2017 M&E Plan has not been conducted to date	• Assess the need for this objective and develop a reporting template/process as necessary. • Determine sources of information

8.0 References

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Appendix C

Objective 22 - M&E and H&S Plans Example Crosswalk Tables

Table 2.22.1: Lewis River spring Chinook salmon cross-walk table that summarizes the monitoring activities in the lower Lewis River (downstream of Merwin Trap), and upper Lewis River (upstream of Swift Reservoir) as they pertain to individual viable salmonid population (VSP) parameter metrics and the corresponding objectives, data collection, and analytical methods, which are detailed in the Lewis River Hatchery & Supplementation (H&S) Plan and the Lewis River Monitoring & Evaluation (M&E) Plan. Metrics for which estimates and precision levels will be calculated according to M&E and H&S objectives are indicated with a "Y" (Yes).

		Lower River					Upper River					Total Population		
VSP Parameter	Metric	e	Data Collection	Analysis	Estimate	Precision	e	Data Collection	Analysis	Estimate	Precision	Analysis [1]	Estimate	Precision
Abundance	Total Escapement (adults and jacks)	NA	-	-	-	-	M&E 11	Trap returns	Census	Y	Y	NA	-	-
	Spawner Abundance (Adults)	H&S 13	Stream surveys	Jolly-Seber	Y	Y	M&E 15	Stream surveys	TBD	Y	Y	TBD	Y	Y
	pHOS	H&S 2	Stream surveys	Spawning Ground Ratios	Y	Y	M&E 15	Stream surveys	Spawning Ground Ratios	Y	Y	TBD	Y	Y
	Juvenile Abundance (migrants)	H&S 13	Screw Trap	Petersen M-R	Y	Y	M&E 6&7	Screw Trap / Fish Surface Collector	Petersen M-R	Y	Y	TBD	Y	Y
Productivity	Spawner to Spawner (recruits per spawner)	M&E 12	Stream surveys	Spawner-recruit	Y	Y	M&E 12	Stream surveys / Trap returns	Spawner-recruit	Y	Y	TBD	Y	Y
	Freshwater survival	NA*	Smolt trap / Stream surveys	Spawner-to-smolt	-	-	NA*	Stream surveys / Screw Trap / Fish Surface Collector	Spawner-to-smolt	-	-	NA*	-	-
	Ocean survival	M&E 12	Stream surveys / Trap returns / Screw Trap	Smolt-to-adult (SAR)/ Ocean Recruit	Y	Y	M&E 12	Stream surveys / Trap returns / Screw Trap / Fish Surface Collector	Smolt-to-adult (SAR)/ Ocean Recruit	Y	Y	TBD	Y	Y
Spatial Structure	Redd Distribution	H&S 14	Stream surveys	Redd count/mapping	Y	-	M&E 15	Stream surveys	Redd count/mapping	Y	-	TBD	Y	-
	Reach Occupancy	NA	-	-	-	-	M&E 15	Stream surveys	GRTS/TBD	Y	Y	NA	-	-
	Redds and/or fish per mile	NA	-	-	-	-	NA	-	-	-	-	TBD	-	-
Diversity	Age Structure	H&S 13	Stream surveys / Trap returns	Age Ratios	Y	Y	M&E 11&15	Stream surveys / Trap returns	Age Ratios	Y	Y	TBD	Y	Y
	Sex Ratios	H&S 13	Stream surveys / Trap returns	Sex Ratios	Y	Y	M&E 11&15	Stream surveys / Trap returns	Sex Ratios	Y	Y	TBD	Y	Y
	Jack Ratio	H&S 13	Stream surveys / Trap returns	Age Ratios	Y	Y	M&E 11&15	Stream surveys / Trap returns	Age Ratios	Y	Y	TBD	Y	Y
	Stock composition	H&S 13	Stream surveys / Trap returns	CWT analysis	Y	-	M&E 11&15	Stream surveys / Trap returns	CWT analysis	Y	-	TBD	Y	-
	Genetic Diversity	NA	-	-	-	-	NA	-	-	-	-	NA	-	-
	Genetic Effective Population Size	NA	-	-	-	-	NA	-	-	-	-	NA	-	-
	Run and/or Spawn Timing	H&S 14	Stream surveys	Cumulative spawner proportion	Y	-	M&E 11&15	Stream surveys / Trap returns	Cumulative Arrival/ spawner proportion	Y	-	TBD	Y	-

NA - The parameter/metric is not applicable.
NA* - There are no PacifiCorp related objectives pertaining to this metric, but WDFW may either collect data or conduct the analysis for this metric.
[1] Analytical methods to estimate population level metrics have not been fully developed
TBD - To Be Determined.

Table 2.22.2: Lewis River coho salmon cross-walk table that summarizes the monitoring activities in the lower Lewis River (downstream of Merwin Trap), and upper Lewis River (upstream of Swift Reservoir) as they pertain to individual viable salmonid population (VSP) parameter metrics and the corresponding objectives, data collection, and analytical methods, which are detailed in the Lewis River Hatchery & Supplementation (H&S) Plan and the Lewis River Monitoring & Evaluation (M&E) Plan. Metrics for which estimates and precision levels will be calculated according to M&E and H&S objectives are indicated with a "Y" (Yes).

		Lower River					Upper River					Total Population		
VSP Parameter	Metric	ve	Data Collectio	Analysis	Estimate	Precision	e	Data Collection	Analysis	Estimate	Precision	Analysis[1]	Estimate	Precision
Abundance	Total Escapement (adults and jacks)	NA	-	-	-	-	M&E 11	Trap returns	Census	Y	Y	NA	-	-
	Spawner Abundance (Adults)	H&S 13	Stream surveys	Jolly-Seber/GRTS	Y	Y	M&E 15	Stream surveys	GRTS/TBD	Y	Y	TBD	Y	Y
	pHOS	H&S 2	Stream surveys	Spawning Ground Ratios	Y	Y	M&E 15	Stream surveys	Spawning Ground Ratios	Y	Y	TBD	Y	Y
	Juvenile Abundance (migrants)	H&S 13	Screw Trap	Petersen M-R	Y	Y	M&E 6&7	Screw Trap / Fish Surface Collector	Petersen M-R	Y	Y	TBD	Y	Y
Productivity	Spawner to Spawner (recruits per spawner)	M&E 12	Stream surveys	Spawner-recruit	Y	Y	M&E 12	Stream surveys / Trap returns	Spawner-recruit	Y	Y	TBD	Y	Y
	Freshwater survival	NA*	Smolt trap / Stream surveys	Spawner-to-smolt	-	-	NA*	Stream surveys / Screw Trap / Fish Surface Collector	Spawner-to-smolt	-	-	NA*	-	-
	Ocean survival	M&E 12	Stream surveys / Trap returns / Screw Trap	Smolt-to-adult (SAR)/ Ocean Recruit	Y	Y	M&E 12	Stream surveys / Trap returns / Screw Trap / Fish Surface Collector	Smolt-to-adult (SAR)/ Ocean Recruit	Y	Y	TBD	Y	Y
Spatial Structure	Redd Distribution	H&S 14	Stream surveys	Redd count/mapping	Y	-	M&E 15	Stream surveys	Redd count/mapping	Y	-	TBD	Y	-
	Reach Occupancy	H&S 14	Stream surveys	GRTS	Y	Y	M&E 15	Stream surveys	GRTS/TBD	Y	Y	TBD	Y	-
	Redds and/or fish per mile	H&S 14	Stream surveys	Survey data expansion	Y	Y	M&E 15	Stream surveys	Survey data expansion	Y	Y	TBD	-	-
Diversity	Age Structure	H&S 13	Stream surveys / Trap returns	Age Ratios	Y	Y	M&E 11&15	Stream surveys / Trap returns	Age Ratios	Y	Y	TBD	Y	Y
	Sex Ratios	H&S 13	Stream surveys / Trap returns	Sex Ratios	Y	Y	M&E 11&15	Stream surveys / Trap returns	Sex Ratios	Y	Y	TBD	Y	Y
	Jack Ratio	H&S 13	Stream surveys / Trap returns	Age Ratios	Y	Y	M&E 11&15	Stream surveys / Trap returns	Age Ratios	Y	Y	TBD	Y	Y
	Stock composition	H&S 13	Stream surveys / Trap returns	CWT analysis	Y	-	M&E 11&15	Stream surveys / Trap returns	CWT analysis	Y	-	TBD	Y	-
	Genetic Diversity	NA	-	-	-	-	NA	-	-	-	-	NA	-	-
	Genetic Effective Population Size	NA	-	-	-	-	NA	-	-	-	-	NA	-	-
	Run and/or Spawn Timing	H&S 14	Stream surveys	Cumulative spawner proportion	Y	-	M&E 11&15	Stream surveys / Trap returns	Cumulative Arrival/ spawner proportion	Y	-	TBD	Y	-

NA - The parameter/metric is not applicable.
NA* - There are no PacifiCorp related objectives pertaining to this metric, but WDFW may either collect data or conduct the analysis for this metric.
[1] Analytical methods to estimate population level metrics have not been fully developed
TBD - To Be Determined.

Table 2.22.3: Lewis River winter steelhead cross-walk table that summarizes the monitoring activities in the lower Lewis River (downstream of Merwin Trap), and upper Lewis River (upstream of Swift Reservoir) as they pertain to individual viable salmonid population (VSP) parameter metrics and the corresponding objectives, data collection, and analytical methods, which are detailed in the Lewis River Hatchery & Supplementation (H&S) Plan and the Lewis River Monitoring & Evaluation (M&E) Plan. Metrics for which estimates and precision levels will be calculated according to M&E and H&S objectives are indicated with a "Y" (Yes).

		Lower River					Upper River					Total Population		
VSP Parameter	**Metric**	**ve**	**Data Collection**	**Analysis**	**Estimate**	**Precision**	**Objective**	**Data Collection**	**Analysis**	**Estimate**	**Precision**	**Analysis**	**Estimate**	**Precision**
Abundance	Total Escapement (adults and jacks)	NA	-	-	-	-	M&E 11	Trap returns	Census	Y	Y	NA	-	-
	Spawner Abundance (Adults)	H&S 13	Stream surveys	Redd Expansion	Y	-	M&E 15	Stream surveys/PIT Tag	TBD	Y	Y	TBD	Y	TBD
	pHOS	H&S 2	Stream surveys	TBD	Y	Y	M&E 15	Stream surveys/PIT Tag	TBD	Y	Y	TBD	Y	Y
	Juvenile Abundance (migrants)	H&S 13	Screw Trap	Petersen M-R	Y	Y	M&E 6&7	Screw Trap / Fish Surface Collector	Petersen M-R	Y	Y	TBD	Y	Y
Productivity	Spawner to Spawner (recruits per spawner)	M&E 12	Stream surveys	Spawner-recruit	Y	Y	M&E 12	Stream surveys / Trap returns	Spawner-recruit	Y	Y	TBD	Y	Y
	Freshwater survival	NA*	Smolt trap / Stream surveys	Spawner-to-smolt	-	-	NA*	Stream surveys / Screw Trap / Fish Surface Collector	Spawner-to-smolt	-	-	NA*	-	-
	Ocean survival	M&E 12	Stream surveys / Trap returns / Screw Trap	Smolt-to-adult (SAR)/ Ocean Recruit	Y	Y	M&E 12	Stream surveys / Trap returns / Screw Trap / Fish Surface Collector	Smolt-to-adult (SAR)/ Ocean Recruit	Y	Y	TBD	Y	Y
Spatial Structure	Redd Distribution	H&S 14	Stream surveys	Redd count/mapping	Y	-	M&E 15	Aerial Radio Tracking	Radio detection mapping	Y	-	TBD	Y	-
	Reach Occupancy	NA	-	-	-	-	M&E 15	Stream surveys	GRTS/TBD	Y	Y	NA	-	-
	Redds and/or fish per mile	H&S 14	Stream surveys	Survey data expansion	Y	Y	M&E 15	Stream surveys	Survey data expansion	Y	Y	TBD	-	-
Diversity	Age Structure	H&S 13	Trap	Age Ratios	Y	Y	M&E 11	Trap returns	Age Ratios	Y	Y	TBD	Y	Y
	Sex Ratios	H&S 13	Trap	Sex Ratios	Y	Y	M&E 11	Trap returns	Sex Ratios	Y	Y	TBD	Y	Y
	Jack Ratio	NA	-	-	-	-	NA	-	-	-	-	NA	-	-
	Stock composition	NA	-	-	-	-	NA	-	-	-	-	NA	-	-
	Genetic Diversity	H&S 11	Trap	Genetic Analysis	Y	Y	NA	-	-	-	-	NA	-	-
	Genetic Effective Population Size	H&S 11	Trap returns/Seining	Genetic Analysis	Y	Y	NA	-	-	-	-	NA	-	-
	Run and/or Spawn Timing	H&S 14	Stream surveys / Trap returns	Cumulative Arrival redd proportions	Y	-	M&E 11&15	Stream surveys/PIT Tag/Trap Returns	TBD	Y	-	TBD	Y	-

NA - The parameter/metric is not applicable.
NA* - There are no PacifiCorp related objectives pertaining to this metric, but WDFW may either collect data or conduct the analysis for this metric.
[1] Analytical methods to estimate population level metrics have not been fully developed
TBD - To Be Determined.

Table 2.22.4: Lewis River fall (Tule) Chinook salmon cross-walk table that summarizes the monitoring activities in the lower (downstream of Merwin Trap), upper Lewis River (upstream of Swift Reservoir), and East Fork Lewis River as they pertain to individual viable salmonid population (VSP) parameter metrics and the corresponding objectives, data collection, and analytical methods, which are detailed in the Lewis River Hatchery & Supplementation (H&S) Plan and the Lewis River Monitoring & Evaluation (M&E) Plan. Estimates and the associated level of precision that will be calculated for each metric are indicated with a "Y" (Yes). Estimates to be collected, analyzed and reported that are to be completed by WDFW are indicated as such.

		Lower River												Upper River	Total Population[1]		
VSP Parameter	Metric	Objective	Data Collection	Analysis	Estimate	Precision	Objective	Estimate	Precision	Objective	Data Collection	Analysis	Estimate	Precision	Analysis[2]	Estimate	Precision
Abundance	Total Escapement (adults and jacks)	**NA**	-	-	WDFW	WDFW	**NA**	-	-	NA	-	-	WDFW	WDFW	**NA**	-	-
	Spawner Abundance (Adults)	H&S 1, M&E 16	Stream surveys	Jolly-Seber	WDFW	WDFW	**NA**	-	-	NA*	Stream surveys	Jolly-Seber, AUC, Redd Expansion	WDFW	WDFW	TBD	Y	Y
	pHOS	H&S 1, M&E 16	Stream surveys	Spawning Ground Ratios	WDFW	WDFW	**NA**	-	-	NA*	Stream surveys	Spawning Ground Ratios	WDFW	WDFW	TBD	Y	Y
	Juvenile Abundance (migrants)	H&S 1, M&E 16	Smolt trap	Petersen M-R	WDFW	WDFW	**NA**	-	-	NA	-	-	WDFW	WDFW	**NA**	-	-
Productivity	Spawner to Spawner (recruits per spawner)	**NA**	Stream surveys	Spawner-recruit	WDFW	WDFW	**NA**	-	-	NA*	Stream surveys	Spawner-recruit	WDFW	WDFW	TBD	-	-
	Freshwater survival	**NA**	Smolt trap / Stream surveys	Spawner-to-smolt	WDFW	WDFW	**NA**	-	-	NA	-	-	WDFW	WDFW	**NA**	-	-
	Ocean survival	**NA**	Smolt trap / Stream surveys / Trap returns	Smolt-to-adult (SAR)	WDFW	WDFW	**NA**	-	-	NA	-	-	WDFW	WDFW	**NA**	-	-
Spatial Structure	Redd Distribution	H&S 1, M&E 16	Stream surveys	Peak Redd count/mapping	WDFW	WDFW	**NA**	-	-	NA*	Stream surveys	Redd count/mapping	WDFW	WDFW	TBD	Y	-
	Reach Occupancy	**NA**	-	-	WDFW	WDFW	**NA**	-	-	NA	-	-	WDFW	WDFW	**NA**	-	-
	Redds and/or fish per mile	**NA**	-	-	WDFW	WDFW	**NA**	-	-	NA	-	-	WDFW	WDFW	**NA**	-	-
Diversity	Age Structure	H&S 1, M&E 16	Stream surveys / Trap returns	Age Ratios	WDFW	WDFW	**NA**	-	-	NA*	Stream surveys	Age Ratios	WDFW	WDFW	TBD	Y	Y
	Sex Ratios	H&S 1, M&E 16	Stream surveys / Trap returns	Sex Ratios	WDFW	WDFW	**NA**	-	-	NA*	Stream surveys	Sex Ratios	WDFW	WDFW	TBD	Y	Y
	Jack Ratio	H&S 1, M&E 16	Stream surveys / Trap returns	Age Ratios	WDFW	WDFW	**NA**	-	-	NA	-	-	WDFW	WDFW	**NA**	-	-
	Stock composition	H&S 1, M&E 16	Stream surveys / Trap returns	CWT analysis	WDFW	WDFW	**NA**	-	-	NA*	Stream surveys	CWT analysis	WDFW	WDFW	TBD	Y	Y
	Genetic Diversity	**NA**	Stream surveys / Trap returns	Genetic Structure	WDFW	WDFW	**NA**	-	-	NA*	Stream surveys	Genetic Structure	WDFW	WDFW	TBD	-	-
	Genetic Effective Population Size	**NA**	-	-	WDFW	WDFW	**NA**	-	-	NA	-	-	WDFW	WDFW	**NA**	-	-
	Run and/or Spawn Timing	H&S 1, M&E 16	Stream surveys / Trap returns	Cumulative spawner proportion	WDFW	WDFW	**NA**	-	-	NA*	Stream surveys	Cumulative spawner proportion	WDFW	WDFW	TBD	Y	-

NA* - There are no PacifiCorp related objectives pertaining to this metric, but WDFW may either collect data or conduct the analysis for this metric.

[1] Analysis or estimates related to East Fork Lewis River monitoring and total population metrics are not required as part of the Utilities annual reporting to FERC. Therefore, these columns will not be included in the annual report.

[2] Analytical methods to estimate population level metrics have not been fully developed by WDFW

Table 2.22.5: Lewis River fall (Bright) Chinook salmon cross-walk table that summarizes the monitoring activities in the lower Lewis River (downstream of Merwin Trap), and upper Lewis River (upstream of Swift Reservoir), as they pertain to individual viable salmonid population (VSP) parameter metrics and the corresponding objectives, data collection, and analytical methods, which are detailed in the Lewis River Hatchery & Supplementation (H&S) Plan and the Lewis River Monitoring & Evaluation (M&E) Plan. Metrics for which estimates and precision levels will be calculated according to M&E and H&S objectives are indicated with a "Y" (Yes).

		Lower River					Upper River			Total Population		
VSP Parameter	**Metric**	**Objective**	**Data Collection**	**Analysis**	**Estimate**	**Precision**	**Objective**	**Estimate**	**Precision**	**Analysis**	**Estimate**	**Precision**
Abundance	Total Escapement (adults and jacks)	NA	-	-	-	-	NA	-	-	NA	-	-
	Spawner Abundance (Adults)	H&S 1, M&E 16	Stream surveys	Jolly-Seber	Y	Y	NA	-	-	Same	Y	Y
	pHOS	H&S 1, M&E 16	Stream surveys	Spawning Ground Ratios	Y	Y	NA	-	-	Same	Y	Y
	Juvenile Abundance (migrants)	H&S 1, M&E 16	Smolt trap	Petersen M-R	Y	Y	NA	-	-	Same	Y	Y
Productivity	Spawner to Spawner (recruits per spawner)	NA*	Stream surveys	Spawner-recruit	-	-	NA	-	-	Same	-	-
	Freshwater survival	NA*	Smolt trap / Stream surveys	Spawner-to-smolt	-	-	NA	-	-	Same	-	-
	Ocean survival	NA*	Smolt trap / Stream surveys / Trap returns	Smolt-to-adult (SAR)	-	-	NA	-	-	Same	-	-
Spatial Structure	Redd Distribution	H&S 1, M&E 16	Stream surveys	Peak Redd count/mapping	Y	-	NA	-	-	Same	Y	-
	Reach Occupancy	NA	-	-	-	-	NA	-	-	NA	-	-
	Redds and/or fish per mile	NA	-	-	-	-	NA	-	-	NA	-	-
Diversity	Age Structure	H&S 1, M&E 16	Stream surveys / Trap returns	Age Ratios	Y	Y	NA	-	-	Same	Y	Y
	Sex Ratios	H&S 1, M&E 16	Stream surveys / Trap returns	Sex Ratios	Y	Y	NA	-	-	Same	Y	Y
	Jack Ratio	H&S 1, M&E 16	Stream surveys / Trap returns	Age Ratios	Y	Y	NA	-	-	Same	Y	Y
	Stock composition	H&S 1, M&E 16	Stream surveys / Trap returns	CWT analysis	Y	-	NA	-	-	Same	Y	-
	Genetic Diversity	NA*	Stream surveys / Trap returns	Genetic Structure	-	-	NA	-	-	Same	-	-
	Genetic Effective Population Size	NA	-	-	-	-	NA	-	-	NA	-	-
	Run and/or Spawn Timing	H&S 1, M&E 16	Stream surveys / Trap returns	Cumulative spawner proportion	Y	-	NA	-	-	Same	Y	-

NA - The parameter/metric is not applicable.
NA* - There are no PacifiCorp related objectives pertaining to this metric, but WDFW may either collect data or conduct the analysis for this metric.
Same - The "Lower River"segment represents the entire Lewis River fall (bright) Chinook population, therefore the total population analysis is the same as that completed for the "Lower River" segment.

Table 2.22.6: Lewis River chum salmon cross-walk table that summarizes the monitoring activities in the lower Lewis River (downstream of Merwin Trap), upper Lewis River (upstream of Swift Reservoir), and East Fork Lewis River as they pertain to individual viable salmonid population (VSP) parameter metrics and the corresponding objectives, data collection, and analytical methods, which are detailed in the Lewis River Hatchery & Supplementation (H&S) Plan and the Lewis River Monitoring & Evaluation (M&E) Plan. Metrics for which estimates and precision levels will be calculated according to M&E and H&S objectives are indicated with a "Y" (Yes). Metrics for which estimates and precision levels will be calculated by WDFW are indicated with "Y (WDFW)".

		Lower River					Upper River			East Fork Lewis[2]					Total Population[2]		
VSP Parameter	**Metric**	**Objective**	**Data Collection**	**Analysis**	**Estimate**	**Precision**	**Objective**	**Estimate**	**Precision**	**Objective**	**Data Collection**	**Analysis**	**Estimate**	**Precision**	**Analysis[1]**	**Estimate**	**Precision**
Abundance	Total Escapement (adults and jacks)	NA	-	-	-	-	NA	-	-	NA	-	-	-	-	NA	-	-
	Spawner Abundance (Adults)	H&S 1, M&E 16	Stream surveys	Presence/Absence, Jolly-Seber, AUC	Y	Y	NA	-	-	NA*	Stream surveys	Presence/Absence, Jolly-Seber, AUC	Y (WDFW)	Y (WDFW)	TBD	Y	Y
	pHOS	H&S 1, M&E 16	Stream surveys	Spawning Ground Ratios (otolith)	Y	Y	NA	-	-	NA*	Stream surveys	Spawning Ground Ratios (otolith)	Y (WDFW)	Y (WDFW)	TBD	Y	Y
	Juvenile Abundance (migrants)	H&S 1, M&E 16	Smolt trap	Petersen M-R	Y	Y	NA	-	-	NA	-	-	-	-	NA	-	-
Productivity	Spawner to Spawner (recruits per spawner)	NA*	Stream surveys	Spawner-recruit	-	-	NA	-	-	NA*	Stream surveys	Spawner-recruit	Y (WDFW)	Y (WDFW)	TBD	-	-
	Freshwater survival	NA*	Smolt trap / Stream surveys	Spawner-to-smolt	-	-	NA	-	-	NA	-	-	-	-	NA	-	-
	Ocean survival	NA*	Smolt trap / Stream surveys / Trap returns	Smolt-to-adult (SAR)	-	-	NA	-	-	NA	-	-	-	-	NA	-	-
Spatial Structure	Redd Distribution	H&S 1, M&E 16	Stream surveys	Peak Redd count/mapping	Y	-	NA	-	-	NA	Stream surveys	Redd count/mapping	Y (WDFW)	-	TBD	Y	-
	Reach Occupancy	NA	-	-	-	-	NA	-	-	NA	-	-	-	-	NA	-	-
	Redds and/or fish per mile	NA	-	-	-	-	NA	-	-	NA	-	-	-	-	NA	-	-
Diversity	Age Structure	H&S 1, M&E 16	Stream surveys / Trap returns	Age Ratios	Y	Y	NA	-	-	NA*	Stream surveys	Age Ratios	Y (WDFW)	Y (WDFW)	TBD	Y	Y
	Sex Ratios	H&S 1, M&E 16	Stream surveys / Trap returns	Sex Ratios	Y	Y	NA	-	-	NA*	Stream surveys	Sex Ratios	Y (WDFW)	Y (WDFW)	TBD	Y	Y
	Jack Ratio	NA	-	-	-	-	NA	-	-	NA	-	-	-	-	NA	-	-
	Stock composition	H&S 1, M&E 16	Stream surveys / Trap returns	CWT/otolith/PBT analysis	Y	-	NA	-	-	NA*	Stream surveys	CWT/otolith/PBT analysis	Y (WDFW)	-	TBD	Y	Y
	Genetic Diversity	NA*	Stream surveys / Trap returns	Genetic Structure	-	-	NA	-	-	NA*	Stream surveys	Genetic Structure	Y (WDFW)	-	TBD	-	-
	Genetic Effective Population Size	NA	-	-	-	-	NA	-	-	NA	-	-	-	-	NA	-	-
	Run and/or Spawn Timing	H&S 1, M&E 16	Stream surveys / Trap returns	Cumulative spawner proportion	Y	-	NA	-	-	NA*	Stream surveys	Cumulative spawner proportion	Y (WDFW)	-	TBD	Y	-

NA - The parameter/metric is not applicable.
NA* - There are no PacifiCorp related objectives pertaining to this metric, but WDFW may either collect data or conduct the analysis for this metric.
[1] Analytical methods to estimate population level metrics have not been fully developed
[2] Analysis or estimates related to East Fork Lewis River monitoring and total population metrics are not required as part of the Utilities annual reporting to FERC. Therefore, these columns will not be included in the annual report.
TBD - To Be Determined.