60-day review DRAFT

Lewis River Hatchery and Supplementation Plan (FERC Project Nos. 935, 2071, 2111, 2213)

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PACIFICORP ENERGY AND COWLITZ PUD

Version 2.0

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EXECUTIVE SUMMARY

The Hatchery and Supplementation Plan (H&S plan) is intended to provide the framework for implementing activities associated with Section 8 of the Lewis River Settlement Agreement (Agreement) dated November 30, 2004. This section describes components of the hatchery and supplementation program including production of hatchery species and reintroduction strategies for target species into Swift, Yale and Merwin reservoirs.

Periodic 5-year updates to this plan are required under Section 8.25 of the Agreement. The initial plan was finalized on December 23, 2009 and this version represents the first update and second version to this original document. This version contains many of the same expected outcomes (Section 8) as the first version because there simply has not been sufficient data collected nor analyzed to update expectations within this section and determine whether expectations are reasonable.

Ocean Recruit methodology (Section 4.0) has been updated as the first version contained calculation errors and did not provide details necessary to calculate an estimate of ocean recruits. This process is still being finalized, and Appendix C provides a summary of how this important metric should be estimated and the challenges associated with providing accurate estimates. Given the complex nature of ocean recruit estimates and the significant time lag in producing estimates, the ACC will need determine if ocean recruit estimates should remain the key metric of smolt performance.

Finally, this version has removed some of the repetition present in the first version. Portions of some sections were deleted because they were duplicated in other sections and the M&E Section was updated to reflect new recommendations based primarily on updated perspectives from the Hatchery and Scientific Review Group and management issues that have developed since incorporation of the first version of the plan.

The goals identified by the parties to the Agreement formed the basis for actions proposed in this plan. The Agreement states that the goals of the hatchery and supplementation program are to support:

1. Self-sustaining, naturally producing, harvestable native anadromous salmonids species throughout their historical range in the North Fork Lewis River, and

2. The continued harvest of resident and native anadromous fish species.

The H&S Plan is designed to be consistent with the priority objective of recovering wild fish stocks in the basin to viable and harvestable levels. When selecting between actions, deference will be given to those that provide the greatest benefit to the protection of wild fish populations.

As called for in the Agreement, the H&S Plan incorporates current recommendations of the Hatchery Scientific Review Group (HSRG), and the Northwest Power and Conservation Council's (NPCC) Artificial Production Review and Evaluation (APRE) program. Both programs were mandated by Congress as a means to reform artificial production in the Pacific Northwest. The recommendations in these reports represent the regions current understanding of what constitutes best hatchery practices. The supplementation approach used in the plan was selected based on the results obtained as part of the Yakima River and Cowlitz River supplementation programs.

Other plans, documents or communications used in the development of the H&S Plan include:

- Washington Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan (for North Fork Lewis River)
- Hatchery and Genetic Management Plans
- Recommendations from hatchery and fishery managers

Inconsistencies with Settlement Agreement

- The H&S Plan was structured to be consistent with the Settlement Agreement. However, although some actions and analyses proposed in the H&S Plan meet the intent of the Settlement Agreement, they may be considered inconsistent based on Settlement Agreement language. Examples include:
- <u>Definition of Ocean Recruits (Section 8.1 of Settlement Agreement)</u>: In the Settlement Agreement jacks should be accounted for in calculating ocean recruits. However, after discussion with members of the ACC, a decision was made to <u>not include</u> this life stage in either defining or calculating ocean recruits for each species in the H&S plan.
- <u>Juvenile Supplementation (Section 8.5 of Settlement Agreement)</u>: In the Settlement Agreement juvenile supplementation above Swift is an action for spring Chinook, steelhead, and coho. However within the H&S Plan, active juvenile supplementation is only proposed for spring Chinook and late winter steelhead. Coho supplementation will rely on surplus adults from the hatchery. Data collected on both the Lewis River and Cowlitz River show that adult coho releases produce a large number of juvenile offspring. Initial steelhead juvenile supplementation will not occur above Swift, but from Merwin hatchery below Merwin Dam. The steelhead program will use wild adults from the lower river as the broodstock. As offspring of these wild fish return to the Merwin or Lewis River collection facilities as adults, they will be transported upstream and released.

1.0 INTRODUCTION

The Settlement Agreement for the Lewis River Hydroelectric Projects dated November 30, 2004 (Agreement) includes a comprehensive suite of salmon and steelhead protection, mitigation, and enhancement measures that PacifiCorp Energy and Cowlitz PUD have agreed to implement over the terms of the new project licenses (PacifiCorp and Cowlitz PUD 2004a). A central, significant feature of the Agreement involves the reintroduction of spring Chinook (*Oncorhynchus tshawytscha*), winter steelhead (*O. mykiss*), and early coho (*O. kisutch*) into their historical range above Merwin Dam by means of hatchery supplementation[1] and newly constructed fish passage facilities.

To address hatchery operations and supplementation during the terms of the new licenses, Section 8 of the Settlement Agreement provides for a Hatchery and Supplementation Program. Primary goals of the Hatchery and Supplementation Program are to use the existing hatchery program to:

- Create self-sustaining, naturally producing, harvestable native anadromous salmonid species throughout their historical range in the North Fork Lewis River basin, and

- Provide for the continued harvest of resident and native anadromous fish species.

To ensure the Hatchery and Supplementation Program is meeting its goals, PacifiCorp Energy and Cowlitz PUD have developed this Hatchery and Supplementation Plan (H&S Plan) to adaptively manage the program and guide its implementation.

This Plan consists of eight sections designed to address the requirements outlined in Section 8.2.2 of the Agreement. These include:

Hatchery Production Program

This section contains the hatchery production targets and protocols applied at each of the Lewis River hatchery facilities to maintain harvest opportunities downstream of Merwin Dam and in project reservoirs (residents). These programs are Segregated programs as defined by HSRG; however, the intent is to integrate these programs as the hatchery and supplementation program matures. Hatchery programs are also needed to provide both adult and juvenile anadromous fish for early supplementation efforts in the basin.

[1] Supplementation is defined as the use of artificial propagation to maintain or increase natural production while maintaining the long-term fitness of the target population, and keeping the ecological and genetic impacts to non-target populations within specified biological limits.

Supplementation Program

This section provides an approach to reintroduce spring Chinook, late winter steelhead and early coho to habitat upstream of Merwin Dam. It includes the use of native broodstock (winter steelhead), and hatchery origin spring Chinook and early coho to initiate reintroduction to the upper basin. This section identifies minimum numeric targets for reintroduction based on EDT and expected ocean recruit estimates designed to create self-sustaining runs.

Ocean Recruit Methodology

Ocean recruits are necessary to provide fish for reintroduction into areas upstream of Merwin Dam. Without consistent returns from natural production upstream of the hydroelectric system the program will not be sustainable and the goals will not be met. This section along with Appendix C introduce the methodology required to estimate ocean recruits including the challenges associated with this calculation.

Monitoring and Evaluation Objectives

Monitoring and evaluation of the program includes both the hatchery and supplementation program components. Because M&E activities, or at least the methodologies, are likely to change annually the H&S plan provides objectives that should be considered to meet the requirements of the Agreement and Endangered Species Act as well as other policies at the state and federal level. Methodologies to meet these objectives will be provided each year in the annual operating plan for the hatchery and supplementation program. Required monitoring includes abundance, distribution and composition estimates, hatchery effects on native or ESA listed stocks (including resident species), and monitoring the adoption of HSRG recommendations at the hatchery facilities.

Fish Marking Strategies

Proposes strategies for marking and tagging both hatchery and supplementation fish. Tags include Passive Integrated Transponder (PIT) tags, Coded Wire Tags (CWT) and Blank Wire Tags (BWT). The marking strategies employed currently are likely to change as natural production increases upstream of Swift and at such time passage facilities may be completed at Yale and Merwin.

Adaptive Management

Adaptive management of the program is critical to achieving objectives of the program. Several mechanisms exist that ensures this occurs including developing of annual operating plans, comprehensive periodic reviews and 5 year updates to this plan. Additionally, there are a number of decision points indicated in this section where assumptions need to be verified and, if unverifiable, an alternative approach may need to be initiated.

Expected Outcomes

This section outlines the expectations for survival of hatchery and supplementation programs that produce natural origin smolts. Expectations are derived from literature sources and modeling through use of the All-H Hatchery Analyzer (AHA) model. It is important to note that the expectations derived from modeling or through ocean recruit targets will vary from year to year and thus the expected outcomes should be viewed as a base for which fish stocks should become self-sustaining through natural production.

Annual Operating Plan

Section 8.2.3 of the Agreement requires the drafting of an annual operating plan to implement the hatchery and supplementation program. This annual plan provides the means to adaptively manage the program within the general context of the H&S Plan as it is updated annually and can incorporate new technology or methods to achieve the goals and objectives of the program.

Program Timeline

The salmon and steelhead supplementation program will follow a phased approach, where Spring Chinook, winter steelhead, and coho will first be reintroduced into habitat above Swift Dam after completion of the Merwin trap and transport facility (By 6 months after the 4th anniversary of Merwin license issuance), and then introduced into the habitat located between Merwin and Swift dams (following the 13th and 17th anniversaries of the new licenses), unless otherwise directed by the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS).

Figures 1-1 through 1-3 illustrate the progression of the program along with key milestones that are present in the Agreement. Figure 1-1 is a general timeline illustrating key milestones through year 2025. Figures 1-2 and 1-3 provide flow charts based on sections within the Agreement to help assist in understanding the many time dependent activities associated with both the hatchery and supplementation plan and separate, but related, monitoring and evaluation plan.

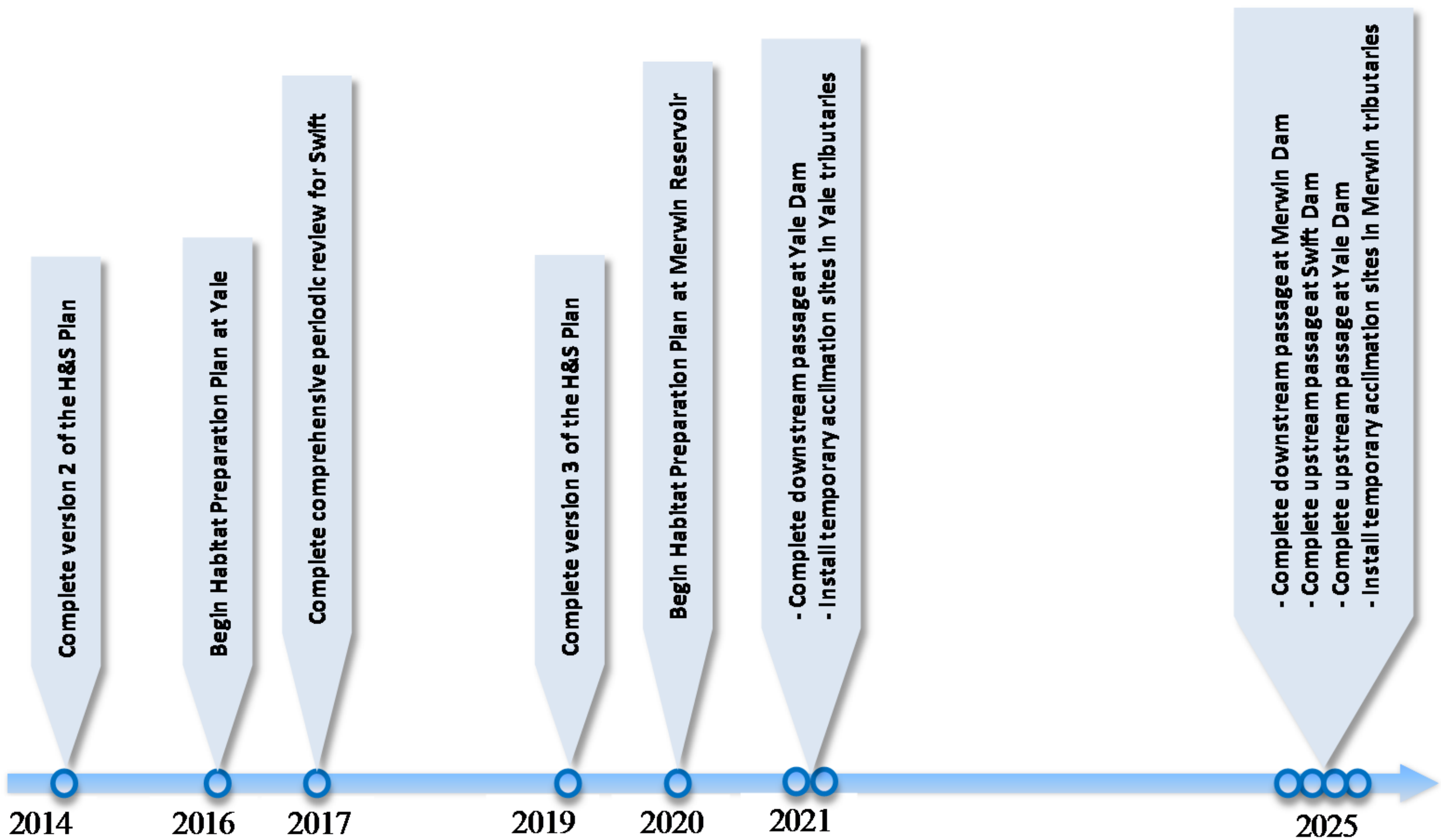

Figure 1-1. Generalized timeline by year for major milestones of the H&S and fish passage programs for the years 2014 through 2025.

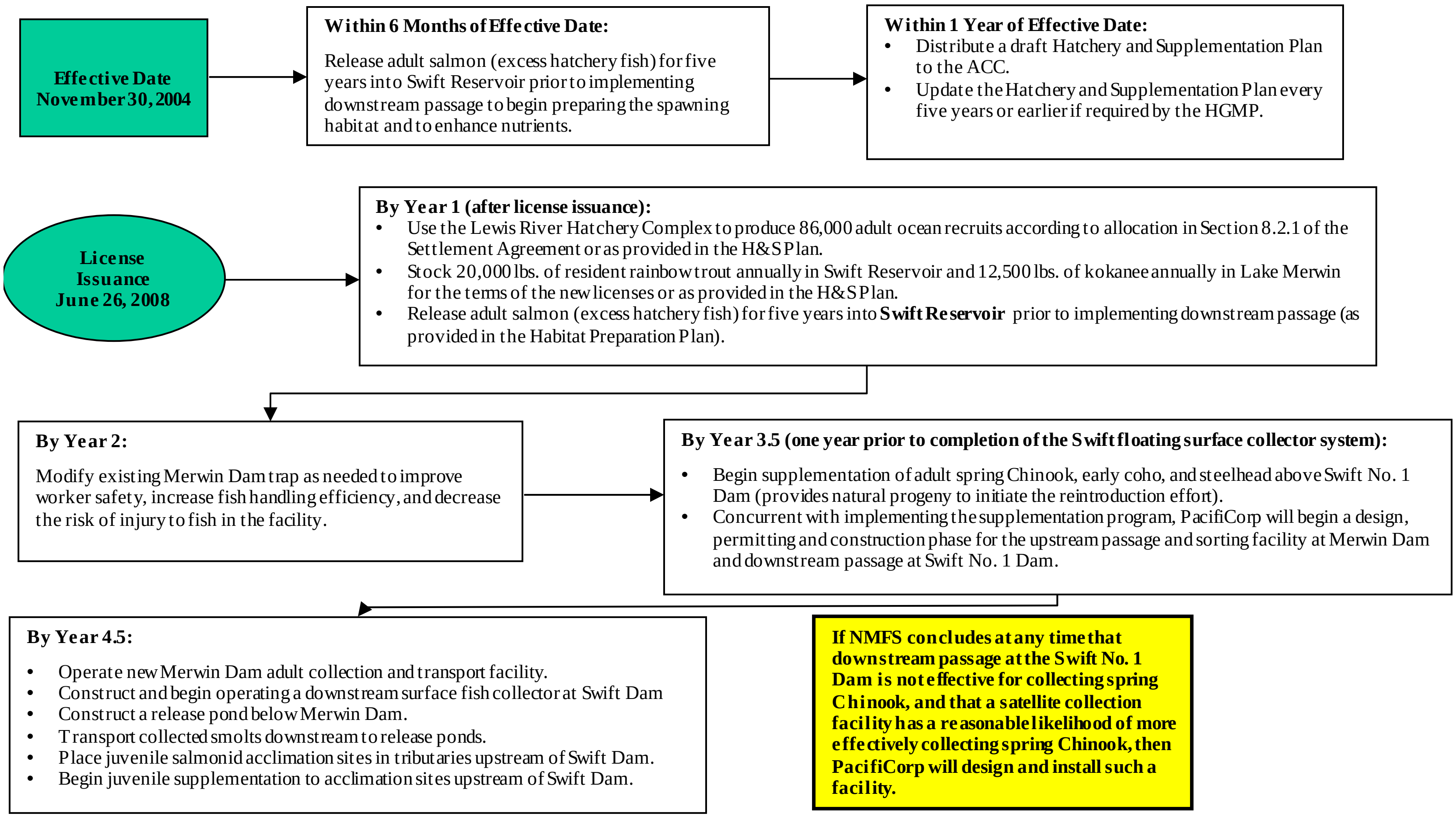

Figure 1-2. Settlement Agreement flow chart for anadromous fish reintroduction upstream of Swift Dam

Prior to Year 13:

- The ACC shall determine the timing for initiating supplementation into Yale Lake and Lake Merwin.
- Concurrent with implementing the Yale Lake supplementation program, PacifiCorp will begin a design, permitting and construction phase for downstream passage at Yale Dam.

Year 8 (five years prior to expected completion of the downstream fish passage facility in Yale Lake):

If adjacent decision box results in a "go" decision, release adult salmon (excess hatchery fish) for five years into **Yale Lake** prior to implementing downstream passage to begin preparing the spawning habitat and to enhance nutrients (as provided in the Habitat Preparation Plan.).

The Licensees will construct and operate the Yale and Merwin downstream facilities and the Yale and Swift upstream facilities as described above unless the Services, upon a review of new information relevant to reintroduction of fish passage into Yale Lake and Lake Merwin, determine at least four and a half years prior to the operation date for a passage facility that the facility should not be constructed.

Year 12 (five years prior to expected completion of the downstream fish passage facility in Lake Merwin):

- Release adult salmon (excess hatchery fish) for five years into **Lake Merwin** prior to implementing downstream passage (as provided in the Habitat Preparation Plan).
- Concurrent with implementing the Lake Merwin supplementation program, PacifiCorp will begin a design, permitting and construction phase for downstream passage at Merwin Dam. The Lake Merwin plan is dependant on the yellow box and is not scheduled to begin if the Agencies decide against passage into Merwin.

By Year 13:

- Install and begin operating a floating surface collector in Yale Lake. Collect fish, sort, mark, and truck to release pond below Lake Merwin.
- Install juvenile acclimation sites in Yale Lake (temporary sites in tributary streams).
- Expand the Yale Lake adult supplementation program to include juvenile salmon and steelhead. **The program will continue for a minimum of 15 years for spring Chinook and winter steelhead and 9 years for early-run coho.** At the end of these time periods, the Licensees shall assess on a year-by-year basis whether to extend the supplementation of juvenile salmonids.

By Year 17:

- Construct and begin operating an upstream adult trap and sorting/trucking facility at Yale Dam.
- Construct and begin operating an upstream adult trap and sorting/trucking facility at the Swift projects.
- Install and begin operating a floating surface collector in Lake Merwin. Collect fish, sort, mark a sub-sample, and truck to a release site below Lake Merwin.
- Install juvenile acclimation sites in Lake Merwin (temporary sites in tributary streams).
- Expand the Lake Merwin adult supplementation program to include juvenile salmon and steelhead. **The program will continue for a minimum of 15 years for spring Chinook and winter steelhead and 6 years for early-run coho.** At the end of these time periods, the Licensees shall assess on a year-by-year basis whether to extend the supplementation of juvenile salmonids.

Figure 1-3. Settlement Agreement flow chart for anadromous fish reintroduction upstream of Yale and Merwin dams

2.0 HATCHERY PROGRAMS AND OPERATIONS

The hatchery program includes the production of fishes for the main purpose of harvest. Juveniles reared at the three hatchery complex are released in both the North Fork Lewis River downstream of Merwin Dam (anadromous) and in Merwin and Swift reservoirs (resident) (Table2-1). Other juvenile production from native winter steelhead or spring Chinook for acclimation are included in Table 2-1, but are discussed in Section 3.0 - Supplementation Programs.

Table 2-1. Juvenile hatchery production for the Lewis River hatchery complex and release locations.

Species	Number of fish or (pounds)	Release Location
Spring Chinook	1,250,000	North Fork Lewis River
Spring Chinook	100,000	Upstream of Swift (supplementation)
Winter Steelhead	100,000	North Fork Lewis River
Winter Steelhead	50,000	North Fork Lewis River (supplementation)
Summer Steelhead	175,000	North Fork Lewis River
Coho Salmon	2,000,000	North Fork Lewis River
Kokanee	93,000 (12,500)	Merwin Reservoir
Rainbow trout	60,000 (20,000)	Swift Reservoir
TOTAL	**3,828,000**	

2.1 RESIDENT FISH PRODUCTION

As part of the H&S Plan, resident supplementation of both rainbow trout (Swift Reservoir) and kokanee (Merwin Reservoir) will continue. Rainbow trout production for Swift Reservoir will total 20,000 pounds; kokanee production of 12,500 pounds will be released into Merwin reservoir. It is important to note that neither of these programs shall interfere with reintroduction efforts and are to be managed separately. Thus, if these programs adversely affect the ability to create self-sustaining anadromous populations; management through the ACC and regulatory agencies will mitigate or possibly eliminate these programs.

2.2 HATCHERY FACILITIES

Hatchery rearing conditions have been modified through hatchery upgrades defined in Section and Schedule 8.7 of the Agreement. These upgrades were designed to improve operational flexibility and rearing conditions. Hatchery programming will be based on providing optimum rearing conditions for stocks regardless of current or historical rearing and release sites. Use of pond loading and agreed upon density and flow index guidelines, mating protocols that maximize genetic variability and modification of hatchery structures to allow volitional migration to the extent possible will enable hatchery populations to develop the physiological, morphological, and behavioral traits important to long-term fitness.

2.3 FISH MARKING

All hatchery fish released downstream of Merwin Dam will be mass marked by removing their adipose fin. The two exceptions being that double-index groups (DIG) of coho and spring Chinook used for harvest management purposes would still possess their adipose fin. All DIG fish will however be tagged with coded wire in their snouts to differentiate these fish from naturally derived stocks. Double-index groups at the hatchery will continue to be used until such time that sufficient numbers of smolts are collected at the floating surface collector(s) to enable an adequate sample size of naturally produced smolts. The second exception is winter steelhead smolts derived from native broodstock. These fish would also not have an adipose clip (to prevent harvest) but will be tagged with a blank (non-coded) wire in their snouts.

Juvenile fish captured at collection facilities at Swift Dam (and eventually other projects) will be subsampled but no marks or tags will be placed on these fish. However, upon completion of Yale downstream collection facility (planned for 2021), juveniles will be marked with a PIT tag, or suitable alternative as recommended by the resource agencies at Yale. This will allow returning fish to be distinguished as to their collection location of either Swift or Yale Dam[2]. Note that when Merwin fish passage facilities are constructed, naturally produced fish would no longer need to be differentially marked, as fish will have access to their natal stream by using passage facilities at each project.

2.4 ARTIFICIAL PRODUCTION MANAGEMENT

Over the short-term (<15-years) the existing spring Chinook and coho (Type S) hatchery programs would be run as Segregated programs. In other words, no wild fish would be used as hatchery broodstock (exception is juvenile spring Chinook used for acclimation). This approach results from the lack of local stocks adapted to stream conditions in the Upper Lewis River from which to integrate the existing program. After 3-5 generations of wild production, it is suggested that the hatchery programs be converted to Integrated consistent with HSRG guidelines.

The long-term objective (>15 years) for spring Chinook and coho (Type S) hatchery programs will be to operate these as an Integrated type as defined by the HSRG. The ratio of wild and hatchery origin fish used as broodstock, and released into the upper basin, would be tightly controlled. The primary goal of an Integrated hatchery program is to ensure that the natural environment and not the hatchery environment drive local adaptation.

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[2] Because fish are not marked at the Swift collector it is assumed that all unmarked NOR transport species that volunteer into the lower river traps will be of Swift origin and thus transported upstream of Swift Reservoir upon capture.

Segregated hatchery program fish will be reared to produce a smolt that migrates rapidly from the basin and maximizes adult production and contribution to fisheries. This will be achieved by implementing volitional release strategies to the extent possible given the limitation of hatchery facilities, and releasing fish at sizes that result in high survival or reduced effects on native salmonids. If volitional release is determined infeasible, then gill ATPase and smolt condition data should be collected on a weekly basis to determine when smoltification has occurred, thus defining the appropriate release time.

2.5 SEGREGATED AND INTEGRATED HATCHERY MANAGEMENT

The APRE identified hatchery-operating procedures that maximize the benefits of artificial production while minimizing the risks to wild fish populations. The APRE was built upon the scientific principles and criteria put forth by the HSRG. The HSRG identifies two primary purposes (or potential benefits) of artificial production, 1) help conserve naturally spawning populations, and 2) provide fish for harvest. To this end, the hatchery criteria put forth by the HSRG vary dependent on whether the hatchery is to operate as an Integrated or Segregated type program. The definitions for both types of programs are as follows:

- ***Segregated***: A hatchery program is considered Segregated if the manager’s intent is for the population to represent a distinct population that is reproductively isolated from naturally spawning populations. The principal intent of a Segregated program is to create a hatchery adapted population that can be used to meet harvest goals. Hatchery broodstock (and programs) are considered genetically Segregated if the broodstock is maintained only with hatchery origin (HOR) adults. Therefore, gene flow from the natural origin population (NOR) to the hatchery broodstock is actively managed against in a Segregated program. In addition, hatchery origin adults are prevented from spawning in the wild to prevent gene flow from the less well-adapted hatchery population to the native or wild population.

- ***Integrated:*** A hatchery program is classified as Integrated if the manager’s intent is for the natural environment to drive the adaptation and fitness of a composite population of fish that spawns both in the hatchery and the wild (i.e. natural environment). In an Integrated program, the proportion of natural origin broodstock in the hatchery and the proportion of hatchery fish on the spawning grounds determine the influence the hatchery and natural environments have on the composite population. The larger the ratio of wild fish to hatchery fish in either environment, the greater the influence wild fish genetics and adaptation will have on overall population genetics. The greater the difference between the hatchery and natural stock components (e.g. run-timing), and the less natural the hatchery environment, the larger the ratio must be to reduce the effects of hatchery selection.

This H&S Plan calls for the development (over time) of up to eight hatchery programs (Table 2-2). The primary purpose of each program is to provide either fish for harvest (Segregated-Harvest), or to reintroduce anadromous fish to the upper river (Integrated-Conservation/Restoration).

Table 2-2. Hatchery program types by species for the H&S Plan.

Program	Program Type	Primary Program Purpose
Lower River Spring Chinook	Segregated	Harvest
Lower River Type N Coho	Segregated	Harvest
Lower River Type S Coho	Segregated	Harvest
Lower River Summer Steelhead	Segregated	Harvest
Lower River Winter Steelhead	Segregated	Harvest
Upper River Spring Chinook	Integrated (long-term goal)	Conservation/Restoration
Upper River Type S Coho	Integrated (long-term goal)	Conservation/Restoration
Upper River Late Winter Steelhead	Integrated (long-term goal)	Conservation/Restoration

Hatchery production and facilities will be operated consistent with HSRG and APRE guidelines for Segregated and Integrated programs. The key HSRG guidelines used for each type of program is presented in Table 2-3.

The HSRG definitions fit well for those basins that have both wild and natural populations of the same species. The nomenclature doesn't fit as cleanly in the Lewis River because the wild fish populations in the Upper Lewis River basin have been extirpated. The exception is for the late winter steelhead program, which would have both a hatchery and wild fish stock component as wild steelhead are still found in the lower river.

The H&S Plan proposes to continue to operate lower river hatchery programs as Segregated type, based on two assumptions:

1) The existing hatchery programs have had no systematic gene flow from the natural populations.

2) Natural spawning population genetics and fitness has been compromised by hatchery fish spawning in the wild.

In short, it is assumed that the hatchery environment, not the natural environment, has been driving fish fitness and genetics in the basin since anadromous fish were extirpated from the Upper Lewis River basin.

Table 2-3. HSRG guidelines used for Segregated and Integrated hatchery programs.

Segregated (Harvest)	Integrated (Conservation)
Maintain an effective population N_e of at least 500 fish.	Use mating protocols that maximize the effective population size (N_e) in the hatchery, including factorial mating, maintenance of the individual pedigrees, and cryopreserved gametes when necessary.
Avoid the use of broodstock from natural populations or other hatchery populations	Collect and spawn adults randomly with respect to time of return, time of spawning, size and other characteristics related to fitness.
Mark or tag all hatchery released fish, so that the proportions of natural and hatchery origin fish among natural spawners and in the broodstock can be monitored and controlled.	Rear in a hatchery environment and with operational protocols that ensure all portions of the population are treated equally and have the same opportunity to contribute to the release population.
Produce fish that have the physiological fitness to migrate rapidly to saltwater and to survive in that environment through growth regimes that promote smoltification.	Mark or tag all hatchery-released fish to ensure correct identification for use in future broodstocks or in other monitoring programs.
Produce fish that have the morphological characteristics to meet harvest goals.	Use a hatchery environment that allows synchronization of adult maturation, incubation, and emergence, and out-migration with natural populations.
Produce fish that have the behavioral characteristics, such as adult run-timing to meet harvest goals.	Rear fish at reduced densities in enriched environments to improve cryptic coloration, territorial fidelity, and social behavior.
Avoid crowding and build-up of wastes and dead fish in fish holding units.	Release fish volitionally during the out-migration timing of the natural stock
Monitor fish health regularly and implement needed treatment immediately	Use a hatchery environment and operational protocols that maximize the survival of each individual including captive rearing.
Use prophylaxis by vaccination where feasible.	Use prophylaxis by vaccination where feasible, monitor the health of stocks regularly, and implement needed treatment immediately.
Use adequate diets that have been stored for only short periods.	Use adequate diets that have been stored for only short periods.
Use locally adapted stocks that are likely to develop reasonable resistance to pathogens likely to be present in the water supply.	Use locally adapted stocks that are likely to develop reasonable resistance to pathogens likely to be present in the water supply.
Avoid practices and situations likely to result in chronic stress (e.g. frequent fish handling etc.)	Avoid practices and situations likely to result in chronic stress (e.g. frequent fish handling etc.)

Comments received from the first version of this plan included several comments indicating reviewers would like to see the hatcheries run as Integrated programs as soon as feasible. The H&S Plan proposes to achieve this objective by following the HSRG methodology shown in Table 2-4. This is the recommended approach given the existing conditions related to hatchery management and hatchery effects on native stocks over several decades. The HSRG recommends that managers allow three to four generations to establish a locally adapted population before integrating the hatchery programs. If reintroduction is successful, then it is likely that sufficient locally adapted spring Chinook and Type S coho adults would be available for integration sometime between years 12-17 of the new license[3]. At that time, according to the HSRG guidelines, the program would move towards the guidelines set in Table 2-4 below. The recommended guidelines do not interrupt fish harvest on the Lewis River which is not preferred in this popular sport fishery.

Table 2-4. HSRG guidelines for developing an Integrated hatchery program if natural production (and thus fitness) has been compromised by hatchery releases.

<table>
<tr><td colspan="2">Transition from an incompletely Segregated program to an Integrated program.
Assumptions:
• Hatchery broodstock has had no systematic gene flow from the natural population
• Natural spawning population has had significant influence from hatchery fish</td></tr>
<tr><th>Recommended Approach: Plus Differential Marking - Recommended approach if attaining harvest goal cannot be interrupted during transition to Integrated program</th><th>Considerations</th></tr>
<tr><td>• Take steps to reduce the number of hatchery fish in the natural population to less than five percent of the natural population (reduce hatchery program, selectively harvest to limit strays, use a weir or other measures to control straying).
• Allow a minimum of three to four generations to promote adaptation to the natural environment.
• Initiate a new hatchery program by collecting representative sample of natural fish.
• Collect a number of brood that allows for an effective population size of the composite population (natural plus hatchery) in excess of 500 fish.
• If a long-term goal of the hatchery program is to provide a conservation benefit, or if the natural spawning of hatchery-origin fish will be difficult to control, then the effective population size of the hatchery component should also be greater than 500 fish.
• Differentially mark and release offspring of hatchery and natural origin broodstock. Preferentially use returns that represent the NOS broodstock. Phase out use of hatchery origin broodstock as natural origin broodstock returns.
• Incorporate a minimum of 10% NORs into hatchery broodstock each year once new broodstock returns.
• Ensure that gene flow from the natural to the hatchery population is greater than gene flow from the hatchery to the natural population (pNOB > pHOS).
• For stocks of moderate or high biological significance and viability (or goals to maintain or improve the biological significance and viability of the stock), pNOB/(pHOS+pNOB) should be greater than 0.70.
• Size program consistent with goals and the ability of the natural population to support hatchery broodstock requirements and gene flow limitations to the natural population.</td><td>Likelihood of achieving natural adaptation: Intermediate likelihood of attaining stock goals because of the uncertainly of adaptation to the natural environment after three to four generations. The likelihood of meeting stock goals increases with the amount of time allowed before initiating a new program and a lower contribution of hatchery fish in the natural population.

Cost: Increase in cost incurred for broodstock collection appears similar for all approaches. An additional cost for differentially marking the two hatchery broodstocks would be incurred. Cost in terms of operational complexity is higher than all other approaches except Approach #4, but should be no greater than rearing an additional species.

Effect on Harvest: Reduces loss of contribution to harvest during transition from the previous approach.</td></tr>
</table>

[3] Type N coho will not be released above Merwin Dam. Late winter steelhead will be run as an Integrated program from the start, as wild adults are available for use as broodstock.

2.6 HATCHERY PRODUCTION

The number of hatchery juveniles to be released as part of the harvest and supplementation programs is presented in Table 2-5.

Table 2-5. Juvenile release numbers by species for hatchery and supplementation programs.

Smolt Production	Spring Chinook	Summer Steelhead	Winter Steelhead	Wild Late-Winter Steelhead	Coho
Hatchery	1,250,000	175,000	100,000	NA	2,000,000
Supplementation	100,000	NA	NA	50,000	NA
Total	**1,350,000**	**175,000**	**100,000**	**50,000**	**2,000,000**

2.6.1 Release Size

Hatchery juveniles would be released at the following size ranges:

1. Coho- 14-16 fish per pound (fpp)
2. Spring Chinook- 8-12 fpp
3. Winter and Summer Steelhead 4.8-8 fpp

Hatchery juveniles release size and timing may be altered once wild fish are captured at the Swift Dam juvenile collection facility starting in year 4.5 of the license. These wild fish would be used as the template for evaluating release size and timing for the basin.

2.6.2 Broodstock Needs

The hatchery broodstock and adult supplementation targets for the H&S Plan are presented in Table 2-6. Adult Supplementation targets represent fish that are transported upstream of Swift Dam to spawn naturally. To achieve these adult targets WDFW will establish a harvest policy in the Lower Lewis River that assists in achieving adult spring Chinook, late winter steelhead and coho return targets to adult collection facilities.

Table 2-6. Approximate adult broodstock targets for the Lewis River needed for hatchery (Segregated) and supplementation (Integrated) programs.

Smolt Production	Spring Chinook	Summer Steelhead	Winter Steelhead	Wild Late Winter Steelhead	Type-N Coho	Type-S Coho
Hatchery Broodstock	1,000	105	90	0	800	800
Adult Supplementation (transported upstream)	2,000	0	0	500	0	9,000
Juvenile Supplementation broodstock*	65	0	0	50	0	0
Total	**3,065**	**105**	**90**	**550**	**800**	**9,800**

*** Value represents broodstock required to meet juvenile supplementation targets.**

2.6.3 Resident Fish

2.6.3.1 Kokanee

No changes are proposed for the existing kokanee program as the continued release of this species poses little risk to the success of the reintroduction effort being undertaken above Swift.

However, as anadromous fish are reintroduced into Merwin reservoir starting in year 12 of the license, the ACC should review the program and determine if it should be continued[4]. The decision to maintain the program would need to consider the importance of Lake Merwin as a rearing area for coho juveniles and management implications and cost of possibly handling large numbers of kokanee juveniles at the proposed Merwin juvenile collection facility. Ideally, all juveniles collected at the Merwin facility would be bypassed directly to the lower river with a minimum of handling. Unless managers allow kokanee to be released below Merwin Dam, then these fish would have to be sorted and released upstream of the dam.

2.6.3.2 Resident Rainbow Trout

The 2006 resident trout program calls for the release of approximately 20,000 pounds of rainbow trout into Swift Reservoir. Releases are sized at approximately three per pound resulting in about 60,000 catchable rainbow trout. These fish provide sport-fishing opportunities for both local residents and visitors to the area.

The H&S Plan proposes that the rainbow trout program continue so long as the number of these fish entering juvenile collection facilities can be sorted accurately without

[4] In year 12, anadromous fish may be released into Merwin, if agreed to by the ACC.

anesthetization and returned upstream (i.e., not transported downstream of Merwin Dam). Data collected on a similar program at Mayfield Reservoir on the Cowlitz River show that rainbow trout released for similar purposes are captured in large numbers (3,000 to 7,000) at the Mayfield juvenile collection facility (Mark LaRiviere, Tacoma Power, pers. comm. 2005). Stocked rainbow trout collected at the Swift floating surface collector are directed to adult holding tanks based on their size and returned to the reservoir (i.e., not passed downstream). In addition, all stocked rainbow will be adipose clipped to facilitate identification and harvest.

The combined actions proposed in the H&S Plan are designed to achieve the hatchery and natural production targets shown in Table 2-7. The values in the table are referred to as adult Ocean Recruits, which include escapement plus the number of fish caught or available in ocean and freshwater fisheries. The methodologies that can be used for estimating ocean recruits are presented in Appendix C of this report.

Table 2-7. Hatchery and natural production adult threshold levels (ocean recruits) for spring Chinook, steelhead and coho.

	Spring Chinook	Steelhead (Summer, Winter, Late Winter)	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**

2.7 MODIFICATIONS TO HATCHERY PRODUCTION

Modifications to hatchery production may be made as natural production in the upper basin increases. As natural production upstream of Merwin Dam for each species exceeds its threshold level, hatchery production levels for that species would be reduced on a 1:1 basis. For example, when natural spring Chinook adult recruits equal 3,977 fish (1,000 fish over threshold value of 2,977), the hatchery production target for this same species would be reduced by 1,000 adults to 11,800 (12,800-1,000 = 11,800). This would be accomplished by reducing the number of juveniles released from the hatchery each year for that species based on the average survival rate calculated over a 5-year period. The decision to adjust hatchery production to achieve threshold levels would be considered by the ACC every 5-years based on the results of the Ocean Recruits analysis (see M&E section)[5]. Note that hatchery targets may be increased back to initial levels if natural production were to decrease to below the threshold level. It is important to note that downward modifications to hatchery production based on increases in natural production are consistent with HSRG recommendations.

[5] The 5-year period was selected, as it is consistent with the independent review process established in the Settlement Agreement. The ACC will have the opportunity to evaluate hatchery production every year as part of their review of the Annual Hatchery operations plan.

However, as called for in the Agreement, hatchery production targets would not be reduced below the "Hatchery Target Floor" levels shown in Table 2-8. In summary, no matter how many anadromous fish are produced above Merwin Dam, Lewis River hatcheries would continue to release sufficient juveniles to achieve the hatchery target floor[6].

Table 2-8. Hatchery target floor levels for adult spring Chinook, steelhead and coho.

	Spring Chinook	Steelhead	Coho	Total
Hatchery Target Floor	2,679	2,763	12,558	18,000

[6] Development and approval of hatchery and genetic management plans may modify this floor to comply with take prohibitions under the Endangered Species Act.

3.0 SUPPLEMENTATION PROGRAM

Supplementation is defined by the Regional Assessment of Supplementation Project (RASP 1992) as follows:

"Supplementation is the use of artificial propagation in an attempt to maintain or increase natural production, while maintaining the long-term fitness of the target population and keeping the ecological and genetic impacts on non-target populations within specified biological constraints."

Because anadromous fish have been extirpated from the Upper Lewis River basin, the supplementation program proposed is designed to re-establish self-sustaining populations of Type S coho, spring Chinook and late winter steelhead upstream of Merwin Dam.

The H&S Plan provides an approach to reintroduce adult spring Chinook, winter steelhead, and Type S coho into stream reaches upstream of Swift Dam, and in later years into Yale and Merwin reservoirs. Adult supplementation strategies will be used as the primary method to jump start fish production in the Upper Lewis River. The source of adult supplementation fish for both spring Chinook and Type S coho will be derived from hatchery stocks. Supplementation of winter steelhead adults will come from returns of juvenile supplementation efforts in the lower river that originate from native stocks but are spawned and reared for one year in the hatchery facility and released as yearlings downstream of Merwin Dam[7]. Wild adult steelhead collection would continue for 12-years to ensure that sufficient genetic diversity was obtained to prevent founder effects (i.e. starting with too little genetic resources)[8].

In addition to adult spring Chinook, yearling spring Chinook will be released upstream of Swift Reservoir as part of acclimation efforts. Yearling spring Chinook will be planted in established acclimation sites upstream of Swift Reservoir and allowed to migrate volitionally from these sites. A 10 percent subsample of these juveniles will be marked with a body cavity PIT tag prior to release in acclimation sites to evaluate acclimation site performance and migration timing upon capture in the floating surface collector. These fish may also provide test specimens for evaluating juvenile collection facilities at Swift Dam.

For adult spring Chinook and Type S coho, returns in excess of hatchery broodstock needs will be transported and released in river reaches upstream of Swift Dam as part of the adult supplementation strategy (Table 3-1).

Returning adult winter steelhead that possess a blank wire snout tag will be transported upstream and not used as hatchery broodstock. Winter steelhead broodstock will be

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[7] The H&S plan considered rearing 2+ smolts for the late winter steelhead program, but this idea was rejected in favor of the 1+ smolt program. The logic being that the longer hatchery residence time would reduce the fitness of the population by selecting traits for traits that increase survival in the hatchery environment.
[8] Collecting 50 wild adults for 12 years meets/exceeds HSRG criteria for eliminating founder effects.

comprised of up to 50 (25 pairs) native winter steelhead parents each year. All potential broodstock genotypes will be compared against the existing native winter steelhead baseline for the Lewis River to ensure that hatchery strays are not used. The program will release up to 50,000 yearling smolts marked with a blank wire tag snout tag (or acceptable alternative), and released downstream of Merwin Dam (Table 3-1). In essence, the late winter steelhead hatchery program would be run as an Integrated type as defined by the HSRG.

As spring Chinook, Type S coho, and steelhead populations become established in the upper basin, hatchery supplementation into this area would be reduced. This action would ensure that local adaptation for each species is driven by the natural not the hatchery environment. However, this action would not be considered for implementation until at least year 9 (2018) for Type S coho, and year 15 (2024) for spring Chinook and late winter steelhead.

Table 3-1. Minimum Supplementation targets for adults and juvenile spring Chinook, coho and winter steelhead upstream of Swift Dam and downstream of Merwin Dam.

	Spring Chinook	Type S Coho	Steelhead
Adults (upstream of Swift Dam)	**2,000**	**9,000**	**500**
Juveniles	**100,000 (acclimation)**	**0**	**50,000 (downstream of Merwin Dam)**

A more detailed description of the proposed supplementation program for each of the three species is presented by species below.

3.1 SPRING CHINOOK

3.1.1 Supplementation Strategy

The reintroduction strategy for spring Chinook will rely on two life stages: smolts and adults. A total of 100,000 smolts and a minimum of 2,000 hatchery adults[9] (when available) will be released above Swift Reservoir to rebuild a natural spawning population[10]. The 2,000 adult minimum escapement target was selected based on EDT estimates of spawning capacity for habitat upstream of Swift No. 1 Dam, required passage survival and collection rates, and the average expected level of surplus hatchery adults (~3,200) available after ocean and freshwater fisheries (See Section 7).

[9] Adults may include a proportion of jacks as described in the Annual Operating Plan.
[10] The 2,000 release target is greater than the 1,200 recommended in the Lewis River Fish Planning Document (Table D-19)

The reintroduction strategy will be conducted as a 15-year[11] program that will continue throughout this period with no trigger points that would discontinue the program prior to its completion[12].

This supplementation program will prioritize natural origin returns as the preferred strategy for supplementation of both adults and for use as broodstock for supplementation juveniles. However, because NOR's are rare for spring Chinook, the program will need to initially use mostly hatchery origin adults (HORs) for the adult supplementation strategy. After adults begin returning from the natural or supplemented releases, hatchery origin fish would only be used in the event that the number of fish produced above Swift are insufficient to meet the desired release numbers. The H&S Plan calls for the continuation of the adult and juvenile supplementation program for at least 15-years without interruption. Priority for the use of natural-origin returns will be as follows:

1. For use as broodstock for juvenile supplementation program: Up to 65 adults.
2. Use for adult supplementation into the upper watershed: All NOR's above juvenile supplementation needs (65 adults).

At the completion of this initial supplementation period, both smolt and adult supplementation will be evaluated annually and the population will be monitored to determine if reintroduction goals have been achieved. This action is consistent with the Agreement that states the primary goal of the program is to establish self-sustaining, naturally producing, harvestable native anadromous salmonid populations. To determine sustainability will require the elimination of the supplementation program at some time in the future. However, any decision to terminate the program would be made in consultation with the ACC.

3.1.2 Broodstock Origin

Broodstock for the reintroduction efforts will initially come from returns to the Lewis River hatchery complex. This stock has been chosen since the original wild stock has been extirpated and the existing hatchery population, although originating from multiple out-of-basin stocks, has been self-sustaining in the Lewis River for approximately four (4) generations (WDFW and PacifiCorp Energy, 2014a). This stock therefore represents the stock most likely to adapt to environmental conditions in the Lewis River. The hatchery stock will be used in the first generation of the supplementation efforts. Once adult fish return from smolt or adult releases, the supplementation program will preferentially use these returns for both juvenile and adult releases. Hatchery origin spring Chinook will only be used if the number of adults produced from above Swift is not sufficient to meet the broodstock needs for the juvenile program (approximately 65 adults) or the adult supplementation objective of 2,000 adults.

[11] The Settlement Agreement calls for supplementation to continue for 15-years.
[12] However, the ACC may stop or continue the program based on collected data.

Although actual spring Chinook productivity and capacity of the upper watershed is currently estimated from modeling, the goal will be to reduce the use of hatchery-origin adults in the upper watershed over successive generations and at some point eliminate the use of HOR spring Chinook. Therefore, all NOR spring Chinook that volunteer into traps will be used first for juvenile supplementation and then adult supplementation efforts in the upper basin. Because this plan recommends the use of all available NOR returning to traps for supplementation, there is no set standard or timeline other than the primary goal is to achieve a self-sustaining population of spring Chinook that does not rely on hatchery origin spring Chinook. That is, supplementation will end at some point.

The approach described above should only be used as a guide for adaptive management decisions by the ACC. The decisions for broodstock use, composition of broodstock, and continuation or suspension of the supplementation program should be based on monitoring of survival rates and productivity in the upper watershed as well as demographic and genetic risks to the supplemented population.

In recent years, there have been inadequate returns of adult spring Chinook available for transport upstream. Because this creates generational gaps and inconsistent cohorts, the adult supplementation program may need to be extended to achieve the NOR composition goals.

If spring Chinook returns continue to be depressed and insufficient to provide adults for supplementation upstream, then the ACC should consider either increasing juvenile supplementation to either supplement adult targets, use of Kalama River returns or abandon adult supplementation entirely. This decision should take into consideration the ability of the Swift collector to achieve collection targets for juvenile Chinook.

3.1.3 Broodstock Collection and Mating

Broodstock for both the smolt and adult supplementation strategies will be collected so that fish for these programs will represent the entire run timing of the returning population. The juveniles released in the program will represent the full range of return timing of the existing stock. In order to accomplish this, eggs for this program must be taken throughout the run, or fish transported to upriver acclimation ponds should be collected as a sub-sample from the entire spring Chinook rearing population. Since adults released into the watershed will select their own mates, only the juvenile portion of the program requires mating protocols. Spawning protocols for the juvenile program should strive for selective neutrality and ensure that maximum genetic effective number of breeders represented in the population. The current protocol of single family pairing and incorporation of jacks into the spawning population should be sufficient to meet these needs when using the hatchery broodstock. Once returns from the upper watershed are used for broodstock, spawning protocols for the juvenile portion of the supplementation program should be modified to a 1X1 mating approach when feasible to increase the genetic effective population size for this portion of the program.

3.1.4 Incubation and Rearing of Acclimation Fish

Spring Chinook for this program will be incubated and reared at Speelyai Hatchery following the protocols described in the most recent WDFW spring Chinook HGMP (WDFW and PacifiCorp Energy, 2014a). Rearing conditions at Speelyai Hatchery will be managed to provide optimal flow and density indexes given current and planned hatchery upgrades. Fish will be held at Speelyai Hatchery until the yearling stage when they will be transferred to upriver acclimation sites following standard WDFW loading guidelines. Feeding of acclimation fish may not be required if adequate natural feed resources are available. This is preferred if practical to imitate conditions and growth patterns of naturally produced smolts. Yearling transfer will generally occur, approximately 6 weeks prior to release. Rearing conditions in the acclimation sites will also be managed to provide similar flow and density indices reached at Speelyai Hatchery.

3.1.5 Release Location and Numbers Released

Up to 100,000 smolts and a minimum of 2,000 adults (when available) will be released upstream of Swift Reservoir. Juveniles will be released volitionally from the acclimation facilities. The target release size will be approximately 8-12 fish per pound. Size released from acclimation sites will attempt to mimic the size of naturally produced spring Chinook outmigrants. A minimum of 2,000 adults will also be released near the head of the Swift Reservoir to spawn naturally in the upper Lewis River. This number of fish is based on the habitat capacity of 1,942 fish estimated by EDT for the Lewis River above Swift Reservoir considering both adult and juvenile passage survival once collection facilities are in place (99 percent and 80 percent respectively).

Although EDT may over or underestimate the habitat carrying capacity of the upper basin, the 2,000 adult release number may not be met in some years. Recent escapement to the hatcheries appears to have fallen and the 10 year average is approximately 2,000 fish (WDFW and PacifiCorp Energy, 2014a). These poor returns do not provide adequate fish numbers to meet the 2,000 supplementation goal after hatchery broodstock needs are met. To help meet supplementation targets, Kalama River returns may also be used for Lewis River supplementation as these fish are derived from Lewis River returns. If neither source provides sufficient adults, expansion of juvenile supplementation may be evaluated and presented to the ACC for approval.

Natural origin returns (NOR) will not be incorporated into the broodstock for the existing spring Chinook Segregated harvest program for the duration of the re-introduction program. At the completion of the 15 years and evaluation of stock sustainability, a decision will be made whether or not to modify the current Segregated harvest program into an Integrated program.

3.1.6 Habitat Preparation Program at Yale Reservoir

The preparation of gravels and nutrient enhancement as part of the Habitat Preparation Plan is anticipated to begin in Yale Reservoir beginning in 2016. This action is dependent on approval by the Services and whether passage facilities will be constructed at Yale. This decision will be based on ongoing studies to determine the feasibility of installing downstream passage at Yale. If the Services determine that downstream passage facilities at Yale are required, spring Chinook (if available) will be planted in Yale in accordance with Section 7.4 of the Agreement. The number of spring Chinook planted in Yale will be determined by the Habitat Preparation Plan drafted for that year but is expected to be low if any based on current run projections and priorities for hatchery broodstock and Swift Reservoir reintroduction efforts. Assuming adequate spring Chinook returns the target release number is likely to be less than 200 based on EDT analysis of available habitat in Yale tributaries.

3.2 COHO SALMON (TYPE S)

3.2.1 Supplementation Strategy

The reintroduction strategy for Type S coho salmon will rely entirely on adult supplementation. The strategy chosen is based on the availability of adult Type S coho from returns to the Lewis River Complex which have averaged over 21,000 returns between 2002 and 2013 (WDFW and PacifiCorp Energy 2014b). Also, coho have relatively high natural productivity and capacity (over 4 recruits/spawner and capacity of nearly 9,000 adults) in habitat upstream of Swift Reservoir that is estimated using EDT. Adult supplementation alone, in this case, should provide both the abundant founding population and the mechanism to increase population fitness as described in the Lewis River Fish Planning Document (Cramer and Associates 2004).

Initially, 9,000 Type S Coho adults (when available) will be released upstream of Swift Dam to rebuild a natural spawning population[13]. The 9,000 adult minimum escapement target has been in place since the original H&S Plan was finalized and was based on EDT estimates of spawning capacity for habitat upstream of Swift Dam. EDT estimates have not changed and assumptions regarding near term return rates for type S coho remain stable. Coho returns in excess of hatchery broodstock and upstream supplementation needs will be surplused by WDFW protocols.[14]

[13] The 9,000 adult release target is greater than the 6,200 proposed in the Lewis River Fish Planning Document (Table D-19)

[14] In years when surplus exceeds 9,500 adults, the ACC will need to determine whether or not to release additional coho into the upper watershed. Note that the release number is greater than the 6,200 proposed in the Lewis River Fish Planning Document (Table D-19).

3.2.2 Broodstock Origin

Broodstock for the reintroduction efforts will initially come from returns of early Type S coho to the Lewis River hatchery complex[15]. This stock has been chosen since the native Lewis River coho provided the initial broodstock for the hatchery program and because historical information suggests that early coho were predominately upper Lewis River spawners (WDFW and PacifiCorp Energy, 2014b). This stock therefore represents the stock most likely to adapt to environmental conditions in the Lewis River. The hatchery stock will be used in the first generation of the supplementation efforts. As adults return from upper basin adult releases, the supplementation program will use these NOR returns for further introduction upstream of Swift Reservoir. Hatchery origin adult coho will only be used if the number of adults produced from above Swift Dam is not sufficient to meet the adult supplementation objective of 9,000 adults. Because this plan recommends the use of all available NOR returning to traps for supplementation there is no set standard or timeline other than the primary goal is to achieve a self-sustaining population of early coho that does not rely on hatchery origin spring coho. That is, supplementation will end at some point.

The approach described above should only be used as a guide for adaptive management decisions by the ACC. The decisions for broodstock use, composition of broodstock, and continuation or suspension of the supplementation program should be based on monitoring of survival rates and productivity in the upper watershed as well as demographic and genetic risks to the supplemented population.

3.2.3 Hatchery Protocols

Since only adult supplementation will be used, broodstock collection, mating, rearing and release protocols will not be necessary.

3.2.4 Broodstock Collection

Adults for the supplementation program will be collected so that fish will represent the entire run timing of the returning population.

3.2.5 Release Location and Numbers Released

Initially, 9,000 hatchery origin adults will be released upstream of Swift Dam to naturally distribute themselves and reproduce. Data collected on adult coho released in the Upper Lewis River basin indicate that hatchery adult coho distribute throughout the watershed and produce large numbers of juveniles (PacifiCorp and Cowlitz PUD. 2004b).

An adult release of 9,000 coho is based on the habitat capacity of 8,800 fish estimated by EDT for the Lewis River upstream of Swift Dam considering both adult and juvenile passage

[15] Broodstock collection dates for Type S coho would be established by the WDFW.

survival once collection facilities are in place (99 percent and 80 percent respectively)[16]. As naturally produced adults from the supplementation program return, priority for introduction into the upper watershed will be given to fish that were produced in the upper watershed. All returning natural origin adults will be transported to the upper watershed to spawn naturally. Hatchery origin fish will only be used in the event that fish produced above Swift Reservoir are not sufficient to meet the 9,000 fish goal. At the completion of the 9-year period, adult supplementation with any hatchery origin fish will be annually evaluated to determine if sufficient natural origin returns are available to spawn in the upper watershed. The population will be monitored to determine if reintroduction goals for this species have been reached.

Natural origin returns will not be incorporated into the broodstock for the existing Type-S coho harvest program for the duration of the re-introduction program[17]. At the completion of the 9 years and evaluation of stock sustainability, a decision will be made whether or not to modify the current Segregated harvest program for Type-S coho into an Integrated Harvest program.

3.3 STEELHEAD

3.3.1 Supplementation Strategy

The reintroduction strategy for steelhead will rely on two life stages: smolts and adults. Since relatively few wild steelhead adults are currently available, approximately 50 adults from the native population will be collected through existing traps and in-river netting. Potential broodstock will be screened through microsatellite analysis (or appropriate alternative) and assigned a probability to existing Lewis River indigenous stock baselines. Only broodstock that meet criteria as outlined in the Annual Operating Plan will be retained for potential spawning. This ensures with reasonable certainty that the program is using only native broodstock for reintroduction into the upper basin.

As the program continues to incorporate native broodstock from the Lewis River it is important to closely monitor the extent of broodstock mining on the natural population and equally important the number of broodstock that are used in the program each year and whether a genetic bottleneck is occurring and potential “Ryman-Laikre” effect to occur (Ryman and Laikre 1991). These concerns should be evaluated each year as part of the monitoring and evaluation portion contained in the annual operating plan.

Up to 50,000 smolts produced from captured native winter steelhead will be volitionally released from Merwin Hatchery as yearling smolts. Upon return, adults from this program

[16] The ACC raised concerns that EDT estimates of carrying capacity may be too low, and suggested more fish be released upstream of Swift. The EDT release exceeds the 6,200 recommended in the Lewis River Fish Planning Document.
[17] The plan uses the HSRG assumption that it will require 3-4 generations to build a truly wild stock that can be used for integrating into the hatchery environment. Until this occurs, the HSRG does not recommend the development of an Integrated program.

will be transported upstream of Swift Reservoir to build a natural spawning population in the upper watershed. Adults returning from the program smolt releases will only be used for reintroduction. Broodstock for the program will be derived each year from existing native stock[18] (non-program returns) in order to improve the effective population size of the reintroduced stock. Supplementation will be conducted for 15-years, unless otherwise determined by ACC through adaptive management. Throughout this period there are no proposed trigger points that would discontinue the program prior to its completion. The 15-year period was selected as it is required in the Agreement (Section 8.5.1 of Settlement Agreement) with provision for continuation of supplementation.

3.3.2 Broodstock Origin

Broodstock for the reintroduction efforts will come from native late winter steelhead returning annually to the North Fork Lewis River or Cedar Creek if necessary. Since each potential broodstock is assigned a genetic probability as to origin, native broodstock are the most appropriate for use in the supplementation program.

As in the reintroduction programs for spring Chinook and coho, the goal of this program will be to reduce the reliance on mining native broodstock for supplementation as natural stocks increase in the upper watershed. A proposed approach is described in Table 3-2 below:

Table 3-2. Priorities for use of hatchery and natural-origin late winter steelhead broodstock (NOR)

Generation after Introduction	Broodstock Source, Number and Composition
1st Generation (3-4yrs)	All broodstock for juvenile supplementation releases obtained from native adults (50 fish goal) all adult returns from the juvenile program transferred to the upper watershed; 500 minimum total adults is the target.
2nd Generation (5-8yrs)	All broodstock for juvenile supplementation releases obtained from native adults (not adult returns from supplemented juveniles); all adult returns from the juvenile supplementation to be transported upstream; 500 minimum total adults is the

[18] Within 4 years after the first release of transported adults upstream there is no accurate method to determine potential broodstock origin from naturally spawning population upstream of Swift Dam or downstream of Merwin Dam.

	escapement target.
3rd Generation (9-12 yrs)	All broodstock for juvenile supplementation releases obtained from wild adults (not adult returns from supplemented juveniles); all adult returns from the juvenile supplementation; 500 minimum total adults is the escapement target
4th Generation (12-15 yrs)	Juvenile supplementation program may be suspended after ACC review and decision; all adults with intact adipose fins arriving at Merwin released upstream of Swift Dam

The approach described above should only be used as a guide for adaptive management decisions by the ACC. The decisions for broodstock use, composition of broodstock, and continuation or suspension of the juvenile supplementation program should be based on monitoring of survival rates and productivity in the upper watershed as well as demographic and genetic risks to the supplemented population.

3.3.3 Broodstock Collection and Mating

Broodstock for the smolt release strategy will be collected so that fish for this program will represent the entire run timing of the returning population. Returns from the juvenile supplementation program will not be used as broodstock. Instead, 100 percent of the broodstock will be collected each year from the native (non-program) stock in order to improve the effective population size of the reintroduced stock. Because fish are collected both at traps and through in-river netting it should be possible to collect a sufficient number of broodstock throughout the duration of this program to prevent founder effects to the progeny produced each year and over the duration of the program. This assumes that spawning crosses are representative of a robust broodstock source and not just a few crosses (families). Since adults released into the watershed will select their own mates, only the juvenile portion of the program requires mating protocols. There is concern that founder effects could adversely affect the native population by releasing large numbers of program smolts into the system that would then spawn with the native population downstream of Merwin Dam in subsequent years. This is especially troublesome if the release is represented by relatively few parents. This will need to be closely monitored through the AOP to mitigate this risk.

Spawning protocols for the juvenile program should strive for selective neutrality and ensure that maximum genetic effective number of breeders represented in the population. Additionally, after disease certification has been met, all broodstock will be "live-spawned" and returned to the lower river when spawning is complete to minimize impacts to this species. Given the relatively small size of donors used to establish the introduced stock, a 1 X 1 mating protocol is preferred. If this is not always possible, 2x2 factorial crosses can be used to maximize the genetic effective population size in the smolt release program.

3.3.4 Incubation and Rearing

Steelhead for this program will be incubated and reared at Merwin Hatchery following the protocols described in the most recent WDFW winter steelhead HGMP (WDFW and PacifiCorp Energy, 2014c). The goal of the program will be to produce a one-year smolt that will rapidly emigrate from the system. The target release size will be between 4.8 and 8 fish per pound with a condition factor of < 1.0 and fork lengths between 180 – 210 mm. These targets were chosen to reduce residualism in undersized juveniles and maximize survival for adult supplementation (NMFS 1999). In order to reach these goals, early rearing water may need to be heated in order to allow multiple egg takes to be combined into a single rearing unit, and to reach the goals for release size.

HSRG guidelines should be incorporated to the extent possible with this Integrated program to ensure that hatchery effects are minimized and risks to the endemic population are minimized. This may include rearing strategies that produce an actively migrating smolt that has behavior and condition factors that mimic natural smolts to the extent possible.

3.3.5 Release Location and Numbers Released

Up to 50,000 smolts will be volitionally released starting in April, to coincide with smolt outmigration timing of wild juveniles. Currently, hatchery managers note that facilities are insufficient to allow for a true volitional release directly into receiving waters. Instead, fish will have to volitionally migrate from the raceways (or ponds) to a collection facility, and then transported and released as directed by the Annual Operations Plan for wild winter steelhead. The release location will be sited so that the recovery of returning adults is maximized (i.e., trapping efficiency is maximized). All returning adults from this program will be released upstream of Swift Dam to spawn naturally in the upper Lewis River.

4.0 OCEAN RECRUITS

According to the Agreement, the H&S Plan needs to be designed to achieve the numeric adult hatchery targets shown in Table 2-7. These targets are referred to as Ocean Recruits.

Ocean Recruits is defined in the Agreement as:

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

Jacks are not included or counted as part of the ocean recruits analysis (May 11, 2006 ACC Meeting).

Estimating ocean recruits is a more appropriate performance measure than counting the just the number of smolts released or produced. Ocean recruit analysis incorporates the fitness and survivability of smolt releases and is thus a more appropriate criterion for assessing survival and fitness performance of both hatchery and natural origin fish.

There are three possible methodologies that could be used to calculate Ocean Recruits:

Age 2 Recruits (Age2 Rec): Number of fish alive at the time of first recruitment into a fishery (typically at age 2). Represents the maximum number of fish available to be managed.

Adult Equivalent Run (AER): The total number of fish that would have returned to the spawning grounds at all ages in the absence of fisheries. AER represents the maximum number of spawners if no harvest occurred. In other words, our best estimate of run-size absent human interference.

Catch Plus Escapement (C+E): Total catch of all ages plus total escapement of all ages. This method is in reality the outcome of the harvest management activities affecting the species.

Because each methodology provides information that could be used to determine program success and improve management, it is recommended that each of the three analyses be completed for at least coho and chinook. Based on the Ocean Recruits definition provided above, it appears that program success should be based on the AER method as it defines total production absent fisheries. A preliminary assessment of each method including recommendations and issues for each method along with calculations is provided by Brian Pyper in Appendix C.

It should be noted that C+E, AER and Age2 Rec would also be calculated for Upper Lewis River origin fish as well as hatchery fish. As fish production increases in the Upper Lewis River basin, WDFW and the ACC should consider whether the Double Index group at the hatchery should be eliminated, as wild fish would provide data needed to estimate harvest impacts to wild Lewis River fish populations.

As natural production for each species exceeds the Natural Production Threshold level identified in Table 2-7, hatchery production levels for that species would be reduced on a 1:1 (one wild fish for one hatchery fish) basis. For example, if natural spring Chinook adult escapement (ocean recruits) is 3,977 fish (1,000 fish over threshold), the hatchery production target for this same species would be reduced by 1,000 adults to 11,800. The decision to adjust hatchery production would be made by the ACC every five years based on the results of the ocean recruits analysis. However, as called for in the Settlement Agreement, hatchery production targets would not be reduced below the "Hatchery Target Floor" levels shown in Table 2-8.

5.0 MONITORING & EVALUATION OBJECTIVES

Monitoring activities in the Lewis River basin as they relate to the Lewis River Settlement Agreement and FERC operating licenses are contained in two plans:

1. Aquatic Monitoring and Evaluation Plan – June 2010
2. Lewis River Hatchery and Supplementation Plan – December 2009

The Aquatic Monitoring and Evaluation Plan (M&E Plan) comprises the majority of monitoring and evaluation (M&E) activities in the basin including fish passage performance monitoring and life history performance of reintroduced species into the upper basin.

The hatchery and supplementation plan emphasizes hatchery monitoring and the effects of hatchery production on native species downstream of Merwin. Additionally, monitoring of coho, spring Chinook and winter steelhead abundance and distribution of both juvenile and adults in the lower river is a primary focus of the plan along with development of ocean recruit methodology and supplementation protocols.

This section describes the M&E Objectives of the hatchery and supplementation program which are consistent with the Agreement, current Hatchery and Genetic Management plans and supportive of Hatchery and Scientific Review Group recommendations as required under the Agreement and FERC operating licenses. This section has five main categories: Hatchery Effects, Hatchery Operations, Supplementation Program, and Life History Metrics. Monitoring of harvest on hatchery or supplementation stocks is not within the scope of this plan, but the M&E section of this plan provides recommendation for harvest managers to consider that protect key program objectives under Harvest Effects.

Study design, methodologies and standards (or targets) for each objective will be provided annually in the Annual Operating Plan (AOP) for this program. Whether objectives are met or not will be reported annually in the annual operating report. The AOP is a collaborative document and changes may be made to adaptively manage and incorporate new technology and monitoring practices as they develop. Additionally, M&E objectives contained in this section are not intended to be all inclusive and addition or subtraction of these objectives is entirely possible through adaptive management and the AOP process.

5.1 HATCHERY EFFECTS OBJECTIVES

The Agreement requires that the H&S Plan incorporate M&E protocols that can determine whether or not hatchery fish are a significant limiting factor to the establishment of self-sustaining, naturally producing, harvestable runs. It is difficult to quantify hatchery fish impacts on native fish populations. The term “significant” is also problematic since no numeric value has been assigned to the term. The task of defining this value shall be determined by the ACC.

Regardless, because hatcheries will provide the fish needed for the reintroduction effort, any effects these fish may have on program success will have to be accepted for upper basin fish populations. Long-term, the H&S Plan calls for eliminating all hatchery releases into the Upper Lewis River basin if data indicate that runs achieve the self-sustaining goal established in the Agreement.

To monitor the effects of hatchery production on native or naturally spawning fishes, the following monitoring and evaluation objectives should be considered as a minimum:

Objective 1: Determine adult composition (pHOS) of steelhead, Chinook and coho on spawning grounds downstream of Merwin Dam

Hatchery fish contribution to the composite spawning population (natural and hatchery) in river reaches below Merwin Dam will be used as the indicator of the level of risk hatchery fish pose to natural populations in this area. Based on HSRG guidelines, hatchery fish from Segregated programs shall not make up more than 5 to 30 percent of the total natural spawning population depending on the designation of that population (Table 5-1). Spawning and carcass surveys would be used to document whether these criteria are being met each year. Results of the surveys would be included in the annual report described in the Agreement. Note that it is unlikely that this HSRG guideline will be met early on in the reintroduction effort because the lower river is composed almost entirely of hatchery origin spring Chinook and coho and no separation between spawn time exists as it does with winter steelhead.

Whether or not hatchery programs should be changed if this criterion is violated is the responsibility of fishery managers and likely a key requirement in the hatchery and genetic management planning process. Options for reducing impacts could include the development of new hatchery release strategies, reduction or elimination of some hatchery programs, harvest management or other removal means for hatchery fish.

Table 5-1. HSRG criteria for populations designated as Segregated or Integrated and whether these populations are considered primary, contributing or stabilizing as defined by the HSRG.

Species	Program	Type	Population Designation	$pHOS_{Eff}$	PNI	Abundance	
						Historical	Target
Spring Chinook	Hatchery	Segregated	Primary	< 5%	> 0.67	15,700	1,500
Coho*	Hatchery	Segregated	Contributing	<10%	> 0.50	40,000	500
Late Winter Steelhead	Supplementation	Integrated	Contributing	<30%	> 0.50	NA	500**
Spring Chinook	Supplementation	Integrated	Primary	<30%	> 0.67	NA	2,000**
Winter Steelhead	Hatchery	Segregated	Contributing	<10%	> 0.50	8,300	400
Early Coho	Supplementation	Integrated	Stabilizing	NA	NA	NA	9,000**

Source: (WA Lower Columbia Fish Recovery Board, 2010)

* includeds both early (typs s) and Late (type n) coho

** Value reflects target abundance upstream of Swift Dam (PacifiCorp and Cowlitz PUD 2009)

$pHOS_{Eff}$ = Effective proportion of Hatchery Origin Spawners (HSRG 2014)

PNI = Proportionate Natural Influence (HSRG 2014)

NOTE: In determining the Proportionate Natural Influence (PNI), the HSRG does not recommend using just census data for fish on the spawning grounds. Rather, the HSRG refers to the effective pHOS which takes into account the reproductive success of hatchery fish relative to natural origin spawners. Because the native spring chinook population is extirpated from the Lewis these criteria don't apply but as natural production in the upper basin increases over time it is important to understand that pHOS should ideally be zero.

Objective 2: Develop and monitor protocols to reduce hatchery effects on juvenile native and ESA listed species present downstream of Merwin Dam.

A primary impact to naturally spawning fish populations downstream of Merwin Dam come from hatchery operations. The release of over 3.5 million hatchery juveniles annually to the lower river put native populations at risk from competition, predation and disease. In addition, hatchery adults spawning with wild adults in lower river tributaries pose both genetic and competition risks to these same populations.

The H&S Plan attempts to reduce these risks by operating the hatchery programs consistent with HSRG guidelines, to the extent possible. The annual operating plans for each species will specify the methodology for applying HSRG guidelines to achieve recovery plan goals.

Objective 3: Estimate Juvenile release behavior or residualism after release from hatcheries downstream of Merwin Dam

Hatchery smolts released from Lewis River hatchery should be tracked periodically to assess residency time and spatial distribution of smolts during emigration from the Lewis. Radio telemetry studies have been performed in the past during different flow regimes on coho. Additional studies would only need to be performed to assess different emigration rates based on different rearing strategies, release sizes or release timing for each species to assess their effectiveness against control groups.

5.2 HATCHERY OPERATIONS AND PRODUCTION OBJECTIVES

Objective 4: Produce an annual hatchery operations report

Hatchery operations include many activities including spawning, rearing, feeding, pathogen testing, permit compliance, fish marking and trapping counts. Each year the WDFW produces an annual report that includes a number of metrics. At a minimum this report should include the following metrics to monitor and ensure that fish health is not compromised:

- Rearing conditions by life stage (e.g., flow indexes, densities)
- Tracking consistency of programs with HSRG guidelines
- Disease presence, prevention (treatments) and loss by life stage
- Growth rate by month from fry ponding to release as smolts
- Length and condition factors (subsample) for each species at release
- Number of fish tagged, tag type and purpose (experimental, production, other?)
- Number of adults (including jacks) collected, spawned, recycled, and sent to food banks or other disposition options.
- All fish transfers in or out of basin including species, number, marks and life stage
- Number of wild fish collected, origin (if possible) and disposition
- Number of hatchery fish collected that originated from outside of the Lewis River basin (based on CWT tag data)

Objective 5: Monitor rearing conditions to be consistent with producing a high quality smolt that emigrates quickly with a relatively high rate of survival

Smolts produced through the hatchery as Segregated programs should produce smolts that will leave the system quickly to minimize adverse effects to native or naturally produced smolts. These smolts should also have survival that surpasses naturally spawning populations (HSRG 2009). To accomplish this, rearing practices should produce a high quality smolt and released when fish are smolting. This may include alternate rearing vessels (e.g., use of circular ponds) or strategies (feed rates, densities, release timing). The AOP process should strive to improve smolt quality for species that show low relative survival (e.g., spring Chinook).

Objective 6: Monitor hatchery upgrades

Schedule 8.7 of the Agreement includes a number of upgrades for all three facilities. These upgrades include pond reconstruction, modification to intakes and sorting facilities and controls upgrades. Most of these upgrades will have been completed by the end of 2014.

These upgrades should continue to be monitored to ensure that the objectives of hatchery production are being met (e.g., rearing conditions and density) and ESA protections continue to be in place (e.g., intake modifications continue to meet NOAA-NMFS criteria). Section 8 of this plan provides current status of these upgrades.

Objective 7: Release strategies that are consistent with HSRG and HGMP recommendations

Hatchery releases are typically performed at areas downstream of natural spawning and rearing areas. However, because a goal of Segregated programs is harvest and efficient trap capture to remove these fish prior to spawn time, release locations may overlap with these areas. The amount of overlap should be monitored and adjusted if necessary or as required through HGMP implementation. Coho and spring Chinook releases are done at Lewis River hatchery, which has some overlap with spawning and rearing areas of native species such as fall Chinook.

Objective 8: Monitor production levels and program release numbers

Hatchery production for all species is currently operated as Segregated programs. However, as more supplementation program fish are produced in the upper basin and released in the North Fork Lewis River, hatchery releases may adversely affect the supplementation program through competition and predation at the juvenile stage and through spawning (pHOS) between supplementation and hatchery fish, which is detrimental to the goals of establishing an integrated population through initial hatchery supplementation. If adverse effects are observed, production levels may need to be modified subject to approval of the services through the HGMP process. Modification to hatchery production are also provided for in Section 8.3.2 of the Agreement to reduce hatchery production (subject to a hatchery floor) when natural production levels increase to a specified threshold level. Ocean Recruit analysis will provide the data necessary to make this determination every five years.

Objective 9: Submit and gain HGMP approval for all hatchery programs on the Lewis River.

The H&S Plan must be consistent with HGMP provisions once approved by the NOAA. An approved HGMP is required to maintain hatchery programs on the Lewis River. Hatchery programs are necessary to initiate the H&S program. Thus, HGMP approval is a key component to maintaining the supplementation programs necessary to meet reintroduction objectives.

5.3 SUPPLEMENTATION PROGRAM OBJECTIVES

Objective 10: Routinely monitor effective population size for returning native winter steelhead and the potential for" Ryman-Laikre" effects on native winter steelhead population from supplementation activities.

As of 2014, the winter steelhead supplementation program has been ongoing for 6 years. Program fish (those with blank wire tags) began returning to the Lewis River in 2012. The effect these fish on the lower native winter steelhead population is unknown and difficult to quantify. The AOP should provide the means to quantify these effects whether beneficial or adverse to the native spawning population. Determining family representation in each return year, documenting program fish on redds (if possible) and ensuring that as many program fish are transported upstream should be a priority. There are no practical means to tell the difference between program fish that have lost their tag, or progeny from naturally spawning program fish from true native stocks. This is of particular importance especially if family representation in any particular program cohort is very small. In these instances, fitness of the native population will be adversely affected when weak cohorts return to spawn with true native winter steelhead. Metrics such as effective population size and inbreeding coefficients should be developed and estimated on an annual basis to monitor this population and adaptively (and proactively) make decisions that limit impacts to the native population (e.g., random pairwise mating, number of broodstock used, family representation in program returns).

Objective 11: Sampling protocols for supplementation adults returning to traps or in-river capture

Beginning in 2012, the supplementation program received its first return year from winter steelhead. These fish are identified by a blank wire snout tag. Supplementation spring Chinook and coho that are progeny from adult supplementation programs in the upper basin will have no tags and be considered technically wild. For winter steelhead returning to the Merwin trap, a genetic subsample of all returns over the run period should be taken to estimate the family representation in the run for each production cohort. For unmarked spring Chinook and coho, these fish would be transported upstream either as program returns are as truly wild fish that volunteered into the trap. Whether any monitoring or tagging of these fish is required would be determined by the ACC and included in the AOP.

Objective 12: Evaluate the effects of Resident Fish Programs

Resident trout plants in Swift reservoir shall be evaluated periodically to determine impacts on reintroduced anadromous fish and native bull trout populations. Impacts can include direct predation or possibly competition for limited food sources present in an already oligotrophic reservoir. In 2014, the opening trout season was delayed to the first Saturday in June and thus stocking schedules were delayed to the last week of May. This action provides some protection to predation on spring outmigrants of naturally produced transported species. To ensure this strategy is effective, periodic sampling should be done to evaluate predation rates of planted rainbow on outmigrating salmonids. Samples may be obtained through bull trout netting activities (preferred) or through creel checks if insufficient samples are obtained through bull trout collection activities.

Competition for food resources in Swift is currently being evaluated through stable isotope studies of all species. Collection activities started in 2013 and will continue through 2014. If data from this work indicate that planted rainbow diets are similar to those of transport species, additional studies should be conducted to evaluate whether food resources are a limiting factor affecting survival or condition of transported species residing in Swift Reservoir prior to collection at the floating surface collector.

In regard to anadromous fish, if the rainbow trout were consuming more than 3 percent of the total estimated number of juvenile anadromous fish of any species entering Swift Reservoir, it is recommended the rainbow trout program be altered or eliminated. The 3 percent value should be considered a placeholder until reviewed by the ACC. It is expected that the Services will provide a value as part of their review of the program.

The hatchery and supplementation program may also pose ecological and disease risks to the native bull trout population and other resident species through anadromous and resident fish plants. The large releases of both hatchery juveniles and adults may result in increased competition for both food and space that may reduce bull trout abundance. Conversely, the expected increase in marine-derived nutrients resulting from the adult supplementation program, and increased prey base, may increase the food availability resulting in greater bull trout abundance. Monitoring of bull trout populations in this area will continue and further action taken if the native bull trout abundance or age structure has substantial adverse changes. A program to quantify possible impacts from supplementation activities on this species should be in conjunction with existing bull trout surveys and netting that capture a substantial number of bull trout (at different ages) and transport species.

Objective 13: Effects of upstream adult and juvenile supplementation on ESA listed Species

Comments received from the ACC on the first draft H&S Plan indicated that they were concerned about the effects of reintroducing anadromous fish into the upper basin may have on ESA listed bull trout and other resident species. For example, a concern was expressed that if coho entered and spawned in Rush Creek or Cougar Creek, they may negatively impact bull trout spawning success.

The Monitoring and Evaluation Plan proposes to conduct carcass surveys throughout the upper basin to collect marks, determine distribution, redd counts and spawning success. These data should provide information to identify those areas where species may compete. However, unless actions such as constructing weirs at the mouths of streams like Cougar Creek to prevent coho access are implemented, then collecting data on distribution and redd location may have little value in preventing redd superimposition or competition and predation between bull trout and resident species.

The H&S Plan assumes that since bull trout and other species were present historically in the upper basin, the reintroduction program would simply restore ecological function in the system. Impacts such as bull trout predation on anadromous juveniles or vice-versa are simply accepted.

5.4 LIFE HISTORY OBJECTIVES

Objective 14: Estimate juvenile and adult abundance of winter steelhead, coho and spring Chinook downstream of Merwin Dam

Obtaining accurate and precise smolt abundance in systems such as the North Fork Lewis River is problematic because of the size of the river and fluctuating flows during outmigration periods. Methods to estimate abundance almost always rely on mark recapture techniques. Collection methods (e.g., traps, netting, seining) must be able to obtain a statistically valid sample size for marks and have the ability to recapture an adequate number of marks to develop a practical estimate for each species. Through the AOP process a system will need to be developed that meets capture efficiency standards to provide a reasonable estimate of smolt abundance for each species.

Objective 15: Determine spatial and temporal distribution of spawning winter steelhead, spring Chinook and coho downstream of Merwin Dam

Monitoring temporal and spatial distribution of spawning locations downstream of Merwin Dam in the mainstem and tributaries should have the ability to detect changes (± 15%) over time with a reasonable amount of certainty (≥80%)(NOAA 2006). The use of index areas within the mainstem downstream of Merwin Dam is not necessary as a complete (or nearly complete) census can be accomplished with acceptable levels of effort. Tributary systems however likely require a probabilistic sampling approach due to the difficulty in accessing these areas and the large geographical area encompassing the available habitat downstream of Merwin Dam.

5.5 HARVEST EFFECTS

Responsibility for setting and monitoring fisheries is the responsibility of the resource co-managers. Therefore, the H&S Plan assumes that the co-managers have in place a well-designed harvest-monitoring plan sufficient to develop accurate estimates of:

- The number, age and sex of marked fish captured in fisheries and spawning in the wild.
- Survival rates for wild fish captured in fisheries and released.
- Stray rates based on CWT's recovered in other basins.
- Double Index Production (DIP) harvest rates
- Harvest goals expressed in terms of number of fish for the Lewis River terminal fishery (HSRG 2010).

Because harvest management is the responsibility of the resource agencies, the H&S Plan can only make recommendations as to best harvest policy for the basin. These recommendations include:

- Anglers should be required to release any fish caught that possess an intact adipose fin
- Extend the closure between Colvin Creek and Merwin Dam from April 1 to May 31 (currently May 1 to May 31). This action protects actively spawning native winter steelhead in this productive section during peak spawning times.
- No targeted harvest would be allowed on spring Chinook, coho or steelhead released into the upper basin (above Merwin Dam) unless it can be assured that escapement goals are met for that species, and potential harvest (bycatch) impacts to resident bull trout populations are effectively managed

All fish returning to adult collections facilities in the Lewis River are to be 100 percent mark-sampled to ensure that not only all tags are recovered but that adult fish are transported and released to the correct portion of the upper basin (Yale or Swift).

A key assumption in the H&S Plan is that the implementation of selective fisheries by the co-managers creates a harvest program that still allows for significant recreational and commercial harvest without jeopardizing the success of the reintroduction program. This is difficult to accurately measure because mark selective fisheries increase the uncertainty and bias in the estimates of fisher impact on native or natural stocks (ISAB 2005). Therefore, for management purposes it is assumed that fishery impacts would be managed based on the data presented in WDFW's Hatchery and Genetic Management Plans (www.nwr.noaa.gov/Salmon-Harvest-Hatcheries/Salmon-Fishery-Management/Fishery-Plans.cfm) and through adaptive management policies required to protect and preserve listed species.

6.0 FISH MARKING STRATEGIES

A fish marking program is needed to not only identify the origin (NOR or HOR) of adults returning to adult collection facilities, but also to determine if hatchery and supplementation goals are being achieved through estimates of ocean recruits (Appendix C).

Currently, juvenile fish released from Lewis River hatchery facilities are marked to quantify overall survival rates, contribution to fisheries (ocean and freshwater), stray rate, and the proportion of hatchery fish that spawn naturally in the basin. Fish released from the hatchery are generally distinguished through a combination of marks:

- Adipose Clip: This mark is used to inform fishers and managers that the fish is of hatchery origin. These fish can be retained in selective fisheries. Nearly all hatchery fish released in the Lewis River are mass marked in this manner: the two exceptions being double-index groups (DIG) and native winter steelhead smolt releases.

- Adipose Clip + CWT: A subset of the spring Chinook and coho salmon released are also marked with a CWT inserted into the nose. The CWT is used to determine overall survival rates of release groups, harvest rates, and stray rate into other basins etc.

- Adipose Present + CWT: This group is referred to as the Double-Index Group (DIG) and is used to estimate the impact mark selective fisheries have on natural populations (See Appendix D for more detail). In these fisheries, fish captured with adipose fins are released while adipose clipped fish are retained. The difference in survival between these groups quantifies harvest impacts to natural stocks.

These three marked groups will be retained as part of the H&S Plan as they are still necessary to determine hatchery performance. However, as wild production from the upper basin increases it is suggested that the DIG group be eliminated and replaced by marking the wild migrants.

A marking program will also be needed for managing the supplementation component of the H&S Plan. Fish will need to be marked so that upon their return to adult handling facilities they can be sorted, transported and released into one of two areas:

1. Winter Steelhead downstream of Merwin Dam

2. A portion of acclimation spring Chinook released upstream of Swift

3. A portion of adults transported upstream (if necessary)

4. Differential marking of fish collected at downstream collection facilities at Swift and Yale (when and if constructed) to determine relative survival for each collection facility.

Once passage occurs at Merwin, all fish will be passed into Merwin where they sort themselves out as to whether they want to stay in a particular reservoir or move upstream.

As was the case with the hatchery releases, marking is needed to determine the success of the supplementation program for Yale and Swift.

The proposed marking scheme for hatchery, supplementation and natural origin fish is presented in Table 6-1. The marking program emphasizes the use of CWT's for spring Chinook and coho, and blank wire snout tags for steelhead because few steelhead are captured in ocean fisheries. PIT tags are recommended for acclimation fish to assess site performance.

No marking program is proposed for natural outmigrants in Swift or Merwin fish as by the time fish production occurs in this Merwin, adult passage facilities would have been built at Yale and Swift; thereby allowing the fish to self-sort. And until such time that Yale downstream passage is finished all transport fish entering the traps will be transported upstream of Swift Dam.

Table 6-1. Marking program for hatchery and supplementation plants, and natural origin spring Chinook, coho and steelhead.

	Mark or Tag			
	Downstream of Merwin Dam	Swift	Yale	Merwin
HATCHERY				
Spring Chinook	• 950,000 AD only • 150,000 CWT only (DIG) • 150,000 CWT + AD			
Coho	• 1,700,000 AD only • 150,000 CWT only (DIG) • 150,000 CWT + AD			
Steelhead	100% AD clip			
Rainbow		100% AD clip		
Kokanee				None
SUPPLEMENTATION				
Winter Steelhead (Juveniles)	50,000 blank wire snout tag			
ADULTS Winter Steelhead Early Coho Spring Chinook		None*	None*	None*
Spring Chinook Juveniles (acclimation)		10 % PIT tagged	10 % PIT tagged	10 % PIT tagged
NATURAL OUTMIGRANTS				
Winter Steelhead Early Coho Spring Chinook		None	100% Marked**	None

*** Although there is no plan to tag returning transport species there may be select tagging to one or all transport species for needed evaluations. **Differential marking will be required prior to Yale downstream collector to identify adult returns originating either from Yale or Swift dams. AD = Adipose Fin; CWT = Coded Wire Tag.**

7.0 ADAPTIVE MANAGEMENT

This section provides the framework to actively and adaptively manage the hatchery and supplementation program on an annual basis. The H&S Plan provides a general framework and specifies targets or goals to meet. The means to reach these goals and monitor performance of the plan will be done on an annual basis. The AOP is a document produced by December 31 of each year that contains specific information and methodologies that will be used in the following year to meet the objectives of the H&S plan. The AOP is a collaborative effort that includes federal, state, tribal and private managers. The AOP has the ability to change program direction during in-season field work and of course through annual planning meetings.

In addition to annual planning, the H&S Plan has provisions contained within the Agreement that provides periodic revisions and review to facilitate and incorporate adaptive management. These two provisions are summarized below:

7.1 COMPREHENSIVE PERIODIC REVIEW

Section 8.2.6 of the Agreement calls for an independent review of the program in year five after reintroduction of transport species into each reservoir. Reintroduction into Swift began in 2012 and this independent review will be performed in 2017. This review will continue to be done even if no reintroduction occurs in Yale or Merwin. The review will assess various components of the H&S Plan including impact of the reintroduction program on listed species, whether goals are being achieved and the efficiency of the hatchery operations. The review will also provide recommendations regarding ongoing management of the program. These recommendations may be incorporated as amendments to the plan pursuant to Section 8.2.5 and 8.2.6 of the Agreement.

7.2 FIVE YEAR PLAN MODIFICATIONS

The H&S Plan shall be updated and modified if necessary at least every five years. Updates or modifications to the plan are to be done through Consultation with the ACC and require approval of the Services. Modifications to the plan may also be required through approval of the Hatchery and Genetic Management Plans for the North Fork Lewis River hatchery facilities. Approval of these plans is not yet complete and if inconsistencies are identified between the H&S Plan and approved HGMP's the plan will be amended to reflect these changes.

7.3 KEY QUESTIONS FOR ADAPTIVE MANAGEMENT

The major assumption, or hypothesis, being tested in this plan is whether hatchery origin fish can be used to restore anadromous fish production above a series of dams. The primary goal of this program is:

To achieve self-sustaining runs of harvestable fish upstream of Merwin Dam.

The H&S Plan assumes that the best approach for achieving this goal is to rear fish using HSRG and APRE guidelines, and to implement a juvenile and adult supplementation program to restore upper basin anadromous fish production. It is assumed that these actions will not only be successful, but also that they will have acceptable effects on other basin fish populations such as ESA listed bull trout and lower river coho, Chinook and steelhead.

The following key questions (or subset of them) will be addressed during the first comprehensive periodic review of the H&S program scheduled for 2017. This should allow adequate time to collect and analyze data to provide answers to these key questions. Depending on the results and answers to these key questions the ACC may need to make changes to the H&S plan and program to ensure that the primary goal stated above is being met or the plan is implemented in such a way that the goal has a reasonable chance of being met.

7.3.1 HSRG Guidelines

The H&S Plan relies on HSRG guidelines as the scientific basis for hatchery operations. However, these guidelines have never been tested, but simply represent HSRG understanding of best management practices for hatcheries attempting to achieve conservation or harvest goals. Although the H&S Plan will not attempt to validate these guidelines, data is needed to ensure that the recommendations are being carried out.

Of critical importance in the success of the reintroduction program is whether or not managers can effectively control the mix of wild and hatchery fish in lower basin tributaries and in the upper basin.

Key Question:

Can the hatchery programs be operated consistent with HSRG guidelines to meet recovery goals?

Decision Point

If the data collected as part of H&S Plan or WDFW sponsored spawning surveys conclude that the guidelines can be met then the programs may continue. If not, the ACC will need to review the collected data and evaluate management alternatives.

7.3.2 Juvenile Supplementation Effectiveness

Four key research questions are associated with the juvenile supplementation program.

Is the survival and collection rate of juveniles released above Swift No.1 Dam sufficient to meet program goals?

The H&S plan recommends that hatchery juvenile supplementation and juvenile supplementation from naturally spawning adults be used to restore anadromous fish production to the upper basin. For this program to be successful, juveniles whether hatchery or from natural spawners must not only survive but be effectively collected, transported and released downstream of Merwin Dam at a rate that is sustainable. If not, the ACC should consider altering or stopping the program temporarily until survival increases (e.g. collection efficiency improves).

Do supplemented juveniles have the same or greater SAR than hatchery fish released below Merwin Dam?

There may be a survival cost associated with releasing juvenile fish above Swift No.1 dam in comparison to below Merwin Dam. Juveniles released in the upper basin have to migrate through reservoirs and dams to reach the lower river, which may result in significant loss. If the overall SAR for supplemented juvenile fish is lower than for fish released below Merwin Dam, then the ACC may want to revisit the need for this strategy. This decision would be influenced by the answer to the third question.

Will returning adults from the late winter juvenile supplementation program spawn successfully in the Upper Lewis River basin?

The H&S Plan collects wild late winter steelhead adults from the lower river, rears the off-spring yearlings, and then releases these fish below Merwin Dam. Upon their return as adults, they are transported and released above Swift Reservoir. As the behavior of these fish is unknown, a portion will need to be radio-tagged and their distribution tracked. If these fish do not distribute themselves throughout the watershed, then the program may need to be revised. Possible changes include transporting adults to other locations within the upper basin.

Do adults from supplemented juveniles have a higher spawning success rate than hatchery adults released into the same streams?

A key assumption of any juvenile supplementation effort is that acclimating or releasing juvenile fish near the spawning grounds results in increased homing fidelity and improved spawning success compared to releases of hatchery adults. If this assumption is false, then considerable resources are being expended for no increase in fish production. Because both adult and juvenile supplementation programs are proposed, at least for spring Chinook, it will be difficult to determine the success of both strategies at the same time, as they confound each other (cannot tell whether resulting juvenile production was from hatchery adults or adults supplemented as juveniles). DNA testing might be used to track parentage over time, but costs may be prohibitive.

Decision Point

The juvenile collector at Swift is schedule for testing in Year 4.5 of the license. It is suggested that at least one year of testing be conducted before juvenile fish are released as part of the supplementation program. If juveniles were released in the same year as testing, coordination would be needed with the facility evaluation program.

Additionally, SAR values will first be available within 3 years of the first releases. The ACC should review the adult survival data to determine if program changes need to be made.

7.3.3 Adult Supplementation Effectiveness

What is the egg-to-smolt (or recruits per adult spawner) survival of hatchery adults released in the upper basin?

Because surplus adult hatchery fish are generally available, the H&S Plan relies on adult supplementation as the only method to reintroduce Type S Coho and late winter steelhead into the upper basin. This strategy has been highly successful for these species on the Cowlitz River according to WDFW biologists (WDFW 2004d). For example, in 2004 WDFW estimated a smolt yield of over 300,000 coho smolts. Studies conducted during Lewis River relicensing also showed large numbers of coho juveniles resulting from adult releases. However, as the Agreement emphasized juvenile supplementation, data is needed on the effectiveness of the adult supplementation strategy to produce smolts. The juvenile collector will be used to estimate egg to smolt survival and to derive an overall survival estimate for all reintroduced species.

Key Decision Point

The evaluation of the spawning and reproductive success of hatchery adults released into the upper basin will start in the first year of reintroduction. Estimates will be derived as part of the M&E plan and reported annually to the ACC. The ACC will then make decisions to make program changes to be reflected in the annual operating plan for each species.

7.3.4 EDT Modeling Results

Do EDT estimates of system productivity align with observed data?

EDT modeling was used to estimate potential juvenile and adult production originating from streams located above Swift No.1 Dam. The accuracy of these estimates is unknown, but do provide a template for which to compare to observed data once fish production is re-established. The EDT estimates of production are important for they were used to set the minimum adult escapement targets for the upper basin. Determining the accuracy of these estimates would help the ACC better adaptively manage the number of juveniles and adult released as part of the supplementation program.

In addition, the Beverton-Holt production function produced by EDT provides managers the ability to forecast resulting juvenile production that may result from different spawner escapements. These estimates could then be compared to the number calculated entering reservoirs and juvenile collection facilities.

Key Decision Point

If after year 10 the observed numbers reported annually do not match estimated productivity, then studies should be undertaken to identify erroneous assumptions in the model. This data would be useful in developing the limiting factors analysis required in year 27.

8.0 EXPECTED OUTCOMES

Although the outcome goal of the Lewis River Hatchery and Supplementation Program has been defined in the Agreement (Section 3), the metrics used to evaluate program success have yet to be developed. The identification of these metrics is the responsibility of NMFS and the USFWS. These two agencies (referred to as the "Services") will make this decision after consulting with the ACC, and taking into consideration the variability of the factors that may influence program success (i.e. ocean survival, fish passage success, freshwater variability etc.). According to the Agreement, the Services decision process needs to be defined prior to the later of: (a) the 27th anniversary of the Issuance of the new license, or (b) the 12th year after reintroduction of anadromous fish above Swift No. 1 Dam

The All-H Hatchery Analyzer

The All-H Hatchery Analyzer (AHA) model used in the development of this H&S Plan used current EDT habitat productivity/capacity estimates, anticipated harvest rates, and proposed hatchery operations to estimate the number of adult salmon and steelhead returning to the upper basin, the hatchery complex, and caught in freshwater and ocean fisheries.

It should be noted that the harvest and smolt-to-adult survival rates used in this analysis were approximated from the Lewis River Fish Planning Document (Cramer and Associates 2004), and comments received from WDFW on the November 2005 Draft H&S Plan. The SAR values used in the AHA analysis are shown in Table 8-1. It should be recognized that survival values could change by an order of magnitude for any given brood year[19].

Table 8-1. A comparison of SARs developed or reviewed as part of the development of the H&S Plan.

Species	Cramer Hatchery[1]	AHA Hatchery	EDT (Wild or NOR)
Spring Chinook	0.5%- 2.2%	0.7%	3%
Type N Coho	2%-4.4%	2.2%	NA
Type S Coho	2%-4.4%	2.2%	4.8%
Late Winter Steelhead	NA	NA	6%
Winter Steelhead	1.4%-2.8%	1.6%*	NA
Summer Steelhead	6.8%-13.6%	2%*	NA

NA- Not applicable as wild fish production is not included in the H&S Plan.
1-Data taken from Table D-5, Cramer and Associates 2004 (Lewis River Fish Planning Document)
*- WDFW supplied survival estimates for winter and summer steelhead

[19] Note that the AHA model varies SAR by brood year over a range of SAR values.

A key difference in the SAR values used in this analysis and the Cramer and Associates (2004) analysis are the values for summer steelhead. Cramer and Associates (2004) used an SAR values greater than 6%, while this plan uses the 2% value submitted by WDFW. To meet steelhead hatchery production targets requires that the combined steelhead SAR (both species) average 4.8%. This SAR assumption would include all steelhead caught in fisheries, observed on the spawning grounds, and collected at the hatcheries or fish ladders. Because of this difference in SAR assumptions between the two analyses, the H&S Plan indicates that hatchery steelhead adult targets may be difficult to achieve.

The Use of Index Stocks

The Lewis River Fish Planning Document (Cramer and Associates 2004) makes a sound argument for using index stocks as a means to determine whether the success or failure of the Lewis River H&S Plan is a result of in-basin or out-of-basin factors. This information would feed into the Limiting Factors Analysis (LFA) called for in Year 27 of the license. The LFA would be used to develop a working hypothesis for why program goals were not met.

It is suggested that the Lower Columbia River spring Chinook, coho and late winter steelhead populations be used as the Index stocks for the proposed analysis. Specific Lower Columbia River salmon and steelhead populations will be identified during the development of the limiting factors analysis. Populations will be selected based on similarities to Lewis River populations and available data.

8.1 SPRING CHINOOK

The H&S Plan spring Chinook supplementation program uses 65 adults from the existing Lewis River hatchery program to produce approximately 100,000 smolts that will be released into the upper watershed (Table 8-2). The upper watershed is also seeded with up to 2,000 adults (based on a corrected (for fish passage) habitat capacity of 1,942 fish).

Table 8-2. Expected outcomes of the Lewis River H&S Plan spring Chinook program.

Phase	Broodstock	NOR's Spawning Naturally	HOR's (Supplemented) Spawning Naturally	Mixed Stock Harvest	Terminal Area Harvest	Average Adult Ocean Recruits
Supplementation Phase	65	1,159	390	372	66	~2,100
End of Supplementation	NA	1,215	NA	264	47	~1,500
Segregated Harvest Program	800 (+3,123 surplus)	NA	NA	1,308	2,319	~7,600

Ideally, the spring Chinook juvenile supplementation program will collect 100 percent of its broodstock from natural origin fish resulting from the "start-up" phase. Also, only natural origin adults would be allowed to spawn in the upper watershed. Hatchery origin spring Chinook will only be used if the number of adults produced from above Swift is not sufficient to meet the broodstock needs (approximately 65 adults) or the adult supplementation objective of 2,000 adults. Under this scenario, the number of spawners of natural origin or produced from the juvenile supplementation program is expected to be approximately 1,559 adults (NOR + HOR Supplemented). Harvest occurs primarily in mixed-stock fisheries, with little harvest occurring in the terminal fishery. On average, in Years 1-12 of the program approximately 2,100 adults would be produced.

Once supplementation efforts are ended, upper basin adult escapement is reduced to 1,215. Harvest still occurs primarily in mixed-stock fisheries, with little terminal harvest. However, WDFW and NOAA may alter harvest patterns as needed. The estimated number of naturally produced adult ocean recruits produced under this scenario is about 1,500 (Table 8-2).

The Spring Chinook Segregated harvest program represents the total catch and escapement of hatchery origin spring Chinook produced from the proposed Segregated harvest program. The total contribution of hatchery origin fish from the proposed Segregated harvest program is on average about 7,600 fish (Table 8-2). This includes meeting the hatchery broodstock needs of 800 fish, having a surplus of 3,123 fish at the hatchery and contributing 3,627 fish to harvest (1,308 in mixed stock harvest and 2,319 in the terminal area). The expected surplus of hatchery fish indicates that on average, the existing hatchery program can supply the juveniles (100,000) and adults (2,000) for re-introduction into the upper watershed.

8.2 COHO

Because of the large number of surplus early coho (Type-S) adults available from the hatchery and the potential productivity and capacity of the upper watershed, no juveniles are needed for the proposed early coho supplementation program. Based on the estimates of habitat productivity and capacity, simply relying on adult supplementation (up to 9,000 adults) results in an average of 5,812 Type-S coho spawning in the upper watershed (Table 8-3). Initially they will be 100 percent hatchery origin, but ultimately should consist of 100 percent natural origin fish.

Under the proposed Type S coho Segregated Harvest program, the total contribution of hatchery origin fish is on average about 19,700 (Table 8-3). This includes meeting the hatchery broodstock needs of 800 fish, having a surplus of 14,044 fish at the hatchery and contributing 4,866 fish to harvest (2,895 in mixed stock harvest and 1,971 in the terminal area). This program contributes a much lower proportion of the total run to harvest (24.6 percent) than the late coho harvest program (51 percent). However, the expected surplus of hatchery fish indicates that on average, the existing hatchery program can supply the 9,000 Type S adults needed for reintroduction into the upper watershed.

Table 8-3. Expected outcomes of the Lewis River H&S Plan early (Type-S) coho program.

Phase	Brood-stock	NOR's Spawning Naturally	HOR's Spawning Naturally	Mixed Stock Harvest	Terminal Area Harvest	Average Adult Ocean Recruits
Type S After Supplementation	NA	5,812	NA	1,013	69	~6,900
Type S Segregated Harvest Program	800	NA	NA	2,895	1,971	~19,700*
Type-N Segregated Harvest Program	800	NA	NA	8,663	2,119	~21,000**

* Includes 14,044 surplus hatchery fish. ** Includes 9,547 surplus hatchery fish.

The proposed Lewis River Type N coho Segregated harvest program produces 900,000 smolts that are 100 percent derived from adult returns to the hatchery. This scenario assumes that 100 percent of the hatchery origin returns from the Segregated Harvest program return to the hatchery. The total contribution of hatchery origin fish from this program is on average about 21,000 fish (Table 8-3). This includes meeting the hatchery broodstock needs of 800 fish, having a surplus of 9,547 fish at the hatchery and contributing 10,782 fish to harvest (8,663 in mixed stock harvest and 2,119 in the terminal area). This program contributes a much higher proportion of the total run to harvest (51 percent) than the early coho harvest program (24.6 percent).

8.3 STEELHEAD

The proposed Lewis River late-winter steelhead supplementation program (Years 1-15) uses 50 adults returning to Lewis River traps to start an Integrated Conservation/Restoration recovery program. These 50 adults produce about 50,000 smolts. When these smolts return as adults, they will all be allowed to spawn in the upper watershed. Harvest is expected to be minimal as it is assumed selective fisheries are in place. Broodstock will continue to be taken from other adult returns to the trap in order to increase the effective population size of the spawners in the upper watershed. On average this strategy results in about 2,000 fish spawning in the upper watershed, with 40 percent being wild origin supplemented spawners (Table 8-4).

Table 8-4. Expected outcomes of the Lewis River H&S Plan winter and summer steelhead program.

Phase	Broodstock[1]	NOR's Spawning Naturally	Wild (Supplemented) Spawning Naturally	Mixed Stock Harvest	Terminal Area Harvest	Average Adult Ocean Recruits
Late-winter Supplementation Years (wild broodstock)	50	1,200	800	65	108	~2,200
Late-winter After Supplementation (NOR)	NA	1,300	NA	42	70	~1,400
Winter Segregated Harvest Program	90	NA	NA	55	915	~1,800*
Summer Segregated Harvest Program	160	NA	NA	239	2,383	~4,000**

1-Broodstock numbers are an estimate; will vary based on fecundity and survival values for upgraded hatchery facilities
* Includes 779 surplus hatchery fish.
** Includes 1,211 surplus hatchery fish.
NA- Not Applicable

The late-winter steelhead (NOR) row represents a potential long-term conservation program for above Swift No. 1 Dam winter steelhead with supplementation efforts eliminated[20]. Under the conditions modeled, spawning escapement in the upper watershed is ~1,300. There is harvest opportunity but it is limited to approximately 112 adults (Table 8-4).

The winter steelhead Segregated harvest program produces approximately 4,000 ocean recruits, 55 adults to mixed stock fisheries and 915 to terminal area harvest. These adults were produced from a release of 100,000 smolts.

The proposed Lewis River summer steelhead Segregated Harvest program produces about 175,000 smolts that are 100 percent derived from adult returns to the hatchery. The total contribution of hatchery origin fish from this harvest program is on average approximately 13,800 fish (Table 8-4). This includes meeting the hatchery broodstock needs of 160 fish, having a surplus of 4,573 fish at the hatchery and contributing 9,055 fish to harvest (827 in mixed stock harvest and 8,228 in the terminal area).

[20] Note that total adult ocean recruits are lower because the lower river wild later winter steelhead population is no longer being mined for supplementation.

8.4 RAINBOW TROUT AND KOKANEE

The proposed resident rainbow trout and kokanee programs are expected to maintain the existing recreational fisheries in Swift Reservoir and Lake Merwin; however, the potential adverse effects of these programs on reintroduced salmon and steelhead are unknown. Resident trout plants in Swift reservoir would be evaluated to determine impacts on reintroduced anadromous fish.

9.0 ANNUAL OPERATING PLAN

The Agreement Calls for the development of an annual operating plan (AOP), which will be designed to implement the H&S Plan. The AOP needs to provide the following information:

1. Production Plan: Specifies the species to be reared and broodstock source.

2. Hatchery and Juvenile Production Targets: Identifies adult and juvenile targets by species for each hatchery program.

3. Fish Release Schedule: Identifies by species the rearing schedule and planned distribution of fish and the schedules and locations of release.

4. List of Hatchery Facility Upgrades: Identifies upgrades to be implemented at each hatchery facility

A discussion of each of the four AOP elements is presented below.

9.1 PRODUCTION PLAN

The species (and stocks) to be released as part of the H&S Plan are presented in Table 9-1.

Table 9-1. Species and broodstock source of hatchery fish reared and released as part of the H&S Plan.

Species and Stock	Broodstock Source
Type N Coho	Lewis River Hatchery Complex
Type S Coho	Lewis River Hatchery Complex
Late Winter Steelhead	Lower Lewis River Wild
Winter Steelhead	Lewis River Hatchery Complex
Summer Steelhead	Lewis River Hatchery Complex

9.2 HATCHERY AND JUVENILE PRODUCTION TARGETS

The adult and juvenile production targets are shown in Table 9-2.

Table 9-2. Adult and juvenile hatchery production targets.

Species and Stock	Adult Hatchery Production Targets (ocean recruits)	Juvenile Hatchery Production Targets
Coho	60,000	2.0 million
Late Winter Steelhead	None	50,000
Steelhead	13,200	275,000
Spring Chinook	12,800	1.35 million
Total	86,000	3.475 million

* Does not include resident species plants of rainbow and kokanee.

9.3 FISH RELEASE SCHEDULE

Hatchery release schedules are developed annually and as part of the WDFW's future brood document. Release windows may change depending on fish condition, fish weight or length but generally fish are released in a volitional manner over the period of weeks at each facility. Generally the release timing for each species follows:

Spring Chinook – February

Coho Salmon – April - May

Steelhead - May

9.4 HATCHERY FACILITY UPGRADES

The hatchery upgrades that have and will be implemented are provided in Table 9-3 and as stipulated in Schedule 8.7 of the Agreement.

Table 9-3. Summary of hatchery upgrades contained in Schedule 8.7 of the Agreement indicating the year in which each upgrade or task was completed (or scheduled for completion).

	YEAR							
Lewis River Hatchery	2008	2009	2010	2011	2012	2013	2014	2015
Pond 15 and Sorting Facility upgrades		✓						
Convert rearing ponds to raceways			✓	✓				
Modify downstream water intake								✓
Inspect Intake Pipe				✓				
Merwin Hatchery								
Ozone PLC upgrade							✓	
Rearing pond flow Enhancement			✓	✓				
Modify smolt release ponds			✓					
Purchase two fish hauling trucks	✓		✓					
Speelyai Hatchery								
Convert Pond 14 into raceways						✓		
Convert burrow's ponds into raceways		✓	✓					
Improve water intake structure							✓	
Improve and Expand adult fertilization area			✓					
Improve adult kokanee trap			✓					
Net Pen purchase and installation			✓					

9.5 Broodstock Collection and Spawning

A substantial portion of the AOP describes the broodstock collection and spawning of native winter steelhead used for supplementation. The plan will continue to adapt as necessary to protect native stocks of winter steelhead by limiting collection and ensuring that only native stocks are used within the Cascade Stratum for spawning.

9.6 Monitoring and Evaluation

A significant portion of the AOP relates to methodology and specifics of monitoring both adult and juvenile salmonids downstream of Merwin Dam. This includes interactions between hatchery and naturally spawning populations and ensuring that hatchery operations are not impacting ESA or native stocks. Future HGMP's will direct much of the monitoring requirements in the basin and the AOP and H&S Plan will be consistent with these plans as they are developed.

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Appendix A

Current Hatchery Facilities and Operations in the Lewis River Basin

APPENDIX A
CURRENT HATCHERY FACILITIES AND OPERATIONS IN THE LEWIS RIVER BASIN

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CURRENT HATCHERY FACILITIES AND OPERATIONS IN THE LEWIS RIVER BASIN

Hatchery fish production in the Lewis River basin originates from the Lewis River, Speelyai, and Merwin hatcheries (collectively known as the Lewis River Hatchery Complex). The three hatcheries are currently operated as a complex, sharing adult return, rearing, and release functions. A detailed description of each of these facilities is presented in the following paragraphs. A description of current hatchery operations is presented in Section 2.0.

1.0 CURRENT HATCHERY FACILITIES

1.1 LEWIS RIVER HATCHERY

Adult Holding and Sorting

The Lewis River Hatchery is located adjacent to the mainstem Lewis River at RM 15.7, approximately 8 miles east of Woodland, Washington. Constructed in 1932, it is the oldest of the three fish production facilities in the Lewis River basin. The hatchery has undergone renovations in the 1980's and more recently through the Lewis River Settlement Agreement (Schedule 8.7). The most recent upgrades modified all rearing ponds into raceways to enhance operational flexibility and improve flow exchange rates. PacifiCorp Energy funds 100 percent of its operation; although, the hatchery is owned by the Washington Department of Fish and Wildlife (WDFW). The Lewis River Hatchery currently produces spring Chinook and Type-S (early) and Type-N (late) coho.

Situated on 119 acres, the Lewis River Hatchery has 312,000 cubic feet of outdoor rearing and adult holding space (WDFW 2013). Adults voluntarily enter the Pond 15 center channel via the existing Denil ladder. Additionally, Pond 15 contains four side ponds which can hold adults from the center channel via removable bulkheads and side crowders or by truck if necessary. All crowding within the center channel is automated by either remote or local controls. Adults held in the center channel, are typically crowded towards the newly constructed sorting facility. Once crowded, the adults are side-crowded by an additional crowder into the entry of a large Archimedes Screw ("pescalator") which leads to the sorting facility. From the pescalator, the fish are elevated to a diverter table where they then fill one of two electro-anesthesia baskets within the sorting facility. Each electro-anesthesia (EA) basket can be operated independently and drops the fish onto a sorting table. Fish that are selected for surplus or lethal spawning are run through a "wallaby whacker," which kills the fish instantly. A series of tubes and spiral flumes direct the fish to various destinations. Return tubes are capable of returning fish to any four of the side holding ponds. Spiral flumes send carcasses to totes for distribution. A large hoist and fry tank lower adults to be returned to stream via an underground tube exiting at the hatchery outlet.

Table 1-1. Lewis River Hatchery fish holding facilities.

Ponds (number)	Pond Type	Volume (cu.ft)	Length (ft.)	Width (ft.)	Depth (ft.)	Available Flow (gpm)
1	Adult sorting pond (Center Channel, Pond 15)	18,500	170	20	6	3,800 -10,000
4	Concrete adult /holding pond (Pond 15)	8,500	83	20	6	1000
12	Concrete raceways	4,000	100	10	4	300
2	Concrete raceways (Pond 13)	26,000	190	20	7	4000
2	Concrete raceways (Pond 13)	28,000	200	20	7	4000
4	Concrete raceways (Pond 14)	24,500	175	20	7	4000
3	Concrete raceways (Pond 16)	15,600	120	20	6.5	2000
3	Concrete raceways (Pond 16)	12,480	120	16	6.5	2000

Source: WDFW 2014a

Source: modified photograph from Tetra Tech/KCM, Inc. 2002

Figure 1-1. Lewis River Hatchery facilities. (*Pond 16 not shown)

Incubation

Inside there are 50 incubator stacks (16 trays per stack) of vertical incubators. There are also four shallow troughs. The hatchery has an eyeing capacity of 13 million eggs and a hatching capacity of 7.7 million fry (Tetra Tech/KCM, Inc. 2002).

Support Facilities

On-site support facilities include three residences, a hatchery/office building, freezer building, two three-bay storage buildings, public restrooms, two intake structures, two pump control buildings, two compressor buildings, and a domestic water well (WDFW 2013).

Water Supply

Water is currently supplied to the Lewis River Hatchery only from the Lewis River via two intakes and nine pumps (WDFW 2014a). Three booster pumps permit further distribution of water to other areas of the facility as needed. Approximately 29,000 gpm can be delivered to the facility depending on hatchery needs (WDFW 2013). According to WDFW (2014a), the upstream pump station has a capacity of approximately 22,000 gpm and conforms to the latest NMFS screening requirements. The lower pump station has a capacity of 6,000 gpm and the screening does not currently meet NMFS criteria (Tetra Tech/KCM, Inc. 2002). As part of the hatchery upgrades (described below), the pump and screen will be upgraded to meet NMFS criteria.

If water entering the Lewis River Hatchery is supersaturated with gas, it is passed through four gas stabilization towers to reduce gas levels prior to being supplied to rearing units. Pumped water can bypass the aerators if gas level is acceptable. All rearing units are supplied with single pass water and the water supply is protected by flow alarms at the intake head box, and holding ponds.

1.2 SPEELYAI HATCHERY

Speelyai Hatchery is located near confluence of Speelyai Creek and Lake Merwin (RM 26), approximately 21 miles east of Woodland, Washington. PacifiCorp Energy owns the 15-acre hatchery property; Cowlitz PUD and PacifiCorp Energy jointly funded its construction and continue to fund 100 percent of its operation. Modifications to the facility in recent years, has modified the burrows ponds and Pond 14 rearing pond to raceways. PacifiCorp Energy has also financed subsequent capital improvements. As described in PacifiCorp and Cowlitz PUD (2004a), the facility was originally built in 1958 to provide mitigation for lost habitat in the Lewis River above Swift Dam. Speelyai Hatchery currently produces rainbow trout and kokanee to supplement reservoir fisheries. The facility also provides support for the Lewis River spring Chinook and coho programs.

Rearing

Speelyai Hatchery has approximately 166,450 cubic feet of outdoor rearing space, including four intermediate troughs, twenty-eight raceways and one asphalt pond that serves as an adult holding pond for spring Chinook and early coho salmon (WDFW 2013) (Table 1-2) (Figure 1-2).

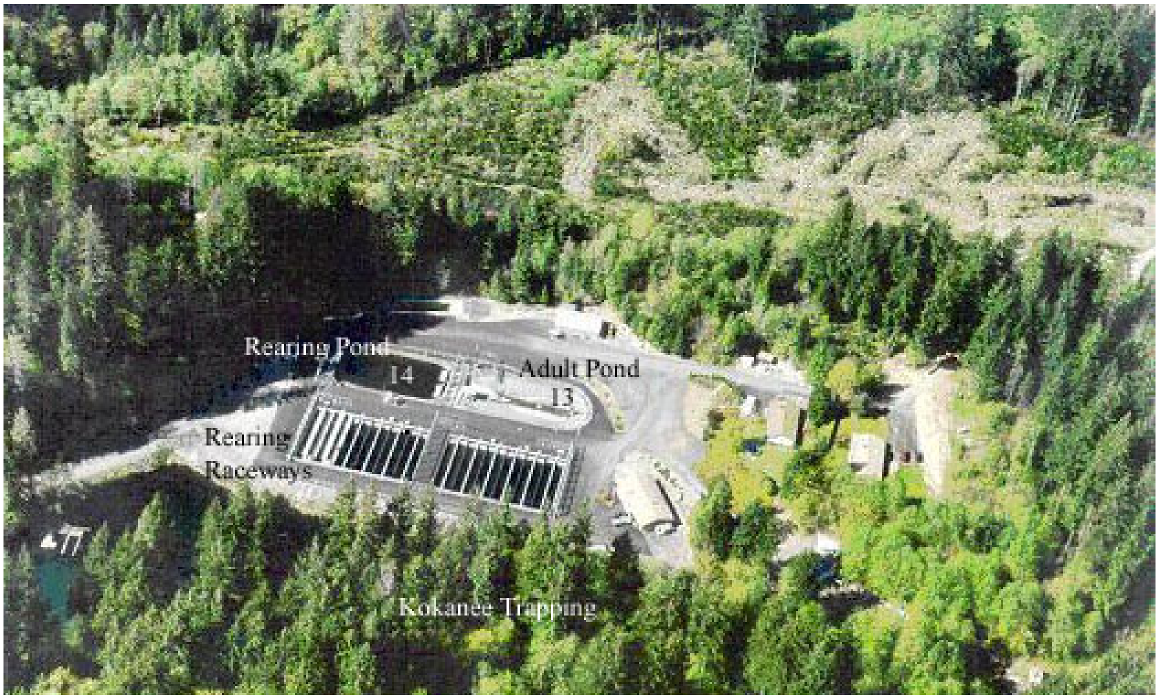
Table 1-2. Speelyai Creek Hatchery facilities.

Function	Units (number)	Size	Facilities
Water Supply			Gravity flow intake on Speelyai Creek (9,200 gallons per minute maximum capacity)
Adult Trap			Small adult trap for kokanee
Adult Holding	1	1/4 acre	Asphalt holding pond
Incubation	50		FAL vertical incubators
Early Rearing	2	17x15x1.5	Shallow Troughs
Raceways	24	80x10x4	Concrete Raceway
Starter Ponds	4	17x3x3	starter ponds
Rearing Ponds	4	115x10x5	Rearing raceways

Source: WDFW 2014a

Water Supply

The available flow to the Speelyai Hatchery intake was recently measured at 30 cfs (13,496 gpm) in August, and the hatchery intake has the capacity to take up to 24 cfs (10,797 gpm). Much of what does not flow into the intake flows past the existing diversion dam and into Speelyai Creek downstream of the diversion dam. Because the water quality in Speelyai Creek above the hatchery is excellent and water temperatures are relatively cool year round (48 to 55°F), the facility is used to hold broodstock and to incubate eggs collected at the Lewis River Hatchery and at the Merwin Dam trap. Net pens are also used to rear a portion (~500,000) of coho salmon production. The net pens also support non-mitigation summer steelhead production for release into the North Fork Lewis River.



Source: modified photograph from Tetra Tech/KCM, Inc. 2002

Figure 1-2. Speelyai Hatchery facilities. **(*photograph does not show upgrades)**

On-site support facilities at Speelyai Hatchery include two residences, a hatchery building, a storage building, a shop/garage, domestic pump house, and the water supply intake (WDFW 2013).

There are also 10 net pens located in Speelyai Bay that provide approximately 50,000 cubic feet of rearing space. Net pens were constructed as part of Schedule 8.7 of the Settlement Agreement to increase rearing space needed for additional coho production.

Incubation

Incubation facilities include fifty stacks of FAL vertical incubators, two deep troughs, and one shallow trough. Total available flow at Speelyai Hatchery is reported to be 9,200 gpm from a gravity flow intake on Speelyai Creek (KCM/Tetra Tech 2002). Eggs are incubated on Speelyai Creek water; flow through the trays is 3.5 gpm. Water temperatures range from 48-55°F, with a DO of 10.5 ppm.

1.3 MERWIN HATCHERY

Merwin Hatchery is located just downstream of Merwin Dam at RM 19, near the town of Ariel, Washington. Constructed in 1993, it is the newest hatchery facility in the Lewis River basin. PacifiCorp Energy owns the facility and currently funds 100 percent of its operation. Merwin Hatchery currently produces summer and winter steelhead and rainbow trout.

Merwin Hatchery facilities include four quarter-acre rearing ponds, ten 9.5x80x2.5 foot fingerling raceways, four covered 7.5x33x4 foot adult holding raceways, two small smolt collection ponds, and two effluent settling ponds (Table 1-3) (Figure 1-3). Indoors are six 4.5x34x2 foot intermediate raceways, four 20 cubic foot fry troughs and 15 double stack Mari Source incubators. Approximate rearing space is 216,500 cubic feet. Support facilities include an operations building with management offices, the ozone plant, a storage building, and three residences (WDFW 2013, Tetra Tech/KCM, Inc. 2002).

Water is supplied to the hatchery from Lake Merwin using a 5,600 gpm pump station on the dam face. Two screened intakes are used at depths of 15 and 90 feet. Ozone water sterilization is used to meet fish health needs and about two-thirds of the flow is ozone-disinfected prior to use. A maximum flow of 3,800 gpm can be sterilized and supplied to the hatchery building, raceways, and rearing ponds. The disinfected water is used in incubation and adult holding. The remaining water is routed to outdoor rearing ponds after passing through packed column degassing units. In addition to treating a portion of the incoming water, all water exiting the adult holding ponds and incubation building is routed into two effluent settling ponds (Tetra Tech/KCM, Inc. 2002).

Table 1-3. Merwin Hatchery fish holding facilities.

(No.)	Type	Volume (cu.ft)	Length (ft.)	Width (ft.)	Depth (ft.)
10	Standard concrete raceway	2034	78	9.66	2.7
6	Intermediate raceways	382	33.5	4.6	2.5
4	Concrete rearing ponds	46000	175	75.4	3.9
4	Adult Holding Ponds	953	33	7.7	4
2	Smolt/adult ponds	1794	39	11.6	4
Heath Vertical Stack Tray Units	30 units (8 tray stacks)		24"	25"	4"

Source: WDFW 2014d

Incubation

The incubation/starter building consists of six intermediate raceways, four fry troughs (not used) and 15 double stack MariSource vertical incubators. It is fitted with back-up pumps to maintain flow through the intermediate raceways in emergency situations, and with secondary packed columns to maintain water oxygenation above 10 ppm. Flow monitors will sound an alarm if flow through the incubation troughs is interrupted.

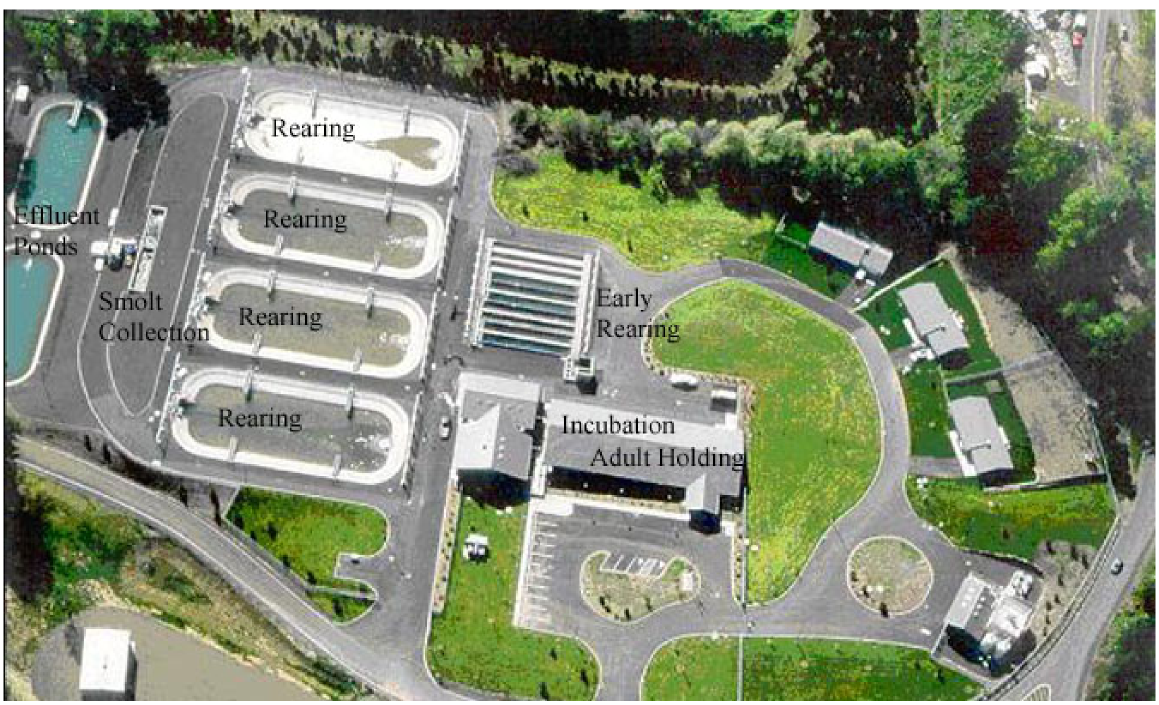
Eggs are incubated on water from Lake Merwin; flow through the trays is 7.6 gpm. The water used to supply the vertical incubators at Merwin Hatchery is pumped directly from Lake Merwin, treated with ozone, and passed through an enclosed stripper. Water quality is generally very good; water temperatures during incubation range from 48-55°F, with a DO of 10.5 ppm. High water temperatures in the summer (58°F to 59°F) can be a problem, but not during incubation or early rearing (Tetra Tech/KCM 2002). Fiberglass troughs are used only for egg disinfection and as a staging area for picking egg mortalities.

Rearing

Each standard raceway can be sectioned off with screening into thirds, if necessary, however this practice is not currently recommended. The intermediate raceways can be sectioned off with screening into fourths. Steelhead are reared in the sectioned intermediate raceways.

Bird netting spans over the juvenile-rearing raceway series, and are supported by opposing counterweights.

Initial feeding and early rearing occurs in the intermediate raceways in the incubation building. When fish reach approximately 100 fpp, they are moved to the outside four concrete rearing ponds, or transferred to the fingerling raceways. During smolting behavior, fish can make their way to two smolt collection ponds where they are transported to the river for release.



Source: modified photograph from Tetra Tech/KCM, Inc. 2002

Figure 1-3. Merwin Hatchery facilities. (photograph does not show Schedule 8.7 upgrades)

2.0 EXISTING HATCHERY OPERATIONS

As described in the previous section, the Lewis River Hatchery Complex currently produces spring Chinook, Type-S (early) coho, Type-N (late) coho, summer steelhead, winter steelhead, late winter steelhead, resident rainbow trout, and kokanee. Existing hatchery operations and production levels are guided by FERC license articles (as amended) and by subsequent mitigation agreements between PacifiCorp Energy, Cowlitz PUD, and WDFW (PacifiCorp and Cowlitz PUD 2004b, Tetra Tech/KCM, Inc. 2002, and WDFW 2013). The actual operation and management of the Lewis River Hatchery Complex is the responsibility of WDFW. WDFW determines annual release goals, planting locations, policies regarding fish disease, harvest and general day-to-day operations. In 2013, the Lewis River Hatchery Complex released more than 3.8 million fish, including approximately 1.35 million spring Chinook, 2 million coho, 100,000 winter steelhead, 175,000 summer steelhead, 60,000 (20,000 pounds) rainbow trout, and 93,000 (12,500 pounds) of juvenile kokanee (Settlement Agreement, WDFW 2013, WDFW 2006)). Current release numbers were negotiated with FERC and are part of the amended Merwin Project license. Past and current production levels at the Lewis River Hatchery Complex are summarized in Table 2-1.

Historically, PacifiCorp Energy and Cowlitz PUD funded 70 percent of the operation and maintenance costs at the Lewis River Hatchery Complex. The remaining 30 percent was funded through the Mitchell Act. Mitchell Act funds were used by WDFW to produce additional fish for other WDFW programs, and for broodstock to provide eggs to other lower Columbia River hatcheries both of which are not part of PacifiCorp Energy's mitigation program. The Mitchell Act funding was eliminated in 2000 and production goals were subsequently reduced by 1.3 million fish (81,000 pounds) (Tetra Tech/KCM 2002).

Table 2-1. Past and current fish production levels at the Lewis River Hatchery Complex.

Species	License Article 50 and 51 Production Levels	Current Production Levels
Spring Chinook	250,000 juveniles to produce 12,800 adult fish	1,250,000 yearlings at about 8 fpp into the North Fork Lewis River. 100,000 for release upstream of Swift Reservoir into acclimation sites.
Coho	2,100,000 juveniles to produce 71,000 adult fish	900,000 Type N smolts at 16.0 fpp and 1,100,000 Type S coho smolts at 16.0 fpp
Steelhead	250,000 juveniles (about 41,600 pounds)	175,000 summer steelhead at 4.8 fpp and 100,000 winter steelhead at 4.8 fpp and 50,000 late winter steelhead from native broodstock.
Sea-run Cutthroat	25,000 juveniles (up to 6,250 pounds).	Discontinued**
Rainbow Trout	800,000 rainbow trout juveniles at 25-30 fpp	20,000 pounds typically at about 3 fpp.
Kokanee	100,000 juveniles at 7-8 fpp	12,500 pounds typically around 93,000 kokanee planted per year.

** WDFW discontinued hatchery production of sea-run cutthroat trout in 1999 and increase steelhead production by 25,000 to 275,000 smolts. Accordingly, FERC modified the Merwin License article to reflect the changes in production.

Source: Tetra Tech/KCM 2002 and WDFW 2013

In June 2000, the ESA listing of Columbia River Chinook and steelhead required WDFW to file Draft Hatchery Genetic Management Plans (HGMPs) for several Lewis River Hatchery Complex stocks. These HGMPs have been resubmitted in 2014 and are currently awaiting approval by NOAA. These plans along with the Hatchery and Supplementation Plan may cause changes to the rearing and release strategies at the hatchery. The following paragraphs describe the current hatchery and fish management goals, production levels, and hatchery operations associated with each species produced at the Lewis River Hatchery Complex.

2.1 SPRING CHINOOK

2.1.1 Current Management Goals and Production Levels

According to WDFW (2014a), the primary purpose of the Lewis River Hatchery Complex spring Chinook program is to "mitigate Columbia River spring Chinook production (predominantly from hatcheries), which is a major contributor to the catches in Washington and Oregon ocean fisheries[1]." Additional goals are to:

1. Plant 1,250,000 smolts at 8 fish per pound (fpp) into the Lewis River (Table 2-1);

2. Plant 100,000 yearlings into acclimation sites upstream of Swift Reservoir.

2. Provide 200,000 eyed eggs for transfer to the Grays River Hatchery for the Deep River Net Pen Programs (not part of PacifiCorp Energy's mitigation program);

3. Provide 150,000 smolts for release from the Fish First (WDFW Co-op) Echo Bay Net Pens (Table 2-1)[2]; and

4. Operate hatcheries consistent with the recovery of spring Chinook salmon in the Lewis River[3]. The major hatchery issues are: 1) to maintain the genetic diversity of spring Chinook in the Lewis River, and ensure the reproductive success of wild spring Chinook meets or exceeds recovery goals, 2) minimize the ecological interactions of hatchery spring Chinook on naturally produced salmon and

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[1] WDFW (2004) also notes that significant commercial net catches and recreational fishing occurs in the mainstem as well as minor catches in the individual tributaries streams.

[2] This program rears and releases Lewis River Hatchery spring Chinook in net pens downstream of the hatchery to spread out fishing opportunities in the lower river.

[3] The spring Chinook recovery goal was not noted in the Draft HGMP; however, the recovery goal presented in the Lower Columbia River Salmon Recovery & Subbasin Plan (December 2004) is 2,200 adults.

steelhead, and minimize the mortality of naturally produced juvenile and adult salmon and steelhead due to facility operations.

According to WDFW, the number of juvenile spring Chinook produced at the hatcheries may be adjusted on the basis of a 5-year rolling average of adult returns (ocean recruits). Current ocean recruit target for spring Chinook is 12,800.

2.1.2 Broodstock Origin

Historically, the Lewis River basin supported an indigenous stock of spring Chinook salmon, but with the construction of Merwin Dam in 1932, the majority of the upper basin spawning habitat became inaccessible and the stock subsequently declined. Early attempts to maintain the stock through hatchery production failed, and by the mid-1950s spring Chinook had completely disappeared from Merwin Dam trap catches (PacifiCorp Energy and Cowlitz PUD 2004b).

Spring Chinook from the Cowlitz River, Carson National Fish Hatchery, and Willamette River were introduced into the Lewis River in the late 1950s; however, relatively few were planted until 1972 (PacifiCorp and Cowlitz PUD 2004b). In 1972, the Lewis River Hatchery manager used Carson and Cowlitz stocks to help reestablish spring Chinook in the basin (Myers et al. 1998). Since then, spring Chinook for the Lewis River Hatchery program have originated from a variety of sources including Cowlitz, Kalama, Carson, and Klickitat stock (Table 2-2) (Hymer et al. 1993, Myers et al. 1998). The stocks used now include only on-station returns to the Lewis River. The last release of non-Lewis River spring Chinook was in 1997; since then, all broodstock has been from returning adults collected at the Lewis River Hatchery and Merwin traps. Recent genetic data compiled by Myers et al. (1998) and Marshall et al. (1995) have shown that Lewis River spring Chinook are closely related to Cowlitz, Kalama and Klickitat stocks. WDFW (2002) considers Lewis River spring Chinook to be a mixed stock with composite production. Acceptable stocks that can be used as broodstock in years of low returns to the Lewis River include Cowlitz and Kalama (WDFW 2006).

Table 2-2. The origin of spring Chinook broodstock used at the Lewis River hatchery Complex.

Broodstock Source	Origin	Year(s) Used
Cowlitz River Spring Chinook	Hatchery	1967 to 1970
Carson National Fish Hatchery Spring Chinook	Hatchery	1960 to 1984
Kalama River Spring Chinook	Hatchery	Unknown
Willamette River Spring Chinook	Hatchery	1986
Lewis River Spring Chinook	Hatchery	1960 to present

Source: WDFW 2014a

2.1.3 Broodstock Collection

Broodstock for the Lewis River spring Chinook program is collected at the Lewis River Hatchery trap and Merwin Dam trap. The Lewis River Hatchery trap is operated approximately 4 months of the year (September through December). The Merwin trap is currently operated year-round. Adult spring Chinook usually arrive in early April and peak in May, June, and July.

All Lewis River Hatchery-origin spring Chinook have been mass marked (adipose fin clip only) since 2002, except for a group of 150,000 that are coded-wire tagged with no adipose fin clip and another group of 150,000 that is coded-wire tagged and adipose fin clipped. When adults are handled, all fish with adipose fins are checked for presence of CWT (WDFW 2006). Those with adipose fins and no tags are top caudal marked and returned to the river as wild fish. All hatchery-origin fish collected in the trap are transported to Speelyai Hatchery and spawned as broodstock. Spring Chinook not used as broodstock are transported upstream of Swift Dam as part of the adult supplementation efforts. After spawning at the hatchery, all spring Chinook carcasses are used for nutrient enhancement or are disposed of at a local landfill.

WDFW has a spring Chinook egg take goal of 1.8 million eggs. To meet this goal, the broodstock collection goal is set at 1200 adults (600 males and 600 females) and 20 jacks, based on an average fecundity of 3,800 eggs/female and a pre-spawning mortality of 10 percent (Table 2-3) (WDFW 2014a). Between 1994 and 2013, an average of 408 adult male and 429 adult female spring Chinook were collected as broodstock at the Lewis River Hatchery Complex annually (Table 2-3).

Table 2-3. The spring Chinook broodstock collection level and egg take at the Lewis River Hatchery Complex (1994 through 2013).

Year	Adult Males	Adult Females	Jacks	Egg Take
Goal*	600	600	20	2,000,000
1994	223	357	4	1,563,300
1995	272	362	3	1,522,000
1996	306	403	5	1,612,000
1997	379	407	3	1,696,000
1998	498	497	2	1,990,000
1999	287	365	40	1,460,000
2000	330	417	7	1,579,630
2001	280	419	14	1,373,232
2002	371	456	7	1,326,200
2003	396	395	8	1,638,459
2004	405	413	17	1,586,241
2005	405	246	8	1,549,900
2006	413	360	0	1,492,300
2007	437	435	1	1,713,600

Year	Adult Males	Adult Females	Jacks	Egg Take
2008	480	460	24	1,668,000
2009	513	500	9	1,788,000
2010	470	464	5	1,681,700
2011	436	422	14	1,578,000
2012	445	424	10	1,346,000
2013	623	602	9	2,015,740

Source: WDFW 2003, WDFW 2014a and pers. comm. Eric Kinne, WDFW, September 27, 2005

*Reflects year 6 goal in the H&S Plan for juvenile production and the broodstock needed to meet that production target

2.1.4 Incubation and Rearing

According to WDFW (2014a), spring Chinook eggs are incubated in vertical incubators at Speelyai Hatchery consistent with loading densities recommended by Piper et al. (1982). Water temperature is monitored with thermographs and recorded temperature units (TU) are tracked during embryonic development. During incubation, all eggs are treated with formalin at 600 part per million (ppm) to keep them free of fungus (WDFW 2004a).

Spring Chinook fry are ponded when the yolk sac slit is approximately 1 millimeter wide (approximately 1,200 TU's) or based on 95 percent yolk sac absorption. Ponding takes place from December through January. In May of each year, approximately 1,100,000 spring Chinook are transferred from the Speelyai Hatchery to the Lewis River Hatchery (WDFW 2014a). Approximately 75,000 spring Chinook are transferred from Speelyai Hatchery to the Echo Bay Net Pens in December for release into the North Fork Lewis River in January. The Echo Bay Net Pen project is located on the Lewis River at RM 10 and is maintained through a cooperative effort between WDFW and Fish First. An additional 75,000 spring Chinook are transferred from Speelyai Hatchery to the Echo Bay net pens in January for release into the North Fork Lewis River in March. The remaining 100,000 spring Chinook at Speelyai Hatchery are transferred to acclimation sites upstream of Swift Dam in early spring as part of juvenile supplementation efforts. According to WDFW, rearing densities are also consistent with those recommended by Piper (1982).

2.1.5 Release Location and Numbers Released

All spring Chinook produced at the Lewis River Hatchery (and Echo Bay net pens) are released on-site into the North Fork Lewis River. Prior to 2014, releases usually occurred from February through March. Releases for 2014 will be staggered for experimental purposes in an effort to improve survival and reduce stress. A portion (about 2/3) of the 2013 cohort will be released in October. The remaining fish will be released in February. According to WDFW, release timing is determined by fish behavior such as aggressive screen and intake crowding, swarming against sloped pond sides, leaner condition factors, a more silvery physical appearance and scale loss during feeding. Prior to release, an area Fish Health Specialist evaluates the population's health and condition.

The vast majority of spring Chinook produced at the Lewis River Hatchery Complex since 1994 have been released as yearlings in February and March (Table 2-4), although fry and fingerlings have been released in the past (WDFW 2014a).

Table 2-4. The number, size, and release dates of spring Chinook yearlings released into the Lewis River (1994 through 2013).

Year	Number Released	Release Dates	Size (fpp)
1994	642,000	3/5	7.0
1995	1,312,600	2/12 through 3/20	6.0
1996	1,178,272	2/8 through 3/22	6.0
1997	1,108,045	2/14 through 3/23	6.0
1998	1,096,841*	1/1 through 3/28	6.5
1999	868,180	2/1 through 3/31	8.5
2000	1,045,056	2/1 through 3/31	5.1 to 7.6
2001	924,115**	2/1 through 3/31	5.3 to 6.2
2002	1,013,814	2/1 through 3/31	8.4
2003	1,076,972	3/1	8.6
2004	1,028,765	3/1	7.5
2005	880,454	2/15 through 3/14	7.5 to 11.4
2006	955,367	3/20	9.0
2007	945,195	3/19	8.0
2008	915,191	3/17	8.0
2009	953,676	2/17 through 3/23	9.0 to 14.0
2010	961,435	2/19 through 3/3	7.7
2011	904,139	March1	8.6
2012	1,256,990	2/1 through 2/15	7.4
2013	731,662	2/1 through 2/15	9.7
Average	987,656	--	--

Source: WDFW 2014a, WDFW 2013

* Low numbers due to a BKD outbreak.

** Numbers do not included fish released from the Echo bay net pens.

2.1.6 Adult Abundance

Between 1994 and 2013, an average of 1,752 adult spring Chinook have returned to the Lewis River Hatchery Complex annually (Table 2-5), exceeding the 500 males and 500 females needed to meet current egg take goals.

Table 2-5. Adult and jack spring Chinook returns to the Lewis River Hatchery Complex (hatchery escapement) from 1994 through 2013 (includes wild and hatchery fish).

	Total Hatchery Escapement	
Year	Adult Spring Chinook	Jack Spring Chinook
1994	786	10
1995	1,574	21
1996	1,080	26
1997	2,273	28
1998	1,199	11
1999	924	78
2000	827	50
2001	1,231	53
2002	1,869	58
2003	3,037	357
2004	2,053	336
2005	4,134	NA
2006	3,939	NA
2007	1,178	NA
2008	2,245	NA
2009	1,384	NA
2010	711	NA
2011	1,214	NA
2012	1,482	NA
2013	1,908	NA

Source: WDFW 2013 and WDFW 2014a

2.2 COHO

2.2.1 Current Management Goals and Production Levels

According to WDFW (2014b), the primary purpose of the Lewis River Hatchery Complex Type S coho program is to:

1. Produce coho salmon to mitigate for hydroelectric system development in the Lewis system and for activities within the Columbia River Basin for the loss of early coho salmon stock that would have been produced naturally in the North Fork Lewis River system in the absence of the hydroelectric dams.

2. Plant 1,100,000 yearling Type S coho smolts at 16.0 fpp into the Lewis River (Table 2-5).

3. Incorporate natural stock into the existing hatchery population to support overall ESU recovery goals.[4]

The primary purpose of the N coho program is to:

1. Produce coho salmon to mitigate for hydroelectric system development in the Lewis system and for activities within the Columbia River Basin for the loss of late coho salmon stock that would have been produced naturally in the North Fork Lewis River system in the absence of the hydroelectric dams.

2. Plant 900,000 Type N smolts at 16.0 fpp into the Lewis River (Table 2-1).

3. Incorporate natural stock into the existing hatchery population to support overall ESU recovery goals

4. Provide for enough returning broodstock to fill the egg needs of regional programs (not part of PacifiCorp Energy's mitigation program). Obligations as of 2005 also include: transferring 460,000 eyed eggs to Fish First for remote site incubator (RSI) production in the North Fork Lewis River tributaries, transferring 1,150,000 eyed eggs to Klickitat Hatchery, transferring 6,250 eyed eggs to Region 5 Salmon in the Classroom (SIC), transferring 5,000 eyed eggs to Steve Syversion project, and if needed transferring 2,700,000 eyed eggs to Washougal Hatchery for the Klickitat River direct release (WDFW 2004c).

2.2.2 Broodstock Origin

Although the original Lewis River Hatchery coho stock was taken from indigenous coho trapped at the Merwin Dam, coho released into the basin in the past 70 years have originated from a variety of stock sources. The majority of these releases have been Cowlitz River (Type-N) and Toutle River (Type-S) stocks. Because of these extensive stock transfers, WDFW considers the existing Lewis River coho population to be a mixed stock of composite production (WDFW 2002). Allozyme analysis of Lewis River Hatchery coho has shown them to be genetically distinct from other Washington coho stocks examined (WDFW 2002).

2.2.3 Broodstock Collection

Both Type S and Type N coho and are collected at Lewis River Hatchery and Merwin Dam traps. The traps are opened for coho collection during the entire the run and run timing is used to identify each stock. Type S coho are trapped from September through early November and Type N coho are trapped from mid November through early January (WDFW 2014c). Like spring Chinook, all Type S and Type N coho are mass marked (adipose fin clipped) except for a group of 75,000 of each stock that are coded-

[4] Under existing operations, natural stocks are not incorporated into the hatchery population (i.e. the program is not integrated at this time) (WDFW 2006).

wire tagged with no adipose fin clip (termed double-indexing) and another group of 75,000 each stock that is coded-wire tagged and adipose fin clipped.

Adult coho collected at the Lewis River Hatchery and Merwin Dam traps are identified as to wild or hatchery origin, through the examination of fin clips or coded wire tags. All hatchery Type S coho selected for spawning purposes are transported to the Speelyai Hatchery holding pond prior to spawning at Speelyai Hatchery. All Type N coho selected for spawning are held and spawned at the Lewis River Hatchery. Coho with adipose fins and no tags are marked, and returned to the river as wild fish (WDFW 2004c). After spawning, all spawned carcasses are either used for nutrient enhancement or are disposed of through the existing carcass contract (WDFW 2006). As part of reintroduction efforts, 9,000 early Type-S adult coho are transported upstream of Swift Dam each year to spawn naturally.

WDFW has a Type S coho has an egg take goal of 1,100,000 and a broodstock collection goal set at 400 females and 400 males, excluding jacks (Table 2-6). The Type N coho egg take goal is 5,100,000 eggs (a 1,900 females and 1,900 males, excluding jacks) (Table 2-7). Both goals are based on an average fecundity of 3,000 eggs per female and pre-spawning mortality of 10 percent. As described previously, the Lewis River Type N coho program also provides eggs to Fish First, the Region 5 Salmon in The Classroom Program, the Steve Syversion project, and to the Klickitat and Washougal hatcheries, if needed (not part of PacifiCorp Energy's mitigation program) (WDFW 2005c).

The vast majority of the coho collected at the Lewis River Hatchery and Merwin Dam trap are hatchery fish. Between 1994 and 2014, an average of 648 adult male and 617 adult female Type S coho and 1,329 adult male and 1,241 adult female Type N coho were used for broodstock at the Lewis River Hatchery Complex (Tables 2-6 and 2-7).

Table 2-6. The Type S coho broodstock collection level and egg take at the Lewis River Hatchery Complex (1994 through 2013).

	Type S Coho			
Year	**Adult Males**	**Adult Females**	**Jacks**	**Egg Take**
Goal*	500	500	NA	1,325,000
1994	1,024	887	17	2,517,000
1995	459	438	4	1,054,800
1996	773	682	7	2,252,700
1997	1,246	1,106	17	3,239,600
1998	1,237	1,142	41	3,463,200
1999	1,148	1,063	28	3,214,000
2000	775	770	13	2,307,000
2001	457	452	8	1,325,300
2002	396	399	3	1,363,157
2003	450	450	10	1,201,600
2004	441	443	24	1,134,119
2005 – 2007	**NA**	**NA**	**NA**	**NA**
2008	416	417	1	1,339,150
2009	500	505	5	1,588,700
2010	478	482	7	1,806,600
2011	643	644	1	1,858,000
2012	221	224	3	591,600
2013	514	503	6	1,926,071
Average	**649**	**617**	**11**	**1,861,533**

* Represent current goal as stipulated in the Settlement Agreement which will increased during the 2014 egg take.

Source: WDFW 2013 and WDFW 2014b

Table 2-7. The Type N coho broodstock collection level and egg take at the Lewis River Hatchery Complex (1994 through 2013)

	Type N Coho			
Year	**Adult Males**	**Adult Females**	**Jacks**	**Egg Take**
Goal*	360	360	NA	1,050,000
1994	3,986	2,331	36	8,936,900
1995	545	521	10	1,680,200
1996	2,453	1,920	40	7,696,400
1997	3,414	3,442	42	9,996,987
1998	2,262	2,296	39	7,750,612
1999	1,714	1,753	35	6,570,833
2000	1,150	1,159	11	4,154,920
2001	462	469	15	1,734,806
2002	584	566	8	2,228,766
2003	1,106	1,120	135	3,510,000
2004	1,052	1,099	48	3,979,051
2005	829	834	7	3,132,450
2006	775	783	11	2,987,441
2007	881	882	1	2,964,481
2008	776	777	1	2,742,882
2009	857	876	19	3,247,521
2010	851	865	18	3,422,401
2011	883	1,131	13	3,803,905
2012	1,036	1,036	50	3,318,584
2013	962	962	34	3,333,388
Average	**1,329**	**1,241**	**29**	**4,359,626**

* Represents mitigation goal for North Fork Lewis segregated program only.
Source: WDFW 2013 and WDFWc

2.2.4 Incubation and Rearing

Lewis River Type S coho are spawned at Speelyai Hatchery and the resulting eyed eggs are shipped to the Lewis River Hatchery in November for incubation in Heath stack incubators.

According to WDFW (2014c), incubation conditions are consistent with loading densities recommended by Piper et al. (1982). Water quality and temperatures are generally very good. Stack flows during incubation are 3.6 gpm and all eggs are treated with formalin to keep them free of fungus (WDFW 2004c).

Lewis River Type N coho are held, spawned, incubated (approximately 2.5 million eyed eggs, and reared at the Lewis River Hatchery. Health stack incubators are also used for this stock and incubation conditions are similar to those described for Type S coho.

Lewis River water quality is generally very good but water temperatures are quite cold (40°F) during incubation and into the early rearing period (WDFW 2004c). Like Type S coho, stack flows during incubation are 3.6 gallons per minute (gpm) and all eggs are treated with formalin to keep them free of fungus (WDFW 2004c).

Both the Type S and Type N coho fry are ponded when the yolk sac slit measures less than 1 mm. The current practice is to start the fry in raceways and then move them into a large pond for rearing until released. To keep the size similar, the growth of Type S coho is slowed until the late coho reach a similar size. The two stocks are then mixed and reared until released on-site. According to WDFW (2004b) and WDFW (2004c), rearing densities are based on standardized agency guidelines, life-stage specific survival studies conducted on-site, life-stage specific survival studies conducted at other facilities, and staff experience. The rearing densities are also consistent with those recommended by Piper et al. (1982).

2.2.5 Release Location and Numbers Released

Both the Type S and Type N coho are released volitionally over a six-week period beginning on or after April 15. According to WDFW staff, approximately 80 percent of the stock migrates volitionally during that time period. The remaining 20 percent are forced out prior to May 20th. Release timing is determined by fish behavior such as aggressive screen and intake crowding, swarming against sloped pond sides, leaner condition factors, a more silvery physical appearance, and scale loss during feeding (WDFW 2014c).

Prior to release, an area Fish Health Specialist evaluates the coho population's health and condition. According to WDFW, the production and release of only smolts through fish culture and volitional release practices fosters rapid seaward migration with minimal delay in the rivers, limiting interactions with naturally produced fish. However, fry and fingerling Type N coho fry and fingerlings were also released into to the Lewis River reservoirs in 1993, 1998, 1999, and 2001 (WDFW 2004b).

Between 1994 and 2004, an average of just over 940,000 Type S coho yearlings and 1.6 million Type N coho yearlings were released into the Lewis River annually (Tables 2-8 and 2-9). It should be noted that prior to 2002, the Lewis River Hatchery Complex also produced one million Type S coho smolts (and 750,000 eyed eggs) as part a Mitchell Act funded tribal program[5]. With the termination of the Mitchell Act funding, the tribal program was discontinued.

[5] In 1997, the Yakama Nation initiated a reintroduction program for selected tributaries in the Mid-Columbia Region with early stock coho salmon from lower Columbia River hatcheries to restore natural production identified in the Yakima Nation's "Coho Salmon Species Plan (CSSP) for the Mid-Columbia Basin. The goal of this program was to initiate restoration of coho salmon populations in mid-Columbia tributaries to levels of abundance and productivity sufficient to support sustainable annual harvest by tribal and other fisheries.

Table 2-8. The number, size, and release dates of Type S coho yearlings released into the Lewis River (1994 through 2013).

Year	Number Released	Release Dates	Size (fpp)
1994	839,300	April-May	14.0
1995	888,400	April-May	13.9
1996	897,200	April-May	13.2
1997	968,369	April-May	14.1
1998	945,321	April-May	13.0
1999	902,448	April-May	11.8
2000	1,395,072*	April-May	14.4
2001	909,038	April	14.7
2002	874,579	May	16.3
2003	912,230	May	15
2004	856,919	May	15
2005	883,851	April-May	15.5
2006	901,746	April-May	15
2007	919,424	April-May	16
2008	841,547	April-May	14
2009	889,003	April-May	16
2010	891,884	April-May	15.9
2011	828,695	April-May	15.8
2012	1,002,933	April-May	15.7
2013	988,411	April-May	15.5
Average	**902,174**	**--**	**15**

Source: WDFW 2013 and WDFWb

* 440,406 of the type S coho released in 2000 were funded by the Mitchell Act (WDFW 2006).

Table 2-9. The number, size, and release dates of Type N coho yearlings released into the Lewis River (1994 through 2013).

Year	Number Released	Release Dates	Size (fpp)
1994	869,400	April-May	14.0
1995	2,199,200	April-May	14.1
1996	2,414,000	April-May	13.0
1997	1,981,379	April-May	14.8
1998	2,289,440	April-May	13.3
1999	2,193,653	April-May	14.2
2000	2,126,655	April-May	13.2
2001	868,756	April	10
2002	841,000	March 8	10
2003	840,219	May 7 - 10	15
2004	833,786	April 6-10	15
2005	853,338	April 21	15.5
2006	827,637	May 15	15.0
2007	857,591	May 22	16.0
2008	856,491	May 19	14.0
2009	834,665	April 14 – May 11	16.0
2010	810,158	May 10	15.9
2011	801,875	April 13-25	15.8
2012	891,156	April 16-23	15.7
2013	875,797	April 1 – 23	16.6
Average	**1,253,310**	**--**	**--**

Source: WDFW 2013 and WDFWc

2.2.6 Adult Abundance

From 1994 through 2004, the total adult Type S coho hatchery escapement (to the Lewis River hatchery and Merwin Dam trap) has ranged from a low of 1,145 in 1995 to 38,783 in 2001, with an average of approximately 16,922 fish (Table 2-10). The vast majority of the Type S coho returning to the facilities are marked hatchery fish.

Table 2-10. Adult and jack Type S coho returns to the Lewis River Hatchery Complex (hatchery escapement) from 1994 through 2013 (includes wild and hatchery fish).

	Type S Coho	
Year	Adult	Jacks
1994	3,916	136
1995	1,145	641
1996	4,784	1,007
1997	5,943	260
1998	7,142	3,528
1999	14,962	2,343
2000	17,031	7,281
2001	38,783	1,291
2002	17,334	8,177
2003	38,367	1,933
2004	21,853	1,438
2005	24,902	NA
2006	22,901	NA
2007	20,215	NA
2008	32,817	NA
2009	15,414	NA
2010	16,172	NA
2011	15,416	NA
2012	2,827	NA
2013	16,516	NA

Source: WDFW 2013 and WDFWb

From 1994 through 2004, the total adult Type N coho hatchery escapement has ranged from a low of 1,299 in 1995 to 60,873 in 2001, with an average of approximately 18,585 fish (Table 2-11). The vast majority of these are hatchery fish and the goal is to remove as many hatchery stock Type N coho as possible to minimize the interaction with those fish that result from wild spawners.

Table 2-11. Adult and jack Type N coho returns to the Lewis River Hatchery Complex (hatchery escapement) from 1994 through 2013 (includes wild and hatchery fish).

Year	Total Hatchery Escapement	
	Adult Type N Coho	Jack Type N Coho
1994	8,513	121
1995	1,299	460
1996	5,291	2,619
1997	12,571	307
1998	10,817	2,089
1999	17,724	6,757
2000	24,006	10,910
2001	60,873	533
2002	13,976	NA
2003	25,587	NA
2004	15,016	NA
2005	24,344	NA
2006	23,226	NA
2007	16,660	NA
2008	27,112	NA
2009	25,624	NA
2010	23,983	NA
2011	15,603	NA
2012	5,682	NA
2013	13,795	NA

Source: WDFW 2013 and WDFWc

2.3 STEELHEAD

2.3.1 Current Management Goals and Production Levels

According to WDFW (2014e), the primary purpose of the Lewis River summer steelhead program is to[6]:

1. Rear and release 175,000 summer steelhead smolts at 4.8 fpp into the Lewis River (Table 2-1),

2. Provide adult harvest under the selective fishery regulations (retention of adipose clipped fish only),

3. Provide some escapement for broodstock for continued Merwin Hatchery production,

[6] A more detailed description of the program goals is available in WDFW 2004e.

4. Cover transfers of 35,000 subyearlings to the Elochoman Hatchery, 60,000 yearlings to the Fish First Echo Bay Co-op Net Pens, 60,000 eyed eggs to Skamania Hatchery (not part of PacifiCorp Energy's mitigation program), and

5. Operate the hatcheries consistent with the recovery of ESA listed steelhead in the Lewis River (i.e. maintain the genetic diversity of naturally spawned steelhead and minimize ecological interactions with naturally produced salmon and steelhead) (WDFW 2014e).

The primary purpose of the winter steelhead program is to[7]:

1. Release 100,000 winter steelhead smolts at 4.8 fpp into the Lewis River (Table 2-1).

2. Provide adult harvest under the selective fishery regulations (retention of adipose clipped fish only) and provide protection to listed fish,

3. Provide some escapement for broodstock for continued Merwin Hatchery production,

4. Operate the hatcheries consistent with the recovery of ESA listed steelhead in the Lewis River (i.e. maintain the genetic diversity of naturally spawned steelhead and minimize ecological interactions with naturally produced salmon and steelhead) (WDFW 2004e).

2.3.2 Broodstock Origin

Summer and winter steelhead are indigenous to the Lewis River basin; however, large numbers Skamania Hatchery summer steelhead and Skamania Hatchery and Beaver Creek Hatchery winter steelhead have been released into the Lewis River since the late 1950s (PacifiCorp and Cowlitz PUD 2004b). Skamania Hatchery summer steelhead were developed from Washougal River and Klickitat River summer steelhead at the Skamania Hatchery, Washington (Crawford 1979). This stock has been widely used in Washington, Idaho, Oregon, and California. Skamania Hatchery winter steelhead were derived from Beaver Creek Hatchery and Skamania Hatchery winter steelhead stocks. Skamania stock early-winter steelhead has been the source of nearly all the early winter hatchery smolts that WDFW releases in the Lower Columbia River region with the exception of Cowlitz River. Following the completion of Merwin Hatchery in 1993, the Lewis River Hatchery Complex egg take needs have been met using eggs from returning steelhead in the Lewis River system or by importing eggs from the Skamania Hatchery. It should be noted that Skamania eggs have not been used at the facility since 1998 (WDFW 2006).

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[7] A more detailed description of the program goals is available in WDFW 2004f.

2.3.3 Broodstock Collection

All summer and winter steelhead broodstock for the Lewis River Hatchery Complex program are volunteers to the Lewis River Hatchery and Merwin Dam traps. All hatchery-origin steelhead are adipose-fin clipped and only adipose fin-clipped adults are used for broodstock. According to WDFW (2014d,e), the vast majority of the steelhead collected in the traps are of hatchery stock. Adult collection and spawning guidelines for summer steelhead at Merwin Hatchery are as follows:

1. Broodstock will be collected from July through September. However, shortfalls may require additional collections through the fall.

2. There will be no size selection.

3. Spawning will occur from December through January and will be completed by January 31.

4. Spawning will be one-to-one female unless shortfalls in broodstock occur; then half of the eggs from one female will be spawned with a different male.

Winter steelhead collection and spawning guidelines at Merwin Hatchery are as follows:

1. Fish entering the racks prior to December 7 will be marked so that they can be identified and will not be used for broodstock.

2. Broodstock retained for spawning from December 7 through January. New fish will be recruited into spawning population throughout the period. Males will be used once, opercle-punched, and returned to the river.

3. Bright (indicating recent freshwater entry) females that are running eggs will not be spawned.

4. There will be no selection for size.

5. Spawning will occur from December through January and will be completed by January 31.

6. Spawning will be one-to-one male to female unless shortfalls in broodstock occur, then half of the eggs from one female will be spawned with a different male.

WDFW has a summer steelhead broodstock collection goal of 225 males and 225 females and a winter steelhead broodstock collection goal of 200 males and 100 females (spawning at 1:1 ratio with a backup male) (Tables 2-12 and 2-13). The egg take goals are 325,000 for summer steelhead and 145,000 for winter steelhead (WDFW 2013).

Table 2-12. The summer steelhead broodstock collection level and egg take at the Lewis River Hatchery Complex (1995 through 2013).

Year	Summer Steelhead		
	Adult Males	Adult Females	Egg Take
Goal	100	100	325,000
1995	NA	53	230,060
1996	NA	NA	276,500
1997	NA	NA	66,500
1998	196	132	247,500
1999	92	46	325,200
2000	206	104	440,609
2001	109	158	634,331
2002	293	227	399,000
2003	305	161	444,500
2004	399	215	669,594
2005	325	162	567,000
2006	271	134	469,000
2007	313	156	546,000
2008	338	169	589,000
2009	227	113	395,500
2010	178	96	384,000
2011	98	97	385,500
2012	131	130	520,000
2013	100	99	396,000

* Current goal, in the past additional brood was collected for use at other facilities.

Source WDFW 2013 and WDFWe

Table 2-13. The winter steelhead broodstock collection level and egg take at the Lewis River Hatchery Complex (1995 through 2013).

Year	Winter Steelhead		
	Adult Males	**Adult Females**	**Egg Take**
Goal	**45**	**45**	**145,000**
1995	NA	NA	570,657
1996	122	122	573,000
1997	136	136	401,575
1998	137	198	546,000
1999	102	102	282,800
2000	122	93	371,957
2001	260	130	398,919
2002	270	136	998,107
2003	322	326	NA
2004	205	102	423,935
2005	190	96	336,000
2006	106	51	178,500
2007	110	55	192,500
2008	136	73	255,500
2009	99	48	182,400
2010	49	43	159,600
2011	30	30	120,000
2012	35	33	138,600
2013	37	37	148,000

* Current goal, in the past additional brood was collected for use at other facilities.
Source: WDFW 2013 and WDFW 2014d

The first adult summer steelhead begin arriving at Merwin Hatchery in April; however, they are not collected until July. After being collected they are held until December before spawning begins. Fish can be held in raceways or holding ponds for maturation. The first adult winter steelhead begin arriving at Merwin Hatchery in December and are held briefly until before spawning begins. Holding adults are treated with formalin or hydrogen peroxide or a combination of both (up to 7 days per week) to control fungus growth. According to WDFW staff, pre-spawn mortality for summer steelhead can be as high as 20 percent due to IHN.. After spawning, all summer steelhead carcasses are taken to the local landfill for disposal. Winter steelhead carcasses fit for human consumption are donated to local food banks. Treated carcasses are taken to a local rendering plant (WDFW 2014e and (WDFW 2013).

Between 1995 and 2004, an average of 229 adult male and 137 adult female summer steelhead broodstock were collected at the Lewis River Hatchery Complex annually (Table 2-12). During this same period, an average of 186 adult male and 149 adult female winter steelhead broodstock were collected at the complex (Table 2-13). Returning hatchery steelhead that are not used for broodstock are marked and returned to the Lewis River just below the confluence with the East Fork Lewis River (RM 3.4) for additional harvest opportunity.

2.3.4 Incubation and Rearing

All adult summer and winter steelhead are held, spawned, and incubated at Merwin Hatchery. Juvenile rearing also takes place at Merwin Hatchery and in net pens located in Lake Merwin near Speelyai Bay[8] (WDFW 2004e and WDFW 2004d). The water used to supply the Mari stack incubators at Merwin Hatchery is pumped directly from Lake Merwin, treated with ozone, and passed through an enclosed stripper. Water quality is generally very good; however, high water temperatures in the summer (58°F to 59°F) can be a problem (Tetra Tech/KCM 2002). According to WDFW staff, 3 fish pool spawnings are incubated separately during the green to eyed-egg stage to monitor for IHN (WDFW 2006). Water temperatures are monitored continuously during incubation and Formalin is used to control of fungus and ecto-parasites.

Initial feeding and early rearing occurs in the incubation trough and ponding is on TU's and visual inspection (WDFW 2013). The fry are then transferred to the appropriate starter raceway. Ponding dates each year run between February 25th and April 5th (WDFW 2014e). According to WDFW, rearing densities are consistent with the loading densities recommended by Piper et al. (1982). In addition, flow rates, water temperatures, dissolved oxygen, and TSS is monitored on a routine basis throughout the rearing period.

2.3.5 Release Location and Numbers Released

Summer and winter steelhead releases occur from approximately mid-April to May 10th. Prior to release into the Lewis River, all steelhead volitionally migrate from two rearing ponds to a "smolt collection pond". They are then pumped into tank trucks on a daily basis and hauled to the release site at the I-5 bridge (RM 5.0) (WDFW 2014e and WDFW 2014d). According to WDFW, this is below much of listed Chinook habitat but above the confluence with the East Fork Lewis River minimizing straying into the East Fork. Prior to release, an area Fish Health Specialist evaluates the population's health and condition. This is commonly done 1 to 3 weeks prior to release and up to 6 weeks on systems with pathogen free water and little or no history of disease.

Between 1996 and 2004, an average of 162,145 summer steelhead yearlings and 105,838 winter steelhead yearlings have been released into the Lewis River annually (Tables 2-14 and 2-15). In the past 10 years, steelhead fry and fingerlings surplus to the anadromous program have also been planted in Lake Merwin and Swift Creek Reservoir to help support the landlocked trout lake fishery (not part of PacifiCorp Energy's mitigation program) (WDFW 2014e and WDFW 2014d).

[8] Approximately 60,000 juvenile steelhead are transferred to the net pens.

Table 2-14. The number, size, and release dates of summer steelhead yearlings released into the Lewis River (1996 through 2013).

Year	Number Released*	Release Dates	Size (fpp)
1996	122,279	April 13 - May 1	5.9
1997	123,776	April 20 - May 11	6.3
1998	155,218	April - May	6.4
1999	149,242	April 17 - May 7	5.7
2000	172,038	April 16 - May 1	4.8
2001	238,188	April 16 - May 17	4.5 - 5.0
2002	178,160	April 16 - May 8	4.9
2003	144,104	May	4.7
2004	176,304	April 18 - May 7	4.7
2005	177,344	Apr 21-May 11	4.9
2006	166,827	May 1-28	5.4
2007	179,356	Apr 16-May 15	5.3
2008	171,822	Apr 16-May 12	4.7
2009	175,263	Apr 16-May 8[a]	5.1
2010	180,621	Apr 23, May 3-11	4.8
2011	189,071	Apr 15-29	5.4
2012	192,080	Apr 20-23, Apr 27-May 30	5.0
2013	192,325	Apr 15-17, 26- 30	5.8

Source: WDFW 2013 and WDFWe

* Releases do not include Echo Bay and Speelyai net pen releases, except in 2001.

Table 2-15. The number, size, and release dates of winter steelhead yearlings released into the Lewis River (1996 through 2013).

Year	Number Released	Release Dates	Size (fpp)
1996	123,248	April 13 - May 1	5.9
1997	123,776	April 20 - May 11	6.3
1998	104,018	April 16 - May 1	6.2
1999	101,542	April 19 - May 7	5.6
2000	101,473	April 17 - May 1	4.8
2001	104,110	April 16 - May 1	4.7
2002	102,633	April 30 - May 6	4.8
2003	89,585	May	4.7
2004	102,154	April 21 - May 7	4.6
2005	93,056	April 27-May 9	4.7
2006	97,359	May 4-29	4.8
2007	96,819	April 16-May 15	4.7
2008	103,684	April 16-May 13	4.4
2009	93,491	April 16-17, May 1	4.5
2010	116,691	April 15	4.9
2011	102,135	April 15	4.8
2012	26,760	April 27	4.5
2013	128,360	April 15	5.7

Source: WDFW 2013 WDFWd

2.3.6 Adult Abundance

From 1995/1996 through 2013, the adult summer steelhead hatchery escapement has ranged from a low of 830 in 1995 to 20,289 in 2006 (Table 2-16). Winter steelhead escapement has ranged from 378 in 1997/1998 to 4,952 in 2001/2002.

Table 2-16. Summer steelhead returns to the Lewis River Hatchery Complex (hatchery escapement) from 1995/1996 through 2013 (includes wild and hatchery fish).

	Total Hatchery Escapement	
Year	Summer Steelhead	Winter Steelhead
1995/1996	830	642
1996/1997	2,069	581
1997/1998	1,216	378
1998/1999	1,446	923
1999/2000	1,126	401
2000/2001	2,079	935
2001/2002	2,819	4,957
2002/2003	6,961	2,132
2003/2004	14,717	3,076
2004/2005	11,329	617
2005/2006	9,354	3,300
2006/2007	20,289	3,263
2007/2008	14,273	4,632
2008/2009	6,293	2,528
2009/2010	11,304	3,497
2010/2011	10,206	2,840
2011/2012	9,521	2,334
2012/2013	4,932	1,119
2013	5,803	

Source: WDFW 2013, WDFWd and WDFWe

2.4 RESIDENT RAINBOW TROUT

2.4.1 Current Management Goals and Production Levels

The overall goal of the Lewis River Hatchery Complex resident rainbow rout program is to maintain the fishery in Swift Reservoir. Prior to 2006, approximately 800,000 to 1,000,000 rainbow trout fry at approximately 40 per pound were stocked in Swift Reservoir annually (as required by Article 51 of the Merwin license) (WDFW 2013). Beginning in 2006, the resident rainbow trout goal is to plant approximately 20,000 pounds of rainbow trout at 3 fpp (Table 2-1) (pers. comm. Eric Kinney, WDFW, Lewis River Complex Manager, October 5, 2005).

2.4.2 Broodstock Origin

Over the past 25 years, the primary resident rainbow stock source for the Lewis River program has been from the Goldendale Hatchery in Washington; however, rainbow trout from the Spokane Hatchery (Washington) and Mt. Whitney Hatchery (California) have also been released into Swift Reservoir. According to Crawford (1979), Goldendale rainbow trout are derived from a combination of "McNott, Meander, and Cape Cod rainbow trout strains." Meander rainbow trout were originally obtained from the meander trout farm in Pocatello, Idaho using eggs from the U.S. Fish Commission's hatchery at Springville, Utah. Cape Cod rainbow trout, originally produced at the Cape Cod Trout Company of Wareham, Massachusetts, were obtained from the McCloud River near Mt. Shasta. Spokane rainbow trout, produced at the Spokane Hatchery since 1942, were also originally obtained from the McCloud River. Mt. Whitney rainbow trout are a mixture of Sacramento River rainbow trout and Klamath River steelhead. This stock was originally obtained by WDFW in 1962 (Crawford 1979). Goldendale rainbow trout spawn from October through February, Spokane rainbow trout spawn from November through December, and Mt. Whitney rainbow trout spawn from February through March (Crawford 1979).

2.4.3 Broodstock Collection

All eggs currently used for the Lewis River resident rainbow trout program are transferred to the Lewis River Hatchery Complex from the Goldendale Hatchery or Spokane Hatchery. In December 2005, approximately 150,000 eyed eggs were transferred to Merwin Hatchery from the Goldendale Hatchery (WDFW 2013).

2.4.4 Incubation and Rearing

Under existing operations (as of 2006), all juvenile rainbow trout are incubated and reared at Merwin Hatchery to approximately 10 fpp. They are then transferred to Speelyai Hatchery where they are reared to about 3 fpp prior to planting in Swift Reservoir in April.

2.4.5 Release Location and Numbers Released

The vast majority of resident rainbow trout produced at the Lewis River Hatchery Complex are released directly into Swift Reservoir; however, rainbow trout also been released into the Swift Power Canal to provide angling opportunities. Between 1995 and 2004, an average of 758,262 resident rainbow trout fingerlings have been released into Swift Reservoir annually (Table 2-17). Releases are typically made in June and July.

Table 2-17. The number, size, and release dates of resident rainbow trout released into Swift Reservoir (1994 through 2013).

Year	Number Released	Average Size (fpp)	Pounds Planted
1995	958,193	35.5	NA
1996	726,656	25	NA
1997	679,580	21.5	NA
1998	930,361	26.5	NA
1999	227,998	29.5	NA
2000	547,361	39	NA
2001	918,187	36	NA
2002	867,924	34.5	NA
2003	857,695	40	NA
2004	868,662	40	NA
2005	302,367	31.7	9,548
2006	57,675	2.3	25,076
2007	63,344	2.8	22,622
2008	60,418	2.0	30,209
2009	55,161	2.6	21,380
2010	60,000	2.0	30,000
2011	51,956	2.5	20,700
2012	69,885	2.6	26,372
2013	71,361	2.2	32,885

Source: WDFW 2013

2.4.6 Adult Abundance

As part of Merwin Project studies in 1990, PacifiCorp Energy biologists completed a creel survey on Swift Reservoir (PacifiCorp 1996). From May through October 1990, anglers on Swift Reservoir had an average catch rate of 0.97 fish per hour. Rainbow trout comprised approximately 99 percent of the fish harvested (PacifiCorp 1996). From April 24 through October 1999, WDFW conducted an additional creel survey in Swift Reservoir and Swift canal (PacifiCorp and Cowlitz PUD 2004b). During this survey, a total of 496 anglers were interviewed. These bank and boat anglers fished a total of 1,800 hours to harvest 1,504 fish. Rainbow trout and cutthroat trout comprised 84.7 percent and 14.7 percent of the fish harvested (PacifiCorp and Cowlitz PUD 2004b).

2.5 KOKANEE

2.5.1 Current Management Goals and Production Levels

The current kokanee production goal at the Lewis River Hatchery Complex is 45,000 fingerlings (12 fpp) and 48,000 yearlings (5.4 fpp) (12,500 pounds) (Table 2-1) (WDFW

2004a). All kokanee associated with this program are planted in Lake Merwin. The WDFW management objective for kokanee is to maintain the fishery.

2.5.2 Broodstock Origin

Kokanee are not native to the Lewis River basin. In the late 1950s and early 1960s, Swift Reservoir, Yale Lake and Lake Merwin all were stocked with kokanee from Kootenay Lake and Cultus Lake, British Columbia. A self-sustaining population currently exists in Yale Lake. Lake Merwin kokanee are thought to persist through escapement over Yale dam (PacifiCorp 1999). In 1996, WDFW decided to supplement the kokanee population in Lake Merwin using hatchery kokanee spawned and reared at Speelyai Hatchery. In 1999, Yale Lake received its first planting of kokanee since 1957 due to low numbers of returning kokanee in Cougar Creek (PacifiCorp and Cowlitz PUD 2000). Plants in Yale Lake were temporary and discontinued in late 2001.

2.5.3 Broodstock Collection

All broodstock used for the Speelyai Hatchery kokanee program are collected at Speelyai Hatchery. As part of scheduled upgrades, a kokanee weir trap was installed at the hatchery. The Speelyai Hatchery water diversion dam, located at the mouth of Speelyai Creek, is a total barrier to upstream fish migration. As a result, fish are not able to access the creek from Lake Merwin. Between 1995 and 2013 the total number of kokanee broodstock collected at Speelyai Hatchery has ranged from 224 in 1996 to 1,701 in 1998 (Table 2-18). Following spawning, all kokanee carcasses are disposed of at a local landfill.

Table 2-18. The kokanee broodstock collection level and egg take at the Lewis River Hatchery Complex (1995 through 2013).

Year	Total Hatchery Escapement	Egg Take
1995	240	48,000
1996	224	14,021
1997	917	69,000
1998	1,701	237,500
1999	1,396	181,200
2000	929	180,000
2001	1,191	162,000
2002	836	145,200
2003	944	144,000
2004	1,075	208,190
2005	NA	NA
2006	930	152,838
2007	729	132,500
2008	683	255,400
2009	400	126,200
2010	400	122,740
2011	368	130,300
2012	380	137,700
2013	363	143,330

Source: WDFW 2013

2.5.4 Incubation and Rearing

Kokanee eggs are incubated at Speelyai Hatchery and are ponded in February of each year. As described previously, the kokanee program consists of two releases of unmarked fish, and early fingerling release directly from the hatchery in the October (45,000 at 12 fpp) and a yearling release from the Lake Merwin net pens in the spring (48,000 at 5.4 fpp).

2.5.5 Release Location and Numbers Released

All kokanee produced at the Lewis River Hatchery Complex are released directly into Lake Merwin. Release numbers and size at release have been highly variable in the past 8 years and recently; releases have exceeded the production targets (Table 2-19). Releases that exceed production targets have been unfed fry plants (except for Cougar Creek plants) (WDFW 2013). There is currently an escapement goal for Cougar Creek and if it is not met WDFW may augment that production with hatchery kokanee fry.

Table 2-19. The number, size, and release dates of kokanee released into Lake Merwin (1995 through 2013).

Year	Number Released	Average Size (fpp)
1997	46,360	1300
1998	NA	NA
1999	97,437	160
2000	44,120	7.9
2001	128,112	129
2002	97,572	10.9
2003	163,713	7.1
2004	112,830	10.6
2005	144,401	9.9
2006	129,461	10.2
2007	90,700	12.3
2008	78,105	8
2009	78,595	9.1
2010	96,135	10.4
2011	61,330	9.6
2012	93,448	7.3
2013	93,415	7.4

Source: WDFW 2013

2.5.6 Adult Abundance

Kokanee are the primary target species for anglers in Lake Merwin. Current adult abundance estimates are no available; however, a 1995 creel survey in Lake Merwin (May through August) estimated that 19,337 hours were expended to catch 3,068 kokanee, 511 resident coho (excess hatchery coho), 20 rainbow trout, and 20,764 northern pikeminnow (Hillson and Tipping 1999).

2.6 SEA-RUN CUTTHROAT TROUT

Prior to 1999, as a condition of the Merwin Project license, Merwin Hatchery annually released about 25,000 sea-run cutthroat smolts (Cowlitz and Skamania stocks) into the North Fork Lewis River. The original goal of the program was to produce sea-run cutthroat trout to mitigate for lost habitat due to construction of the three PacifiCorp Energy dams on the Lewis River (Hillson and Tipping 1999). Because of a low return to the creel in 1997 and 1998 and concerns over potential interactions (predation and competition) with wild cutthroat and fall Chinook salmon, the program was discontinued in 1999. The existing Lewis River coastal cutthroat trout population is considered native with wild production (WDFW 2000).

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Appendix B

Section 8 of the Lewis River Settlement Agreement

SECTION 8: HATCHERY AND SUPPLEMENTATION PROGRAM

8.1 Hatchery and Supplementation Program. The Licensees shall undertake a hatchery and supplementation program. The goals of the program are to support (i) self-sustaining, naturally producing, harvestable native anadromous salmonid species throughout their historical range in the North Fork Lewis River Basin, and (ii) the continued harvest of resident and native anadromous fish species (the "Hatchery and Supplementation Program"). The Hatchery and Supplementation Program shall be consistent with the priority objective of recovery of wild stocks in the basin to healthy and harvestable levels. The intention of the foregoing sentence is not necessarily to eliminate the hatchery program but it recognizes the importance of recovering wild stocks and a potential that hatchery production may adversely affect recovery. The Hatchery and Supplementation Program shall be consistent with the ESA, applicable state and federal fisheries policies, and regional recovery plans, and should be consistent with recommendations of the Hatchery Science Review Group and the Northwest Power Planning Council's Hatchery Review (Artificial Production Review & Evaluation) to the extent practicable. The supplementation portion of the program shall be a part of the reintroduction program (in addition to fish passage) and shall be limited to spring Chinook, steelhead and coho as provided in this Section 8.

To ensure that the Hatchery and Supplementation Program is meeting its goals, the Licensees, in Consultation with the ACC and with the approval of the Services, shall develop and implement a hatchery and supplementation plan to adaptively manage the program and guide its management as set out in Section 8.2 below ("Hatchery and Supplementation Plan" or "H&S Plan"). The Licensees shall incorporate best methodologies and practices into the Hatchery and Supplementation Plan. The Hatchery and Supplementation Plan shall be designed to achieve the numeric Hatchery Targets provided for in Section 8.3 below, and those targets shall be calculated in terms of ocean recruits of hatchery origin, taking into account harvest and escapement. For purposes of this Agreement, "Ocean Recruits" shall mean total escapement (fish that naturally spawned above Merwin and hatchery fish) plus harvest (including ocean, Columbia River, and Lewis River harvest). Subject to the ESA, applicable federal and state fisheries policies, regional recovery plans, other applicable laws and policies, and the terms of this Agreement, the Licensees shall provide for the implementation of the Hatchery and Supplementation Program for the terms of the New Licenses.

As of the Effective Date, WDFW owns the existing Lewis River Hatchery facility. Use and operation of the Lewis River Hatchery is subject to agreements between PacifiCorp and WDFW. The Licensees shall ensure the existing Lewis River, Merwin, and Speelyai hatchery facilities (the "Hatchery Facilities") are modified pursuant to Section 8.7 below to meet their obligations under this Section 8. The Licensees shall ensure the Hatchery Facilities, including the relevant or necessary support facilities (e.g., employee housing, shops, hatcheries, and related infrastructure), as modified, are maintained as necessary to consistently deliver a high-quality hatchery product that will meet their obligations. The Licensees' hatchery production obligations as set forth in Section 8.4 below, including both anadromous and resident fish, shall be limited by the combined production capacity of the Hatchery Facilities ("Hatcheries Capacity Limit") as established after implementation of upgrades as set forth in Section 8.7. The Licensees may, after Consultation with the ACC, use different hatcheries than those described above; provided that such different hatcheries (a) have equal or greater capacity than the Hatchery Facilities if that capacity is still required to meet the Licensees' obligations under this Section 8, (b) are of quality equal to or greater than that of the Hatchery Facilities, and (c) comply with transfer and disease protocols and other requirements of the H&S Plan.

8.2 Hatchery and Supplementation Plan. The Licensees, in Consultation with the ACC and subject to the approval of the Services, shall develop a Hatchery and Supplementation Plan to address hatchery operations, supplementation, and facilities as provided in Section 8.2.1 below. Until implementation of the Hatchery and Supplementation Plan, PacifiCorp shall continue to implement the hatchery program set forth in Articles 50 and 51 of the 1983 Merwin license, as amended.

The Hatchery and Supplementation Plan will address both anadromous and resident fish. The Licensees shall incorporate best methodologies and practices into all components of the H&S Plan, including, but not limited to, the Hatchery Facilities and supplementation facilities. When developing the H&S Plan, the Licensees and the ACC shall be guided, at a minimum, by the Fish Planning and Hatchery Review Documents (submitted as AQU-18 with the Licensees' applications for the Merwin, Swift No. 1, and Swift No. 2 Projects in April 2004), and shall take into consideration the results of ongoing relevant hatchery reviews and the experience of other supplementation programs in the region, such as the Yakama Nation's Cle Elum facility. The Licensees shall transition from the hatchery program set forth in Articles 50 and 51 of the 1983 Merwin license, as amended, to implementing the Hatchery and Supplementation Plan as soon as practicable after Issuance of the New License(s) for the Merwin Project or the Swift Projects, whichever occurs earlier, provided that supplementation will commence as provided in Section 8.5. When finalized, the Licensees shall submit the Hatchery and Supplementation Plan to WDFW and NOAA Fisheries for consideration in their development of applicable hatchery genetic management plans ("HGMPs").

8.2.1 Development of Plan/Timing. The Licensees, in Consultation with the ACC, shall produce and distribute a draft Hatchery and Supplementation Plan to the ACC by the first anniversary of the Effective Date. The Yakama Nation may chair a subgroup of interested members of the ACC for purposes of coordinating the ACC's input regarding the supplementation elements of the draft H&S Plan. The members of the ACC shall have 60 days to comment on the draft H&S Plan. The Licensees shall provide a 60-day period for the public to provide written comments. The Licensees shall consider and address in writing the written comments provided by the members of the ACC, including the rationale behind the Licensees' decision to not address a comment in the final H&S Plan. The Licensees shall consider comments and submit a revised H&S Plan to the Services for approval within 120 days of the first anniversary of the Effective Date.

8.2.2 Hatchery and Supplementation Plan Contents. The H&S Plan shall address the means by which the Licensees shall use the Hatchery Facilities to accomplish the goals and requirements of the Hatchery and Supplementation Program, including, without limitation, the Hatchery Targets. It shall also be consistent with the objective of restoring and recovering wild stocks in the basin to healthy and harvestable levels. The H&S Plan shall address, at a minimum, the following topics:

8.2.2.1 A description of the Hatchery Facilities, including the upgrades identified in Schedule 8.7;

8.2.2.2 Identification of species and broodstock sources to be used for the Hatchery and Supplementation Program;

8.2.2.3 The quantity and size of fish to be produced;

8.2.2.4 The allocation of smolts and adults between the hatchery and supplementation programs and a description of how the two programs are to be implemented at the same facility without causing unacceptable adverse impacts on each other;

8.2.2.5 Rearing and release strategies for each stock including, but not limited to, timing, planned distribution, locations for release, procedures to transport smolts to acclimation sites for supplementation purposes, and upward and downward production adjustments to accommodate natural returns;

8.2.2.6 The Ocean Recruits Methodology referenced in Section 8.3.2.2 below;

8.2.2.7 Plans and protocol for supplementation stocks;

8.2.2.8 Broodstock collection and breeding protocols;

8.2.2.9 Policies in effect regarding in-basin and out-of-basin stock transfers;

8.2.2.10 Measures to minimize potential negative impacts of the Hatchery and Supplementation Program on ESA-listed species;

8.2.2.11 Measures to protect production processes from predators, e.g., netting, consideration of evolving hatchery practices to condition fish to avoid predators;

8.2.2.12 A description of how the Hatchery and Supplementation Program monitoring and evaluation requirements will be implemented, including, but not limited to, marking strategies;

8.2.2.13 A description of the methods to prevent unacceptable adverse impacts, if any, of (1) the hatchery program on the reintroduction program, and

(2) the supplementation program on native resident species; and

8.2.2.14 Fish health protocols.

8.2.3 Annual Operating Plan. The Licensees shall provide for the implementation of the Hatchery and Supplementation Plan through an annual plan ("Annual Operating Plan"). The Annual Operating Plan shall be consistent with the Hatchery and Supplementation Plan. The Licensees, in Consultation with the hatchery managers and with the approval of the Services, shall develop the initial Annual Operating Plan as part of the Hatchery and Supplementation Plan. The Licensees shall develop subsequent Annual Operating Plans in Consultation with the hatchery managers and subject to the approval of the Services. The Annual Operating Plan may be included as part of the detailed annual reports of the ACC activities required by Section 14.2.6.

The Annual Operating Plan shall, at a minimum, contain: (1) a production plan, which shall specify the species and broodstock sources; (2) the current Hatchery Target and Juvenile Production Target for each species to be produced at the Hatchery Facilities; (3) a release plan which shall identify by species the rearing schedule and planned distribution of fish and the schedules and locations for releases; (4) a list of facility upgrades to be undertaken that year; and (5) a description of relevant monitoring and evaluation to be undertaken that year.

8.2.4 Reporting Requirements. On an annual basis, the Licensees shall provide to the ACC for review and comment a report compiling all information gathered pursuant to implementation of the Hatchery and Supplementation Plan. The report also will include recommendations for ongoing management of the Hatchery and Supplementation Program. The ACC shall have 60 days to comment on the annual report. Within 60 days of the close of the comment period, the Licensees shall finalize the report after consideration of all comments. The Licensees shall also provide the comprehensive periodic review undertaken pursuant to Section 8.2.6 below to the ACC. The Licensees shall provide final annual reports and the comprehensive periodic review to the Services during the development of any required ESA permit or authorization for hatchery operations, including NOAA Fisheries' HGMP process. The report may be included as part of the detailed annual reports of the ACC activities required by Section 14.2.6.

8.2.5 Plan Modifications. The Licensees shall update the Hatchery and Supplementation Plan every five years or earlier if required by the HGMP, in Consultation with the ACC and with the approval of the Services, using the process set out in Section 8.2 above in order to adaptively manage the Hatchery and Supplementation Program. The Licensees shall consider recommendations from members of the ACC and the comprehensive review set forth below, and identify those recommendations that have not been incorporated into the H&S Plan with a brief statement as to why the changes were not made.

8.2.6 Comprehensive Periodic Review. The Licensees shall undertake a comprehensive periodic review within 5 years after reintroduction above Swift No. 1 Dam, within 5 years after reintroduction into Yale Lake, and within 5 years after reintroduction into Lake Merwin, and then every 10 years after that. This schedule is to be followed even in the event that reintroduction into either Yale Lake or Lake Merwin does not occur. The Licensees, in Consultation with the ACC, shall hire an independent consultant to review the Hatchery and Supplementation Program to assess (i) the Program's impact on the reintroduction program and on listed species, (ii) the Program's effectiveness in achieving the goals set out in Section 8.1 above, and (iii) efficiency of hatchery operations. Factors to be considered in the review include current federal and state policies and plans, relevant best practices, and existing information regarding recent scientific advances. The reviewer will provide recommendations regarding ongoing management of the Hatchery and Supplementation Program and, if needed, recommend amendments to the Hatchery and Supplementation Plan. The Licensees shall incorporate recommendations for ongoing management of the Hatchery and Supplementation Program set forth in the review into the Hatchery and Supplementation Plan pursuant to Section 8.2.5 or explain why the recommendation is not being adopted.

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:

Table 8.3.1 – Hatchery Targets

	Spring Chinook	Steelhead	Coho	Total
Hatchery Targets (adult Hatchery Ocean Recruits)	12,800	13,200	60,000	86,000

8.3.2 Modifications to Hatchery Targets.

8.3.2.1 Hatchery Targets. The Licensees shall not increase any of the Hatchery Targets above the Hatchery Targets in Table 8.3.1 above during the terms of the New Licenses without the unanimous approval of the ACC.

8.3.2.2 Methods to Document Ocean Recruits. The Licensees, in Consultation with the ACC, shall determine the methods to document the number of Ocean Recruits and to separately identify Hatchery Ocean Recruits and Ocean Recruits from natural spawning in the Hatchery and Supplementation Plan ("Ocean Recruits Methodology"). The Ocean Recruits Methodology shall identify the appropriate assessment time frame over which to measure Hatchery Ocean Recruits and Natural Ocean Recruits.

8.3.2.3 Reductions in Hatchery Targets. When the Licensees determine, in Consultation with the ACC, through application of the Ocean Recruits Methodology that the number of Ocean Recruits from natural spawning grounds of any species exceeds the relevant natural production threshold(s) for that species identified in Table 8.3.2 ("Natural Production Threshold"), the Licensees shall decrease the appropriate Hatchery Target(s) identified in Table 8.3.1 on a fish-for-fish (1:1) basis. The Licensees shall not apply the amount of excess numbers of one species against another species' Hatchery Target. The Licensees shall not decrease the Hatchery Targets below the hatchery target floor ("Hatchery Target Floor") specified in Table 8.3.2.

8.3.2.4 Unacceptable Adverse Impacts on Reintroduction Program or Fisheries Management Objectives. If the Services determine that there are unacceptable impacts from hatchery production on the reintroduction program or fishery management objectives including, but not limited to, the recovery of wild stocks in the basin, then the Licensees, in Consultation with the ACC, shall identify and consider options to mitigate or avoid such unacceptable impacts. In Consultation with the ACC and at the direction of the Services, the Licensees shall implement options necessary to address such unacceptable adverse impacts, including, without limitation, modifying hatchery practices, reducing Hatchery Targets, or implementing other options that are identified pursuant to this Section 8.3.2.4.

8.3.2.5 Increases in Previously Reduced Hatchery Targets. If the Licensees reduce Hatchery Targets based on the number of Natural Ocean Recruits as determined by the Ocean Recruits Methodology, but the number of Ocean Recruits subsequently declines under such methodology, the Licensees, in Consultation with the ACC and at the direction of the Services, shall increase the Hatchery Targets on a fish-for-fish (1:1) basis, provided that the increased Hatchery Targets shall not exceed the initial Hatchery Targets in Table 8.3.1, and available data demonstrates that the hatchery fish are not the cause of decline or a significant limiting factor to self-sustaining, naturally producing, harvestable native anadromous salmonid species.

Table 8.3.2 – Numbers Governing Modifications to Hatchery Targets

	Spring Chinook	Steelhead	Coho	Total
Natural Production Threshold for Hatchery Reduction	2,977	3,070	13,953	20,000
Hatchery Target Floor	2,679	2,763	12,558	18,000

8.4 Anadromous Fish Hatchery Juvenile Production. Each year, the Licensees shall provide for the production of spring Chinook salmon smolts, steelhead smolts, and coho salmon smolts at levels specified below ("Juvenile Production"). The Licensees shall use the Juvenile Production to provide (1) juveniles for the supplementation program under Section 8.5, and (2) juveniles for harvest opportunities. To the extent that there are not sufficient juveniles for the Hatchery and Supplementation Program and to ensure that enough adults will return to ensure adequate broodstock for the Hatchery and Supplementation Program in future years, the Licensees shall, in Consultation with the ACC and subject to the approval of the Services, determine how best to allocate juveniles.

8.4.1 Juvenile Production Targets. The Licensees shall provide for the implementation of the following Juvenile Production targets ("Juvenile Production Targets") when the Hatchery and Supplementation Program commences. The following Juvenile Production Targets shall be used unless and until modified by the Licensees pursuant to Section 8.4.2 as part of the Hatchery and Supplementation Plan in accordance with Section 8.2.5:

Table 8.4 – Juvenile Production Targets

Smolt Production	Spring Chinook	Steelhead	Coho
H&S Plan Years 1 – 3	1.35 million	275,000	1.8 million
H&S Plan Years 4 – 5	1.35 million	275,000	1.9 million
H&S Plan Years 6 – 50	1.35 million	275,000	2.0 million

8.4.2 Adjustment of Juvenile Production. The Licensees, in Consultation with the ACC, shall adjust the Juvenile Production as needed to achieve the Hatchery Targets subject to the Hatcheries Capacity Limit, e.g., at some point in the future a smaller number of juveniles may be needed to get the same number of returning adults. When determining whether adjustments should be made, the Licensees, in Consultation with the ACC, shall consider the hatchery practices component of the Hatchery and Supplementation Plan (e.g., density, best management practices), data from the Monitoring and Evaluation Plan identified in Section 9 (including, but not limited to, fish quality and adult return requirements), the periodic comprehensive review described in Section 8.2.6 above, and the terms of Section 8.1.

8.4.3 Stock Selection. The Licensees shall select stocks for the production of juveniles that are the most appropriate for the basin. The stock selected and the rationale shall be set forth in the Hatchery and Supplementation Plan. The following stocks shall be used unless and until modified by the Licensees as part of the Hatchery and Supplementation Plan in accordance with Section 8.2.5:

Table 8.4.3 – Broodstock

	Spring Chinook	Steelhead	Coho
Juveniles for Supplementation (release above Merwin)	Lewis River hatchery stock with Cowlitz River hatchery stock as contingency	Lewis River wild winter stock with Kalama hatchery stock as contingency	Lewis River hatchery early (type S) stock

Juveniles for Harvest (release below Merwin)	Same as for supplementation	Same as for supplementation **and** existing Lewis River hatchery summer and winter stock	Same as for supplementation **and** Lewis River hatchery late (type N) stock

8.5 Supplementation Program.

8.5.1 Juvenile Salmonids Above Swift No. 1 Dam. The Licensees shall, for the purpose of supplementation, provide for the transport of juvenile anadromous salmonids to acclimation sites selected pursuant to Section 8.8.1, for the following periods of time:

(1) Spring Chinook and Steelhead. The Licensees shall provide the means to supplement juvenile spring Chinook and steelhead for a period of 15 years commencing upon completion of the Swift Downstream Facility pursuant to Section 4.4.1; and

(2) Coho. The Licensees shall provide the means to supplement juvenile coho salmon for a period of 9 years commencing upon completion of the Swift Downstream Facility.

At the end of these time periods, the Licensees shall assess on a year-by-year basis whether to extend the supplementation of juvenile salmonids. Upon ACC agreement and subject to the Services' approval, the Licensees shall continue to supplement juvenile salmonids. In evaluating whether to extend the supplementation of juveniles, the ACC shall consider, among other things, the impact of continuing supplementation on the overall reintroduction program and on ESA-listed species.

8.5.2 Juvenile Salmonids to Yale Lake and Lake Merwin. PacifiCorp shall, for the purposes of supplementation, provide for the transport of juvenile anadromous salmonids to appropriate release sites in Yale Lake and Lake Merwin, as described in Section 8.8.2 below, for the following periods of time:

(1) Spring Chinook and Steelhead. PacifiCorp shall provide the means to supplement juvenile spring Chinook and steelhead for a period of 15 years to Yale Lake commencing upon completion of the Yale Downstream Facility as provided in Section 4.5; and for a period of 15 years to Lake Merwin commencing upon completion of the Merwin Downstream Facility as provided in Section 4.6; and

(2) Coho. PacifiCorp shall provide the means to supplement juvenile coho salmon into Yale Lake for a period of 9 years commencing upon completion of the Yale Downstream Facility and into Lake Merwin for a period of 6 years commencing upon completion of the Merwin Downstream Facility.

At the end of these time periods, PacifiCorp shall assess on a year-by-year basis whether to extend the supplementation of juvenile salmonids. Upon ACC agreement and subject to the Services' approval, the Licensees shall continue to supplement juvenile salmonids. In evaluating whether to extend the supplementation of juveniles, the ACC shall consider, among other things, the impact of continuing supplementation on the overall reintroduction program and on ESA-listed species.

8.5.3 Adult Salmonids. The Licensees shall begin providing for the supplementation of adult fish one year prior to completion of the Swift Downstream Facility. Throughout the terms of the New Licenses, the Licensees shall provide for the transport and release of supplementation stocks of adult spring Chinook, coho, and steelhead above Swift No. 1 as directed by the ACC. Throughout the terms of the New Licenses, PacifiCorp shall provide for the transport and release of supplementation stocks of adult spring Chinook, coho, and steelhead into Yale Lake and Lake Merwin as directed by the ACC. The ACC shall determine the timing for initiating supplementation into Yale Lake and Lake Merwin. The ACC, subject to the approval of the Services, may recommend discontinuing or recommencing the supplementation of such supplementation stocks, provided that any such recommendations are biologically based and not contrary to the goals of the ESA.

8.5.4 Supplemental Juveniles. The Licensees shall not mark supplementation juveniles in the same manner as hatchery fish are marked for harvest.

8.6 Resident Fish Production.

8.6.1 Rainbow Trout Production. Each year, for the terms of the New Licenses, subject to Section 8.6.3, the Licensees shall provide for the production of 20,000 pounds of resident rainbow trout. When the New License is Issued for either the Merwin Project or the Swift Projects, whichever is earlier, the Licensees shall fulfill their obligation by providing for the production of 800,000 juveniles with an estimated weight of 40 juvenile fish per pound, or an equivalent number, in pounds, of resident rainbow trout of a different life stage as directed by WDFW, following Consultation with the ACC. The Licensees shall provide for the stocking of such rainbow trout in Swift Reservoir. Resident rainbow trout will be managed separately from steelhead and shall not significantly interfere with the recovery of self-sustaining, naturally producing, harvestable populations of native steelhead.

8.6.2 Resident Kokanee Production. Each year, for the terms of the New Licenses, subject to Section 8.6.3, PacifiCorp shall provide for the production of 12,500 pounds of resident kokanee. When the New License is Issued for either the Merwin Project or the Swift Projects, whichever is earlier, PacifiCorp shall fulfill its obligation by providing for the production of 93,000 juveniles of various sizes which have an estimated weight of 12,500 pounds or an equivalent number, in pounds, of resident kokanee of a different life stage as directed by WDFW, following Consultation with the ACC. Unless otherwise determined by the ACC through the Hatchery and Supplementation Plan, PacifiCorp shall provide for the annual stocking of such resident kokanee in Lake Merwin.

8.6.3 Modifications in Resident Rainbow Trout and Kokanee Production. The Licensees shall modify resident rainbow trout and kokanee production numbers as part of the Hatchery and Supplementation Plan, in Consultation with the ACC and subject to the approval of the Services and WDFW, to address other management goals, including, without limitation, harvest considerations and impacts of the resident fish hatchery program on the reintroduction program; provided that the Licensees shall not increase (i) resident rainbow trout production above a cap of 20,000 pounds and, (ii) resident kokanee production above a cap of 12,500 pounds.

8.7 Hatchery and Supplementation Facilities, Upgrades, and Maintenance. The Licensees shall, in collaboration with the hatchery managers and hatchery engineers and in Consultation with the ACC, undertake or fund facility additions, upgrades, and maintenance actions as provided in Schedule 8.7, consistent with best methodologies and practices. The Licensees, in collaboration with the hatchery managers and hatchery engineers, and in Consultation with the ACC, shall design these facilities, upgrades, and maintenance actions to include elements that ensure usefulness of the facilities for supplementation and production fish culturing practices and to accommodate the facility additions, upgrades, and maintenance actions identified in Schedule 8.7. The Licensees shall complete the upgrades or actions by the deadlines identified in Schedule 8.7, provided that the Licensees shall schedule the updates or actions consistent with (i) the required hatchery production or (ii) the reintroduction program. The Licensees shall not be required to construct new hatchery facilities or to expand the existing Hatchery Facilities except as provided pursuant to this Section 8.7. WDFW retains the right and authority to operate its hatchery and conduct other or additional fish production activities that do not impact the goals set forth in Section 8.1 at the state-owned Lewis River Hatchery at no additional cost to the Licensees.

8.8 Juvenile Acclimation Sites.

8.8.1 Above Swift No. 1 Dam. Beginning upon completion of the Swift Downstream Facility, the Licensees shall place juvenile salmonid acclimation sites in areas reasonably accessible to fish hauling trucks and in practical areas in the upper watershed above Swift No. 1 Dam, as determined by the Licensees in Consultation with the Yakama Nation and the ACC. The acclimation sites shall consist of fish containment areas that allow juvenile fish to acclimate in natural or semi-natural waterways and allow necessary pre-release juvenile fish management; such sites will not consist of or include concrete-lined ponds or waterways, but may include other concrete structures necessary for facility functionality and structural integrity during the supplementation program.

8.8.2 In Yale Lake and Lake Merwin. Beginning upon completion of the Yale Downstream Facility and the Merwin Downstream Facility, respectively, PacifiCorp shall provide in-stream enclosures to confine juvenile salmonids in tributaries to Yale Lake and Lake Merwin after they are transported from rearing facilities for the purpose of allowing juveniles to adjust to the natural environment for a short period of time, to be determined by the Licensees, in Consultation with the ACC and with the approval of the Services, prior to being exposed to natural mortality factors such as predators. These enclosures are intended to provide an opportunity for the juveniles to acclimate to the natural environment prior to being exposed to predators. While it is assumed that there will be sufficient food in the natural stream, if evidence suggests, prior to placing juveniles in the enclosures, that this is not the case, the Licensees will Consult with the ACC to determine if feeding of juveniles in the enclosures should occur. Prior to completion of the Yale Downstream Facility and the Merwin Downstream Facility, respectively, the Licensees shall, in Consultation with the ACC, evaluate whether Hatchery and Supplementation Program goals will be cost-effectively served by establishing and operating acclimation sites for any of the targeted stocks in Yale Lake, Lake Merwin, or their tributaries. In the event that funding becomes available for acclimation facility establishment and operation in Yale Lake, Lake Merwin or their tributaries from Parties other than the Licensees or from third parties, the Licensees shall amend the H&S Plan, subject to the approval of the Services, to provide for placing of juvenile anadromous salmonids in such acclimation facilities for so long as the funding continues to be available and placement does not negatively impact the supplementation program or otherwise alter the obligations of the Licensees.

Appendix C

Memo to PacifiCorp from Brian Pyper - Preliminary assessment of methods and steps required to compute ocean recruits of salmon for the Lewis River

Preliminary assessment of methods and steps required to compute ocean recruits of salmon for the Lewis River

Brian Pyper, Fish Metrics

March 31, 2014

Summary

For this contract, I was tasked to provide assistance with the interpretation and implementation of methods for computing ocean recruits for components of Lewis River salmon production. It is my opinion that considerable effort is required to produce a (reasonably) defensible framework for computing the desired metrics. While considerable progress was made, there is still much work to do to (1) complete the general statistical framework; (2) integrate ocean-wide CWT recovery data (RMIS) with specific sampling programs for fisheries and escapements within the Lewis River basin; and (3) develop robust procedures for annually computing ocean recruits. In this report, I provide a rough outline of the various methods, data, and tools required to compute ocean recruits, and conclude with recommendations for steps needed to complete these tasks.

Background

The Lewis River Hatchery and Supplementation Plan (H&S Plan) identified three indices that could be used to measure ocean recruits (PacifiCorp Energy and Cowlitz PUD 2006). These were reiterated in the Aquatic Monitoring and Evaluation Plan ("AM&E Plan") for the Lewis River (PacifiCorp Energy and Cowlitz PUD 2010). In both reports, it is noted that "ocean recruits" is defined in the Settlement Agreement as "*… the total escapement (fish that naturally spawned above Merwin and hatchery fish) plus harvest (including ocean, Columbia River, and Lewis River Harvest)*." Furthermore, in both reports it is noted that jacks are <u>not</u> to be included or counted as part of the ocean recruits analysis (May 11, 2006 ACC Meeting).

The three measures discussed are:

1. **Age 2 Recruits (Age 2)**: Number of fish alive at the time of first recruitment into a fishery (typically at age 2). Represents the maximum number of fish available to be managed.

2. **Adult Equivalent Run (AER)**: The total number of fish that would have returned to the spawning grounds at all ages in the absence of fisheries. In other words, AER is the best estimate of adult run-size absent human harvest.

3. **Catch Plus Escapement (C+E)**: Total catch of all ages plus total escapement of all ages. This method is in reality the outcome of harvest management activities affecting the species.

Further details in the H&S Plan indicate that: (1) all three methodologies will be used to calculate spring Chinook and coho ocean recruit numbers, while only the third method (catch plus escapement) will be used for the steelhead calculation (due to limited harvest); and (2) program success for Chinook and coho should likely be based on the AER method because it defines total production absent fisheries.

Formulas for computing the above recruitment metrics were provided in the H&S plan and duplicated in Appendix D of the AM&E Plan. However, the computations for AER are not correct. The flow chart presented in Figure D-1 (PacifiCorp Energy and Cowlitz PUD 2010) depicts a simple cohort model, while the "AER equations" are actually cohort-reconstruction equations (with additional errors) used to estimate age-specific ocean recruits. I recommend that these formulas be disregarded.

In the following sections, I outline methods required to compute the three measures of ocean recruits. Computations of catch plus escapement (C+E) are relatively trivial, although considerable effort may be required to tabulate catch and escapement data. Estimates of age-2 recruits and AER require cohort modeling (or some suitable proxy thereof). Thus, I begin with a simple cohort model and then discuss addition complexities in later sections.

Example cohort model

The following model provides a very simple depiction of age-specific processes and fisheries for a typical brood-year cohort of Chinook salmon. For initial consistency, the model structure is very similar to that presented in Appendix D of the AM&E Plan, which included possible straying and pre-spawn mortality. A model schematic is provided in Figure 1; variables and parameters are defined in Table 1.

In this example, it is assumed that ocean recruitment starts at age $a = 2$ and ends at age $a = 5$. Catch (C) and incidental fishing mortalities (I) are defined for three sequential fisheries: ocean (subscript "1"); Columbia River (subscript "2"); and terminal (subscript "3"). Abundances (N) are depicted at four stages: N_0, the starting ocean abundance of a given age before applying the natural survival rate (s); N_1, the abundance just prior to ocean fishing; N_2, the abundance of mature recruits entering the Columbia River; and N_3, the abundance of mature recruits entering the Lewis River and terminal fishery.

For illustrative purposes, the sequential equations for propagating a cohort forward through time are as follows (e.g., starting with an assumed age-2 abundance, $N_{0,a=2}$):

$$N_{1,a} = s_a N_{0,a}$$ Abundance before ocean fisheries

$$N_{2,a} = m_a (N_{1,a} - C_{1,a} - I_{1,a})$$ Abundance to Columbia River

(1) $$N_{3,a} = (1 - r_a)(N_{2,a} - C_{2,a} - I_{2,a})$$ Abundance to terminal fisheries

$$E_a = (1 - p_a)(N_{3,a} - C_{3,a} - I_{3,a})$$ Escapement

$$N_{0,a+1} = (1 - m_a)(N_{1,a} - C_{1,a} - I_{1,a})$$ Abundance next year

The computations end with the final age group for which the maturity rate, m_a, is 1.0 (100%).

Our interest lies in cohort reconstruction. For a given brood-year cohort, it is assumed that age-specific values of catch (*C*) and escapement (*E*) are known, and estimates of incidental mortalities (*I*) are available. The reconstruction equations run backwards starting with age-5 data, providing the following age-specific estimates of abundance and maturity rate:

	$\hat{N}_{3,a} = E_a/(1-p_a) + C_{3,a} + \hat{I}_{3,a}$	Abundance to terminal fisheries
	$\hat{N}_{2,a} = \hat{N}_{3,a}/(1-r_a) + C_{2,a} + \hat{I}_{2,a}$	Abundance to Columbia River
(2)	$\hat{N}_{1,a} = \hat{N}_{0,a+1} + \hat{N}_{2,a} + C_{1,a} + \hat{I}_{1,a}$	Abundance before ocean fisheries
	$\hat{N}_{0,a} = \hat{N}_{1,a}/s_a$	Starting abundance
	$\hat{m}_a = \hat{N}_{2,a}/(\hat{N}_{2,a} + \hat{N}_{0,a+1})$	Estimate of maturity rate

where $\hat{N}_{0,a=6} = 0$. Incidental mortalities and parameter assumptions are discussed further below.

Table 1. Variables and parameters in the cohort model.

Symbol	Description
t	Subscript denoting brood year
a	Subscript denoting age
N	Abundance (number of fish)
C	Catch (number of fish)
I	Incidental fishing mortality (number of fish)
E	Escapement (number of fish)
s	Natural survival rate
m	Maturity rate
r	Stray rate
p	Pre-spawn mortality rate

Cohort Model

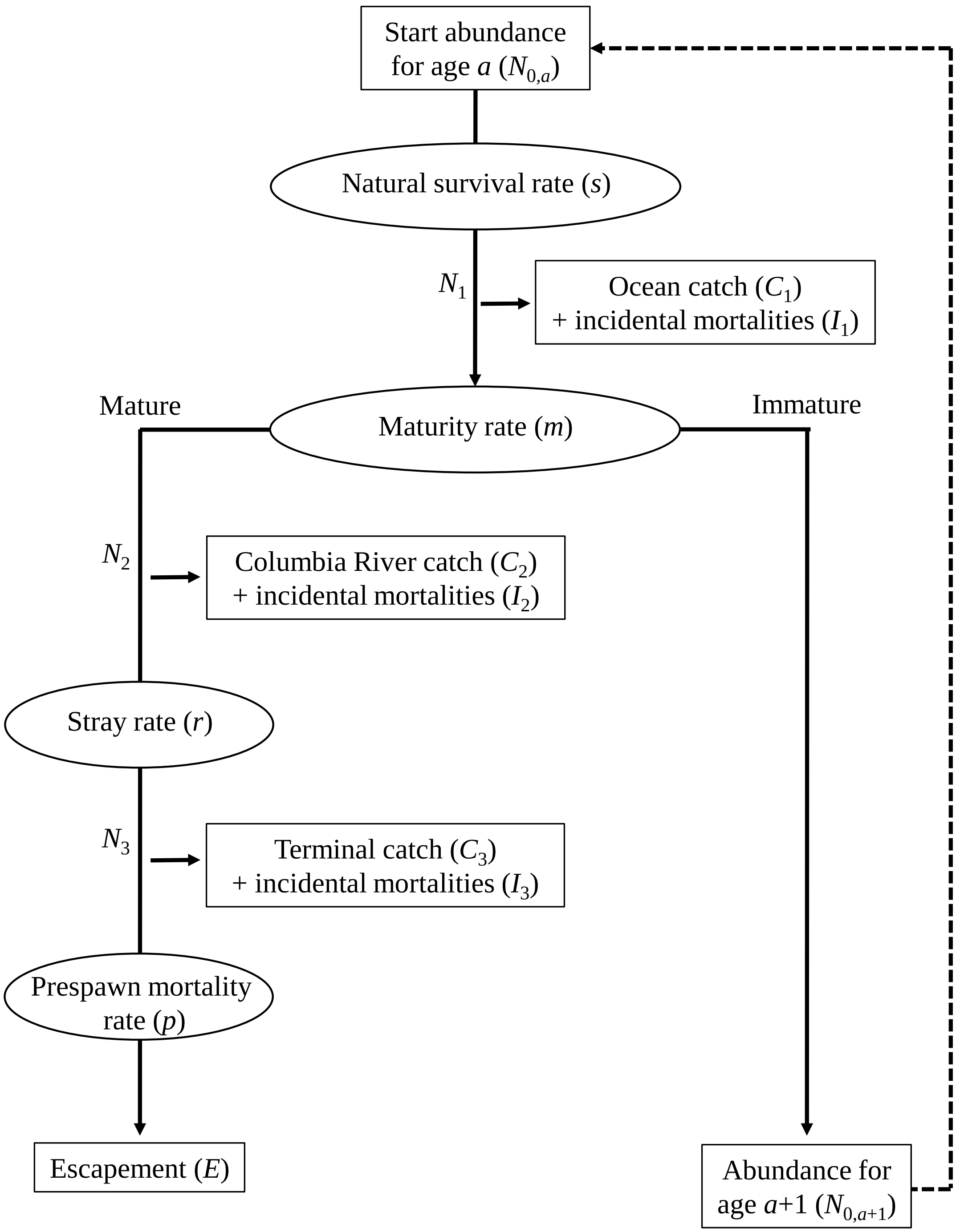

Figure 1. Cohort model depicting processes and fisheries for a given age (subscript "*a*" omitted for clarity). See text for details.

Measures of ocean recruits

The following provides simple formulas for computing measures of ocean recruits, predicated on the above cohort model and symbol definitions. Additional details are provided in later sections.

Catch plus escapement

Catch plus escapement, $(C+E)_t$, for brood year t is computed as the sum of age-specific escapement (E) and catch (based on expanded CWT recoveries) in ocean fisheries (C_1), Columbia River mainstem fisheries (C_2), and terminal fisheries (C_3):

(3) $$(C+E)_t = \sum_{a=2}^{5} \left(E_{a,t} + C_{1,a,t} + C_{2,a,t} + C_{3,a,t} \right).$$

Age-2 recruits

A cohort reconstruction is required to estimate age-2 recruitment (e.g., see equation 2). To reiterate, the definition provided in the AM&E Plan for age-2 recruits is the "[n]umber of fish alive at the time of first recruitment into a fishery." This value is given by $\hat{N}_{1,a=2}$ in equation (2). Additional data requirements and computational details are discussed below.

Adult equivalent run (AER)

As noted above, the AER measure was defined as:

> "The total number of fish that would have returned to the spawning grounds at all ages in the absence of fisheries. In other words, AER is the best estimate of adult run-size absent human harvest."

This is somewhat ambiguous in terms of the final destination; on one hand it's the "spawning grounds" whereas "adult run-size" could be interpreted as, for example, "entering the Columbia River" or "entering the Lewis River." However, as outlined below, this distinction only matters if straying rates (r) and/or pre-spawn mortality rates (p) are greater than zero.

A general formula for adult equivalent returns (AER) is given by:

(4) $$AER_t = \sum_{a=2}^{5} \left(f_{E,a} E_{a,t} + f_{1,a}[C_{1,a,t} + \hat{I}_{1,a,t}] + f_{2,a}[C_{2,a,t} + \hat{I}_{2,a,t}] + f_{3,a}[C_{3,a,t} + \hat{I}_{3,a,t}] \right)$$

where f denotes an adult equivalent factor (AEF). Two sets of AEFs are considered: (1) AEFs that exclude strays and pre-spawn mortalities as adult equivalents (i.e., only recruits that would have reached the spawning grounds); and (2) AEFs that include strays and pre-spawn mortalities as adult equivalents (i.e., all recruits that would have entered the Columbia River). Note that when all stray rates (r_a) and pre-spawn mortality rates (p_a) are equal to zero, both sets of AEFs will be the same.

For AER estimates that exclude strays and pre-spawn mortalities, the AEF factors are defined as (for ages 2 through 5):

(5)
$$
\begin{aligned}
f_{E,a} &= 1 && \text{AEF for escapement} \\
f_{1,a=5} &= (1-p_5)(1-r_5) && \text{AEF for age-5 ocean impacts} \\
f_{1,a=4} &= m_4(1-p_4)(1-r_4) + (1-m_4)s_5 f_{1,a=5} && \text{AEF for age-4 ocean impacts} \\
f_{1,a=3} &= m_3(1-p_3)(1-r_3) + (1-m_3)s_4 f_{1,a=4} && \text{AEF for age-3 ocean impacts} \\
f_{1,a=2} &= m_2(1-p_2)(1-r_2) + (1-m_2)s_3 f_{1,a=3} && \text{AEF for age-2 ocean impacts} \\
f_{2,a} &= (1-p_a)(1-r_a) && \text{AEF for Columbia River impacts} \\
f_{3,a} &= (1-p_a) && \text{AEF for terminal impacts}
\end{aligned}
$$

Here, ocean impacts and Columbia River impacts are reduced by straying rates and pre-spawn mortality rates, while terminal impacts are reduced by pre-spawn mortality rates.

For AER estimates that include strays and pre-spawn mortalities, the AEF factors are defined as:

(6)
$$
\begin{aligned}
f_{E,a} &= 1/[(1-p_a)(1-r_a)] && \text{AEF for escapement} \\
f_{1,a=5} &= 1 && \text{AEF for age-5 ocean impacts} \\
f_{1,a=4} &= m_4 + (1-m_4)s_5 f_{1,a=5} && \text{AEF for age-4 ocean impacts} \\
f_{1,a=3} &= m_3 + (1-m_3)s_4 f_{1,a=4} && \text{AEF for age-3 ocean impacts} \\
f_{1,a=2} &= m_2 + (1-m_2)s_3 f_{1,a=3} && \text{AEF for age-2 ocean impacts} \\
f_{2,a} &= 1 && \text{AEF for Columbia R. impacts} \\
f_{3,a} &= 1/(1-r_a) && \text{AEF for terminal impacts}
\end{aligned}
$$

Here, escapements are expanded by straying rates and pre-spawn mortality rates, while terminal impacts are expanded by straying rates.

For either set of AEFs, the ocean-fishery AEFs ($f_{1,a}$) are computed recursively beginning with $f_{1,a=5}$, and require values for age-specific maturity rates (m_a), which can be estimated from reconstructed abundances (e.g., see $\hat{m}_a$ in equation 2). Additional data requirements and computational details are discussed below. It is worth noting that a cohort model can provide an equivalent but simpler approach to estimating AER. Specifically, if a cohort reconstruction is conducted (equation 2), then a parallel forward cohort model (equation 1) can be implemented using the reconstructed estimates for age-2 recruits ($N_{1,a=2}$) and maturity rates (m_a). After setting all fishery impacts (C and I) to zero, the model values of E_a and $N_{2,a}$ represent adult equivalents excluding (E_a) and including ($N_{2,a}$) strays and pre-spawn mortalities.

Comments

As noted in the Background, it was indicated in the H&S Plan that jacks (i.e., age-2 fish) would not be included in measures of ocean recruits. As such, a more appropriate measure may be "age-3 recruits" rather than age-2 recruits. Note that if all coho salmon are assumed to recruit and mature at age 3, estimates of age-3 recruits and AER will only differ if either (1) stray rates and/or pre-spawn mortality rates are greater than zero and the AER measure of interest excludes these adult equivalents (equation 5); or (2) natural survival rates are applied at time steps after recruitment to ocean fisheries. For Chinook salmon, the age-2 (or age-3) recruits measure will be much greater than $C+E$ and AER, depending on maturity schedules and natural survival rates (i.e., these early measures of recruits contain a high proportion of fish that would be expected to perish naturally, in contrast to AER, which accounts for natural survival rates). In short, the AER measures for Chinook or coho salmon will be of primary interest, as suggested in the H&S Plan.

Cohort model details

As described above, a cohort-model framework (e.g., Prager and Mohr 2001; Palmer-Zwahlen et al. 2006) will be required to estimate the age-2 and AER measures of ocean recruitment. However, it is currently unclear what level of spatial and temporal complexity is appropriate. The example cohort model (Figure 1) defines only three fisheries (ocean, Columbia River, and terminal) and an annual time step. While this might be sufficient for the Columbia River and terminal fisheries, greater complexity will be required to model incidental mortalities in ocean fisheries. Before addressing options for spatial complexity of fisheries, it is useful to review sources of incidental mortality.

Computing incidental mortalities

A key challenge of a cohort reconstruction is estimating incidental fishing mortalities (I). In general, three types of fisheries are applicable here (e.g., MEW 2008): (1) retention fisheries (in which all retrieved fish of legal size are retained); (2) non-retention fisheries (all retrieved fish are released); and (3) mark-selective fisheries (only landed ad-clip fish of legal size are retained). In conventional assessments, two types of incidental mortalities are computed, referred to here as "release mortalities" (fish that are retrieved and released but later die of injury) and "drop-off mortalities" (in hook and line fisheries, these are fish assumed to have been hooked but that were lost before retrieval and died due to gear-inflicted injury or predation).

All sources of fishing mortality depend on the number of fish "encountered" (or "contacted") by the ocean fishery, that is, the number of fish caught and successfully retrieved. For the jth fishery (at a given time step), example calculations of the various age-specific mortalities are as follows (e.g., Prager and Mohr, 2001; Pyper et al. 2012):

$$V_{j,a} = N_a v_{j,a}$$ Encounters (contacts)

$$C_{j,a} = V_{j,a} q_{j,a}$$ Catch

(7) $$R_{j,a} = V_{j,a}(1 - q_{j,a}) r_{j,a}$$ Release mortalities

$$D_{j,a} = V_{j,a} d_{j,a}$$ Drop-off mortalities

$$I_{j,a} = R_{j,a} + D_{j,a} = V_{j,a}[r_{j,a}(1 - q_{j,a}) + d_{j,a}]$$ Incidental mortalities

where

V = number of encounters
v = proportion of age-specific abundance (N) encountered (contact rate)
q = proportion of encounters retained
R = number of release mortalities
r = catch-and-release mortality rate
D = number of drop-off mortalities
d = additional fraction of the total encounters assumed as drop-off mortalities

As observed in equation (7), incidental mortalities are the sum of release mortalities (R) and drop-off mortalities (D). In a retention fishery, catch by age (C_a) can be estimated via CWT expansions, and q_a represents the proportion of fish that are of legal size (assuming size limits). In this case, the number of total encounters is given by $V_a = C_a / q_a$, and hence, incidental mortalities can be computed as

(8) $$I_{j,a} = \frac{C_{j,a}}{q_{j,a}}[r_{j,a}(1 - q_{j,a}) + d_{j,a}].$$

If virtually all fish (e.g., at age 2) are below the size limit, q_a is effectively zero, and an alternative estimate of encounters is required (as for non-retention fisheries below). Size limits may only be applicable for Chinook, in which case, incidental mortalities for coho would be simply $I_{j,a} = C_{j,a}[1 + d_{j,a}]$, where j represents all retention fisheries.

A non-retention fishery is more problematic. There are no CWT recoveries to estimate encounter rates, so an estimate of v_a (the proportion of age-specific abundance N_a encountered) is required. In non-retention fisheries, $q_a = 0$ (all retrieved fish are released), and hence, incidental mortalities are given by

(9) $$I_{j,a} = N_a v_{j,a}[r_{j,a} + d_{j,a}].$$

A mark-selective fishery is essentially the same as a retention fishery for marked fish (e.g., ad-clipped hatchery fish), or the same as a non-retention fishery for unmarked fish (e.g., natural production).

<u>Spatial complexity for ocean fisheries</u>

The most broadly applied (conventional) uses of cohort modelling for Chinook and coho salmon are contained within the assessment models used by technical committees of the Pacific Marine Fisheries Council (PFMC) and Pacific Salmon Commission (PSC). These include the coho and Chinook versions of FRAM (MEW 2008) and the PSC Chinook Model (CTC 2014a). I also searched relevant agency literature and contacted several WDFW staff to see if other cohort reconstructions had been specifically developed for Lewis River (or similar) salmon stocks. The only examples I found with specific relevance were by Cramer (1996, 1997), in which reconstructions were completed for several Cowlitz River and Lewis River runs.

My thoughts on model complexity have evolved. Initially, I pursued an approach in which cohort models for Lewis River runs would mimic (to the extent possible) the fishery structures and methods used in the coho/Chinook FRAMs and/or PSC Chinook Model. My reasoning was that:

(a) These model frameworks provide the most defensible methods and structures available;
(b) The present complexity of ocean fisheries and regulations is extensive (e.g., Figure 2);
(c) The PFMC and PSC assessments are updated annually, documenting changes in fishery regulations and relevant parameter values; and
(d) I thought it would be relatively easy to obtain the essential “data tables” (e.g., within FRAM) that translate RMIS recovery locations (for CWTs) to modelled fisheries, as well as those tables that link fisheries with their specific annual regulations (e.g., size limits, periods of non-retention, mark-selective status, etc.).

However, I had recent discussions with Gary Morishima and Larry Lavoy (who collectively have decades of experience with these assessment models), which discouraged this idea. My impression is that it would be a challenge to obtain the essential “data tables” in (d) above, and that the entire approach would be overly complex. As noted by Larry Lavoy, the accuracy of cohort reconstructions usually depends, to a much greater extent, on having solid estimates of age-specific escapement and terminal fishing harvests, rather than having precise estimates of incidental mortalities.

I therefore recommend use of a relatively simple structure for ocean fisheries in Lewis River cohort reconstructions (focused on marked fish). I have not flushed out all of the details yet, but it will likely involve omitting incidental mortalities for certain fisheries (e.g., non-retention fisheries for Chinook, low impact net and seine fisheries, etc.). For validation, reconstructed estimates of incidental mortalities could be compared with (or supplemented by) those estimated for specific indicator stocks that are modelled in PFMC and PSC annual analyses (e.g., Willamette River spring Chinook). Total fishing mortalities for unmarked fish (i.e., accounting for mark-selective fisheries) will be derived using escapement recoveries of DIT releases.

As discussed below, I developed a preliminary model and conducted reconstructions for Lewis River spring Chinook for numerous brood years. These analyses provide an initial indication of maturity rates, incidental mortalities, and relative differences among the three measures of ocean recruits.

Table 4.1 Mark-selective fisheries occurring 2003–2011 (√).

Fishery	Location	Period	2003	2004	2005	2006	2007	2008	2009	2010	2011
Sport	B.C. Strait of Juan de Fuca, selected subareas	Mar–Apr						√	√	√	√
Sport	WA/OR Ocean Area 1-4	June								√	√
Sport	WA PS Area 5	Summer	√	√	√	√	√	√	√	√	√
Sport	WA PS Area 6	Summer	√	√	√	√	√	√	√	√	√
Sport	WA PS Area 7	Winter						√	√	√	√
Sport	WA PS Area 8.1	Winter			√	√	√	√	√	√	√
Sport	WA PS Area 8.2	Winter			√	√	√	√	√	√	√
Sport	WA PS Area 9	Summer					√	√	√	√	√
Sport	WA PS Area 9	Winter						√	√	√	√
Sport	WA PS Area 10	Summer					√	√	√	√	√
Sport	WA PS Area 10	Winter						√	√	√	√
Sport	WA PS Area 11	Summer					√	√	√	√	√
Sport	WA PS Area 11	Winter							√	√	√
Sport	WA PS Area 12	Winter								√	√
Sport	WA PS Area 13	Summer					√	√	√	√	√
Sport	Nooksack	Sep–Dec		√	√	√	√	√	√	√	√
Sport	Skykomish	Jun–July	√	√	√	√	√	√	√	√	√
Sport	Carbon and Puyallup	Aug–Dec	√	√	√	√	√	√	√	√	√
Sport	Upper Skagit	Jun–July			√	√	√	√	√	√	√
Sport	Nisqually	Jul–Jan				√	√	√	√	√	√
Sport	Skokomish	Aug–Dec								√	√
Sport	Quillayute	Feb–Dec	√	√	√	√	√	√	√	√	√
Sport	Hoh	May–Aug						√	√	√	√
Sport	Willapa Bay and tributaries	Jul–Jan								√	√
Commercial	Willapa Bay	Aug–Nov								√	√
Sport	Columbia	Summer	√	√		√		√		√	√
Sport	Lower Columbia	Spring	√	√	√	√	√	√	√	√	√
Sport	Lower Columbia tributaries	Fall									√
Commercial (tangle net)	Lower Columbia	Spring	√	√	√	√	√	√	√	√	√
Commercial, (large net)	Lower Columbia	Spring	√	√	√	√	√	√	√	√	√
Sport	Willamette	Spring	√	√	√	√	√	√	√	√	√
Sport	Yakima	Spring		√				√		√	√
Sport	Lower Snake	Fall						√	√	√	√
Sport	Lower Snake	Spring								√	√
Sport	Oregon terminal	Spring						√	√	√	√

Note: See SFEC (2013) for more detailed information on MSF proposals and fisheries.

Figure 2. Summary of mark-selective fisheries for Chinook salmon (Table 4.1 in CTC 2014a).

Parameter values

Some of the required parameter values used in the cohort reconstructions can be obtained from FRAM (or PSC Chinook model) documentation (e.g., MEW 2008; CTC 2014a, 2014b). These include age-specific survival rates (*s*; equation 2) and incidental mortality rates (*r* and *d*; equation 7). For spring Chinook, we will need to derive age-specific estimates for *q* (proportions of legal-sized fish), and perhaps *v* (contact rate), or obtain surrogate estimates for a suitable stock (e.g., Cowlitz or Willamette spring Chinook, both of which appear to have been modelled within FRAM over the years). These latter parameters will most influential for age-3 fish (assuming age-2 fish or "jacks" can be omitted); age-4 fish and older are predominantly of legal size.

Example parameter values, as well as straying rates, are discussed below in the context of the preliminary model and reconstructions.

Preliminary analyses

To get an initial understanding of the data, I used the RMIS database to obtain all CWT releases and corresponding recovery data for Lewis River hatcheries (Lewis River, Merwin, and Speelyai). Initially, I found the "report" formats for RMIS output to be either cumbersome or limiting, so I extracted all of the data in raw format (csv files) for use in Excel and R (a statistical programming package). I then developed "key tables" that allowed me to filter and process the raw data as needed (in R). This overall approach provided an efficient and flexible platform for analysis.

The following data summaries and analysis are exploratory only. It was not my intention to examine only certain release types (e.g., production versus experimental releases) or address other nuances. Rather, I was interested in developing analytical procedures (for later use with refined datasets) and characterizing general patterns of age-specific CWT recoveries across years (i.e., to get a "sense" for the data and runs).

Data summaries

Hatchery releases were filtered to include only those for spring Chinook and coho (type N and S) released in the Lewis River basin. Releases began in brood year 1972 for spring Chinook, 1976 for coho (type S), and 1986 for coho (type N). I further limited releases to brood years 1988-2008 (a period when releases were made for all runs in each year, with almost ages of spring Chinook recovered). This provided a total of 115 releases (by specific tag code), which are summarized in Table 2. The total number of CWTs released were roughly 5.1, 2.4, and 2.7 million for spring Chinook, coho (N), and coho (S), respectively.

Table 2. Total hatchery releases (by tag code) across brood years 1988-2008.

	LEWIS	SPEELYAI
Chinook (spr)	43	1
Coho (type N)	35	0
Coho (type S)	34	2

A key step for simplifying cohort models is to define a limited set of fisheries for computing incidental mortalities. Recovery locations in RMIS are defined via a “fishery code” and a “location code” (among other variables). Across the 115 releases, CWTs recoveries were associated with 36 unique fishery codes (Table 3) and over 400 location codes. Note that fishery codes (Table 3) include recoveries at hatcheries (code 50) and spawning grounds (code 54). To simplify the recovery structure, I pooled fishery codes into ten categories (“pooled groups”), which were then further pooled into four “lumped groups” for summaries (Table 3). Again, these are tentative and for exploratory purposes only.

Recoveries (across years) are summarized by pooed group in Table 4. These data correspond to “estimated” recoveries (i.e., expanded estimates provided by RMIS that account for sampling fractions), with the exception of “Spawning Ground” recoveries for coho (these were reported almost exclusively as observed recoveries without expansions). Note that the miscellaneous fishery codes assigned to the “Other Ocean” and “Other Freshwater” pooled groups (Table 3) account for very low proportions of the total recoveries (Table 4).

Other interesting summaries included age-specific recoveries by lumped group (Table 5) and by group and month (not shown).

Strays

To provide a rough indication of potential straying rates, I tabulated recoveries by specific location (RMIS field “location name”) within the four fishery codes corresponding to hatchery (Table 6), spawning ground (Table 7), freshwater sport (Table 8), and Columbia River sport recoveries (Table 9).

For example, across brood years, 3.4% of the estimated recoveries of spring Chinook occurred at hatchery facilities outside of the Lewis River basin (Table 6). (Assuming I identified in-basin facilities correctly). Only 0.1% of coho were recovered at out-of-basin facilities. Roughly 1% to 2% of observed spawning-ground recoveries appear to be outside the Lewis River basin (e.g., Kalama River; Table 7). Similar inferences can be drawn using freshwater sport (Table 8) and Columbia River sport recoveries (Table 9), recognizing that these are much more ambiguous in nature (i.e., fish captured in other tributaries or upstream in the Columbia River may have returned to the Lewis River basin).

Table 3. Recovery locations for Lewis River hatchery releases by RMIS fishery code and name. Fishery codes were pooled (Pooled group) and then further combined (Lumped group).

Fishery code	Fishery name	Pooled group	Lumped group
10	Ocean Troll (non-treaty)	Ocean Troll	Ocean Catch
11	Ocean Troll - Day Boat	Ocean Troll	Ocean Catch
12	Ocean Troll - Trip Boat	Ocean Troll	Ocean Catch
15	Treaty Troll	Ocean Troll	Ocean Catch
20	Ocean Gillnet non-treaty	Other Ocean	Ocean Catch
21	Columbia River Gillnet	Columbia River Gillnet	Freshwater Catch
22	Coastal Gillnet	Other Ocean	Ocean Catch
23	Mixed Net and Seine	Other Ocean	Ocean Catch
24	Freshwater Net	Other Freshwater	Freshwater Catch
25	Commercial Seine	Other Ocean	Ocean Catch
26	Terminal Seine	Other Freshwater	Freshwater Catch
27	Freshwater Seine	Other Freshwater	Freshwater Catch
40	Ocean Sport	Ocean Sport	Ocean Catch
41	Sport (charter)	Ocean Sport	Ocean Catch
42	Sport (private)	Ocean Sport	Ocean Catch
43	Sport (jetty)	Ocean Sport	Ocean Catch
44	Columbia River Sport	Columbia River Sport	Freshwater Catch
45	Estuary Sport	Estuary Sport	Ocean Catch
46	Freshwater Sport	Freshwater Sport	Freshwater Catch
50	Hatchery	Hatchery	Hatchery
52	Fish Trap (freshwater)	Other Freshwater	Freshwater Catch
54	Spawning Ground	Spawning Ground	Spawning Ground
61	Test Fishery Net	Other Ocean	Ocean Catch
64	Test Fishery Unkn Mult Gr	Other Ocean	Ocean Catch
70	Juv Sampling - Troll(Mar)	Other Ocean	Ocean Catch
72	Juv Sampling - Seine(Mar)	Other Ocean	Ocean Catch
74	Juv Sampling - trawl(mar)	Other Ocean	Ocean Catch
80	Hake Trawl, At-Sea	Other Ocean	Ocean Catch
81	Groundfish Obs (Gulf AK)	Other Ocean	Ocean Catch
82	Grdfish Obs (Ber/Aleuts)	Other Ocean	Ocean Catch
83	Foreign Research Vessels	Other Ocean	Ocean Catch
85	Ocean Trawl By-Catch	Other Ocean	Ocean Catch
88	Juvenile Sampling - trawl	Other Ocean	Ocean Catch
90	Multiple Gear	Other Ocean	Ocean Catch
95	Confiscated	Other Ocean	Ocean Catch
800	Hake Trawl, Shoreside	Other Ocean	Ocean Catch

Table 4. Recoveries by pooled group for Lewis River hatchery releases of spring Chinook and coho (all years combined).

	Estimated			Percent		
Pooled group	Chinook	Coho (N)	Coho (S)	Chinook	Coho (N)	Coho (S)
Ocean Troll	2273	2140	974	12.4%	2.7%	1.4%
Ocean Sport	331	12052	7799	1.8%	15.2%	11.1%
Other Ocean	101	261	77	0.5%	0.3%	0.1%
Estuary Sport	50	682	1580	0.3%	0.9%	2.2%
Columbia River Gillnet	348	15242	1578	1.9%	19.2%	2.2%
Columbia River Sport	342	37	190	1.9%	0.0%	0.3%
Freshwater Sport	3971	2171	1568	21.7%	2.7%	2.2%
Other Freshwater	4	1	15	0.0%	0.0%	0.0%
Hatchery	9404	45923	55494	51.3%	57.9%	78.7%
Spawning Ground	1492	815	1212	8.1%	1.0%	1.7%
Total	18315	79322	70487	100.0%	100.0%	100.0%

Table 5. Recoveries by lumped group and age for Lewis River hatchery releases of spring Chinook and coho (all years combined).

Run	Group	age=2	3	4	5	6	7
Chinook	Ocean Catch	41	474	1852	357	30	0
	Freshwater Catch	289	292	1661	2279	142	2
	Hatchery	169	407	3651	4837	332	7
	Spawning Ground	8	41	469	919	55	0
Coho (N)	Ocean Catch	22	15101	6	4	0	0
	Freshwater Catch	747	16704	0	0	0	0
	Hatchery	5846	40076	0	0	0	0
	Spawning Ground	27	788	0	0	0	0
Coho (S)	Ocean Catch	34	10395	0	0	0	0
	Freshwater Catch	352	2996	4	0	0	0
	Hatchery	7589	47905	0	0	0	0
	Spawning Ground	28	1184	0	0	0	0

Table 6. Estimated recoveries at hatchery facilities by location (all years combined).

Location	Chinook (Spr)	Coho (N)	Coho (S)
ALSEA HATCHERY	0	1	0
BIG CR (LWR COL R)	0	1	1
BONNEVILLE HATCHERY	0	2	5
COLE RIVERS HATCHERY	0	5	2
COWLITZ SALMON HATCH	99	0	3
EAGLE CR NFH	0	0	1
ELK R HATCHERY	0	2	0
ENTIAT NFH	1	0	0
FALLERT CR HATCHERY	0	0	25
GEORGE ADAMS HATCHRY	0	1	0
KALAMA FALLS HATCHRY	249	18	17
LEWIS RIVER HATCHERY	1544	37848	45152
LTL WHITE SALMON NFH	0	0	1
MERWIN DAM FCF	7512	8034	10276
MINTER CR HATCHERY	0	1	1
ROCK CR HATCHERY	0	0	1
SALMON R HATCHERY	0	2	0
SANDY HATCHERY	0	2	1
WASHOUGAL HATCHERY	0	5	7
Total	9404	45923	55494
Lewis total	9056	45882	55428
Other total	348	41	66
Percent other	3.7%	0.1%	0.1%

Table 7. Observed spawning-ground recoveries by location (all years combined).

Location	Chinook (Spr)	Coho (N)	Coho (S)
ABERNATHY CR 25.0297	0	0	1
BITTER CR 27.0367	0	1	0
CEDAR CR 27.0339	26	22	554
COLVIN CR 27.0392	0	21	119
ELK VALLEY CR	0	1	0
FIDDLE CR (SILTCOOS)	0	1	0
GNAT CR (LWR COL R	0	1	0
JOHNSON CR 27.0327	0	7	6
KALAMA R 27.0002	3	2	15
LEWIS R -EF 27.0173	1	3	29
LEWIS R -NF 27.0168	39	388	162
LEWIS R 27.0168	35	41	26
LEWIS R & CEDAR CR	122	0	0
LEWIS R + LEWIS R-NF	45	320	288
LITTL WHITE SALMON R	0	1	0
MILL CR 25.0284	0	1	2
MOON CR TRIB A (N FK COQU	0	1	0
NETTLE CR (ALSEA R)	0	1	0
NEWTON CR	0	0	1
PARADISE CR SEC #2	0	0	1
PUP CR 27.0345	0	0	2
ROSS CR 27.0305	0	3	0
SCHOLFIELD CR (UMPQU	0	0	1
SILVER CR (ROGUE R)	0	0	1
UMPQUA R SPAWN 43	0	0	3
WIND R 29.0023	0	0	1
Total	271	815	1212

Table 8. Estimated recoveries in "freshwater sport" fisheries by location (all years combined).

Location	Chinook (Spr)	Coho (N)	Coho (S)
CASCADE R -LOWER 3.1411	0	0	9
CHEHALIS R 22.0190	0	4	0
COWLITZ R 26.0002	14	0	0
KALAMA R 27.0002	109	0	0
LEWIS R -NF 27.0168	561	1175	870
LEWIS R 27.0168	2635	630	644
LEWIS R & CEDAR CR	227	0	0
LEWIS R + LEWIS R-NF	365	362	31
TOUTLE R-NF 26.0314	0	0	14
WILLAMETTE R LWR BTS	51	0	0
WIND R 29.0023	8	0	0
Total	3971	2171	1568

Table 9. Estimated recoveries in Columbia River sport fisheries by location (all years combined).

Estimated	Chinook (Spr)	Coho (N)	Coho (S)
COL R OR SPORT SEC 2	0	6	0
COL R OR SPORT SEC 3	20	0	0
COL R OR SPORT SEC 4	46	0	0
COL R OR SPORT SEC 5	18	7	16
COL R OR SPORT SEC 6	8	0	0
COL R OR SPORT SEC 7	18	7	70
COL R OR SPORT SEC 9	9	0	0
COL R OR SPT SEC 10	16	0	38
COL R WA SEC 10	55	0	0
COL R WA SEC 4	24	0	6
COL R WA SEC 6	9	0	13
COL R WA SEC 7	0	0	26
COL R WA SPORT SEC 3	22	0	0
COL R WA SPORT SEC 5	65	0	6
COL R WA SPORT SEC 8	27	18	15
COL R WA SPORT SEC 9	9	0	0
Total	342	37	190

Example cohort reconstructions and measures of ocean recruits

To develop initial methods, I conducted reconstructions for spring Chinook using pooled releases by brood year. (These analyses were coded in R to quickly produce results across brood years). The cohort model included:

(a) Ages 3 to 6;
(b) Annual time steps;
(c) Survival rates (applied at year end) of 0.7 for age 3, 0.8 for age 4, and 0.9 for age 5 (consistent with CTC 2014a);
(d) Fisheries defined by the "pooled groups" in Table 3; and
(e) Incidental mortality rate parameters (*r* and *d*) used in CTC (2014a), as summarized below in Table 10.

The model did not include straying rates or pre-spawning mortality, and all hatchery and spawning ground recoveries were included regardless of location. Crude estimates of the proportion of legal-sized fish (*q*) were derived using fork length distributions of hatchery recoveries and an assumed size limit of 24 inches (Figure 3). The estimates of *q* were 0.07 for age 3, 0.95 for age 4, and 1.0 for ages 5 and 6.

Results: Estimates of maturity rates are presented in Table 11, while Table 12 summarizes estimated recoveries and measures of ocean recruits by brood year. Obviously, recoveries were limited for some brood years (e.g., 1991 and 1995), yielding unreliable estimates, but again this is just exploratory. Across years, median estimates of maturity rate were 0.02 for age 3, 0.33 for age 4, and 0.95 for age 5. As expected, reconstructed estimates of age-3 "ocean recruits" were much greater than C+E measures (about 65% higher on average). Estimates of adult equivalent returns (AER) tended to be slightly higher than C+E measures (about 4% higher on average).

Conclusions

I have developed procedures to rapidly extract and process RMIS data, and conduct the necessary cohort reconstructions to generate measures of ocean recruitment. Additional refinements to the cohort model are needed, but the framework is in place. The preliminary results for spring Chinook suggest that differences between measures of C+E and AER will be relatively minor (due in large part to low harvest rates), reducing the practical importance of simplified structures and assumptions in the cohort model (i.e., keep it reasonably simple). Reconstructions for marked coho will be even simpler with one age class and no size limits. The current framework allows for rapid assessment of historic data, which may be important if comparisons with other stocks (e.g., FRAM index stocks) are needed or requested.

Table 10. Incidental mortality rate parameters used in the cohort model (values from Appendix F of CTC 2014b).

	Catch-and-release (*r*)		
Pooled group	Sublegal	Legal	Dropoff (*d*)
Ocean Troll	0.220	0.185	0.016
Ocean Sport	0.123	0.123	0.069
Other Ocean	0	0	0
Estuary Sport	0.123	0.123	0.069
Columbia River Gillnet	0.9	0.9	0
Columbia River Sport	0.123	0.123	0.069
Freshwater Sport	0.123	0.123	0.069
Other Freshwater	0	0	0

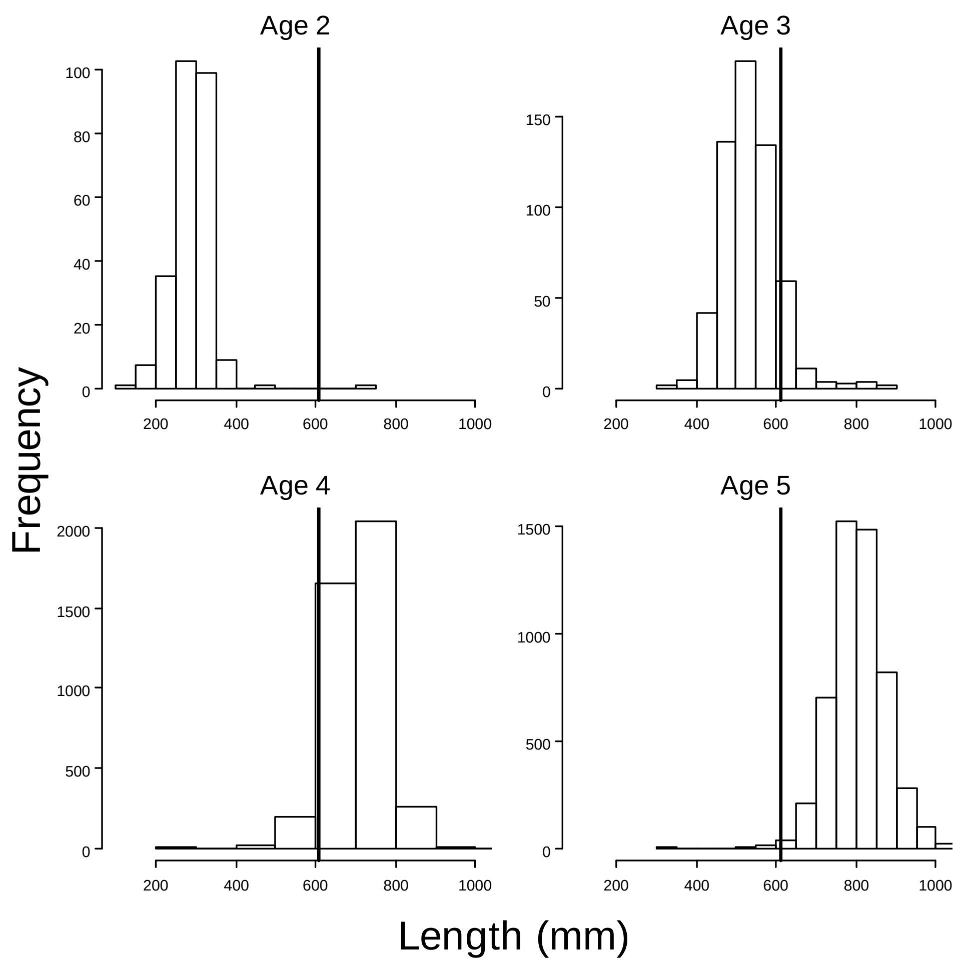

Figure 3. Fork length distributions of spring Chinook recoveries at hatchery facilities by age (all years). Solid vertical line depicts an example size limit of 24 inches.

Table 11. Estimates of maturity rates by brood year derived from cohort reconstructions of hatchery releases of spring Chinook.

BroodYr	Age 3	Age 4	Age 5
1988	0.040	0.322	0.968
1989	0.041	0.332	0.790
1990	0.043	0.199	0.966
1991	0.000	0.330	0.796
1992	0.020	0.337	0.913
1993	0.004	0.274	0.925
1994	0.004	0.219	0.988
1995	0.000	0.398	1.000
1996	0.026	0.438	0.965
1997	0.021	0.397	0.951
1998	0.018	0.239	0.922
1999	0.004	0.118	0.832
2000	0.070	0.645	0.975
2001	0.034	0.310	0.907
2002	0.015	0.315	0.956
2003	0.020	0.295	0.927
2004	0.057	0.327	0.950
2005	0.045	0.596	0.935
2006	0.118	0.732	0.992
2007	0.021	0.411	0.942
2008	0.107	0.909	1.000

Table 12. Estimated recoveries and measures of ocean recruitment (by brood year) for hatchery releases of spring Chinook.

Brood Year	Estimated recoveries: Ocean Catch	Freshwater Catch	Hatchery	Spawning Ground	Ocean recruits: C+E	Age 3	AER
1988	501	1264	246	286	2297	3890	2410
1989	176	269	72	100	618	1118	687
1990	58	352	205	31	646	1147	693
1991	2	6	21	0	29	50	30
1992	15	107	231	40	393	651	398
1993	36	19	95	15	166	287	171
1994	34	29	170	46	278	466	276
1995	3	24	50	8	85	140	86
1996	10	301	194	60	565	927	584
1997	330	614	754	261	1959	3476	2162
1998	345	301	1028	358	2031	3457	2066
1999	414	167	1003	149	1734	3097	1766
2000	49	159	707	0	915	1370	924
2001	110	98	490	12	711	1195	733
2002	320	396	1909	62	2687	4471	2719
2003	89	101	535	2	727	1230	746
2004	16	23	223	0	262	422	264
2005	36	41	218	55	349	582	383
2006	69	71	676	0	816	1243	873
2007	20	16	144	0	181	289	180
2008	79	17	256	0	352	494	356
Total	2713	4374	9228	1484	17799	30002	18508

Next steps

Remaining tasks include:

(1) Finalize the cohort models for marked spring Chinook and coho runs. I recommend that the time steps, equation structures, and assumed parameter values mimic those of the Chinook and coho versions of FRAM, which are most applicable to Lewis River runs (I currently have used PSC Chinook Model structures/assumptions). This will be a relatively easy task and would provide a clearly defensible framework. For spring Chinook, it is critical that a defensible age-3 estimate of *q* (proportion of vulnerable fish) be developed. For all runs, we need to account for, or defensibly dismiss, straying rates and pre-spawn mortality rates (review methods in Cramer 1996 & 1997 for strays).

(2) Develop ocean recruit measures for unmarked runs based on DIT releases. It is not practical to model mark-selective fisheries and incidental mortalities within a cohort reconstruction. Fishery-specific computations within FRAM are complex and evolving (Conrad et al. 2013). It is much more reasonable to develop metrics using either DIT releases or exploitation-rate estimates for regional index stocks modelled in FRAM.

(3) Review the Lewis River sampling programs and data sources that determine age-specific terminal harvests and escapements. These data are crucial for measuring brood-year ocean recruits. It is unlikely that the terminal harvest and escapement data pulled from RMIS will be complete or sufficient. The process will begin with in-river harvest/escapement data, followed by CWT releases and RMIS data, and finalized by appropriately expanding results to obtain complete production of hatchery and natural runs.

(4) Outline annual procedures for (a) integrating the terminal harvest and escapement data with RMIS recoveries (ocean and Columbia River), and (b) computing measure of ocean recruits for Chinook, coho, and steelhead runs.

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Appendix D

ISAB Clarification on Mass Marking and Mark-Selective Fisheries

Independent Scientific Advisory Board
for the Northwest Power and Conservation Council,
Columbia River Basin Indian Tribes,
and National Marine Fisheries Service
851 SW 6th Avenue, Suite 1100
Portland, Oregon 97204
ISAB@nwcouncil.org

MEMORANDUM (ISAB 2005-4A) July 29, 2005

TO: Melinda Eden, Chair, Northwest Power and Conservation Council

FROM: Eric J. Loudenslager, ISAB Chair

SUBJECT: ISAB Clarification on Mass Marking and Mark-Selective Fisheries

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Purpose

On July 12, 2005, the ISAB report on harvest management of Columbia River Salmon and Steelhead was summarized for the Northwest Power and Conservation Council (Council). In response to several questions raised by Council members during the ISAB presentation, this briefing paper summarizes technical issues surrounding the impacts of mass marking and mark-selective fishing.

Background – the critical importance of the Coded-Wire Tag (CWT) system

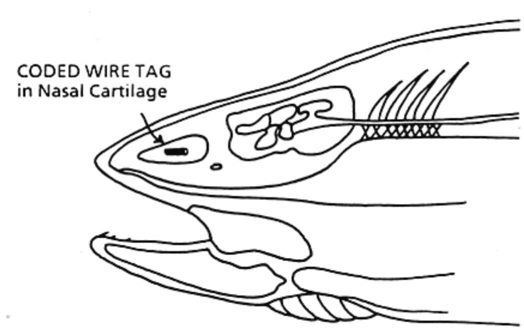


FIGURE 1.—Longitudinal section through the head of a juvenile salmonid showing the correct placement of a coded wire tag in the nasal cartilage. (After Koerner 1977.)

Coded-Wire Tag (CWT) data are central to the management of natural stocks of Chinook and coho salmon. These species are impacted by a variety of commercial and recreational fisheries at various stages of the life history throughout their migratory ranges, making efficient coastwide data collection systems essential for stock and fishery assessments. Current fishery regimes for Chinook and coho salmon are inextricably linked to the CWT system. In his introductory remarks to a CWT Workshop, convened by the Pacific Salmon Commission in June 2004, Larry Rutter from the National Marine Fisheries Service described this relationship as follows:

"Over the past thirty years or so we have constructed an elaborate and interdependent fishery management and stock assessment scheme that is heavily reliant upon data comprised of CWT recoveries. Billions of CWTs have been placed in salmon over the years, mostly in Chinook and coho salmon. And, through an elaborate,

coastwide sampling program that sifts through escapements and catch in fisheries far and wide, millions of CWTs have been recovered. Over time, we have accumulated what surely must be one of the most extensive fishery management data sets found anywhere in the world. This data set is analyzed and manipulated with increasingly complex models and algorithms; the results of these analyses provide the backbone of our system for managing Chinook and coho salmon fisheries coastwide."

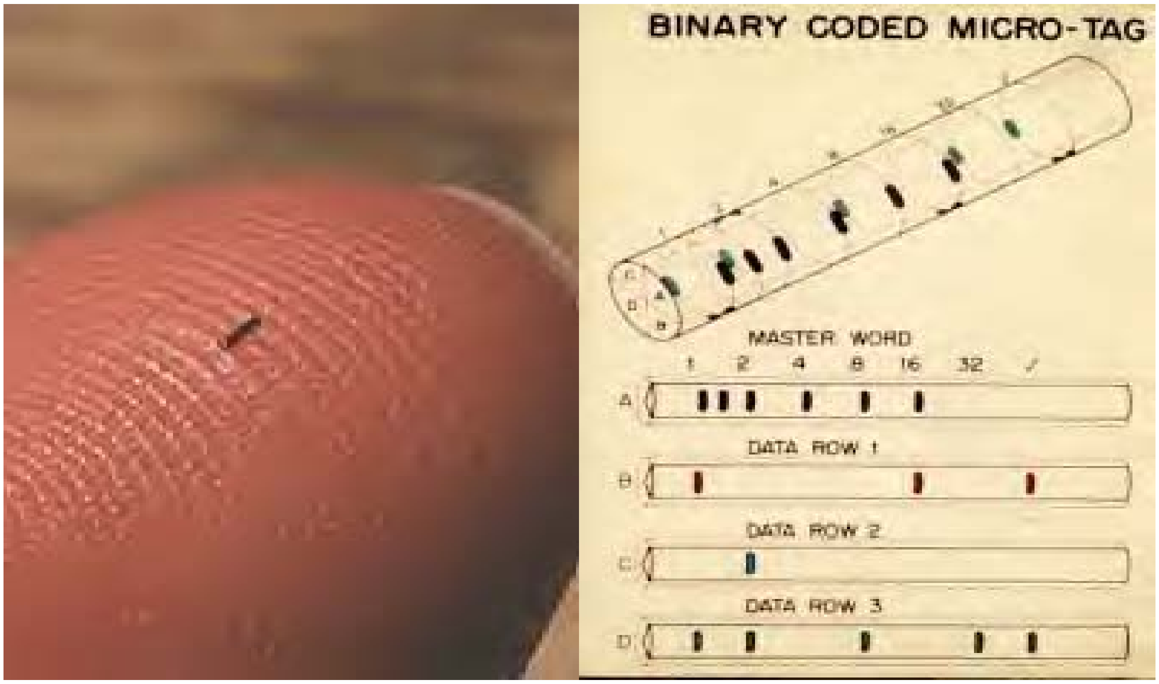


Fig 2. CWT size and coding system.

Harvest management regimes for *natural stocks* of Chinook and coho salmon are largely based upon data collected through a system of CWT releases of hatchery indicator stocks that are selected to represent specific natural stocks and are based on brood stock and rearing/release strategies.[1] Direct tagging of wild fish is rarely performed due to the costs and logistics of marking and recovering sufficient numbers of fish; hatcheries provide large concentrations of juvenile salmon for tagging and represent convenient places where mature salmon can be recovered.

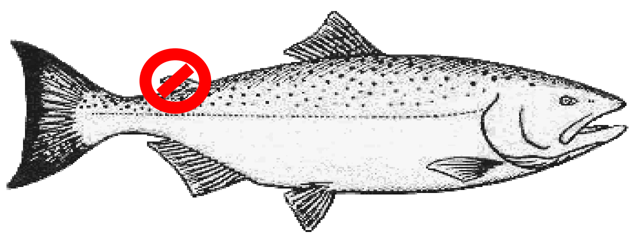
Prior to the advent of mass marking and mark-selective fishing, both the hatchery indicator stocks and the natural stocks they represent were subject to the same fishing patterns (locations and exploitation rates). Consequently, estimates of fishery impacts derived from cohort reconstruction (e.g., maturation rates, fishery-age exploitation rates) of CWT hatchery indicator stock groups could be employed as surrogate measures for naturally spawning populations (i.e., the hatchery indicator and the associated natural

[1] Wild smolt tagging experiments in Puget Sound, southern British Columbia, and the Washington Coast support the belief that hatchery indicator and wild coho salmon stocks are subjected to similar fishing patterns. This relationship is less clear for Chinook salmon, but tagging experiments with progeny from wild and hatchery brood stock suggest that the use of indicator stocks is reasonable, but not certain.

stock were assumed to experience the same exploitation history and impacts). The advent of mark-selective fishing, however, can seriously compromise the ability to make inferences regarding fishery impacts on natural stocks from CWT data.

Mass Marking and Mark-Selective Fisheries

When survivals plummeted in the early 1990s, conservation concerns resulted in several natural stocks being listed under the Endangered Species Act (ESA). To a large degree, the data necessary to establish jeopardy standards for ESA listed stocks and monitor compliance is provided by the CWT system through the use of hatchery indicator stocks.



In fisheries that exploit complex stock mixtures, mass marking and mark-selective fishing developed as a means to increase utilization of hatchery fish within constraints established to protect natural stocks of concern. Currently, mass marking involves clipping the adipose fin to provide a visual cue that allows differential retention of marked fish while requiring unmarked fish to be released in mark-selective fisheries. While some of the unmarked fish will die as a result of stress and injury when caught and released in mark-selective fisheries, some will survive. In theory, the lower mortality suffered by natural fish enables more hatchery fish to be caught while allowing more natural fish to escape to their natal streams and increase the spawning abundance.

The United States and Canada share common issues that exert pressure for the wider application of mass marking and mark-selective fisheries in management of Chinook and coho salmon. Both countries have experienced severe fishery restrictions resulting from the need to conserve natural stocks. Both countries have large investments in hatchery infrastructure to mitigate for destruction of fish production due to damage to habitat and to provide harvest opportunity for fisheries. Both countries are suffering from intense budgetary pressures for fiscal austerity. Both countries recognize that if investment in their hatchery programs is to continue, then some means must be found to provide harvest opportunity that relies upon hatchery production to support economically and socially viable fisheries, while constraining impacts to wild salmon stocks at levels appropriate for their conservation and rebuilding.

Canada and the United States currently mass mark millions of hatchery coho salmon each year. The United States has also mass marked millions of Chinook salmon in recent years (Canada has not mass marked Chinook salmon). New technology has been developed to automate the process of mass marking and/or inserting CWTs into large numbers of hatchery-produced Chinook and coho salmon. The concept of mass marking to support mark-selective fisheries has become so appealing to some that it recently found its way into federal legislation in the United States in the 2004 appropriation bill for the U.S. Fish and Wildlife Service (USFWS) (Bowhay 2004), regardless of potential adverse consequences for the future viability of the CWT system. Under the provisions of the appropriations bill, the USFWS is directed to *" ...implement a system of mass marking of salmonid stocks, intended for harvest, that are released from Federally operated or Federally financed hatcheries including, but not limited to fish releases of coho, chinook, and steelhead species. Marked fish must have a visible mark that can be readily identified by commercial and recreational fisheries*." As a consequence of this legislation, many millions more Chinook and coho salmon originating in the Pacific Northwest will be mass marked.

In the early 1990s, when mass marking and mark-selective fisheries were in their infancy, the Pacific Salmon Commission (PSC) found itself at the center of heated policy and technical debates over potential impacts of mass marking and mark-selective fisheries to the CWT system. Recognizing the reality that political pressures would press for continued implementation of mass marking and mark-selective fishing and that these methods could adversely affect the viability of the CWT system that has been essential to Chinook and coho salmon management for three decades, the Pacific Salmon Commission ultimately adopted an "Understanding of the PSC Concerning Mass Marking and Selective Fisheries" and established a permanent Selective Fishery Evaluation Committee (SFEC) in 1998. This committee has addressed the technical issues surrounding mass marking and mark-selective fisheries and has documented the extent and magnitude of mass marking and mark-selective fisheries in various reports (http://psc.org/publications_tech_techcommitteereport.htm#SFEC).

Issues Pertaining to Mass Marking and Mark-Selective Fisheries

Differential fishery impacts on natural fish and their hatchery indicators

Because marked hatchery fish and unmarked natural fish are no longer subject to the same patterns of exploitation under mark-selective fisheries, CWTs on hatchery indicator stocks can no longer serve as suitable surrogates to evaluate and monitor fishery impacts on natural stocks. In the presence of mass marking and mark-selective fisheries, impacts on natural stocks cannot be inferred from direct samplingbecause unmarked fish must be released. In addition, analytical results increasingly rely upon new assumptions on fishery impacts that are difficult to validate (e.g., assumed values for release and drop off mortality rates, plus mark retention and unmarked recognition error).

A concept termed Double Index Tagging (DIT) has been proposed as a means to provide data to help evaluate the impact of mark-selective fisheries on natural stocks. With DIT, two groups of fish with CWTs are released, identical in every respect except that: (a) the groups carry different CWT codes; and (b) only one of the groups is mass marked. When these fish are subjected to mark-selective fishing, fish from the unmarked DIT pair are released while fish from the marked DIT pair are retained. In mark-selective fisheries, only CWTs from the marked DIT pair can be recovered while in non-mass-selective fisheries, CWTs from both marked and unmarked DIT releases could be collected.

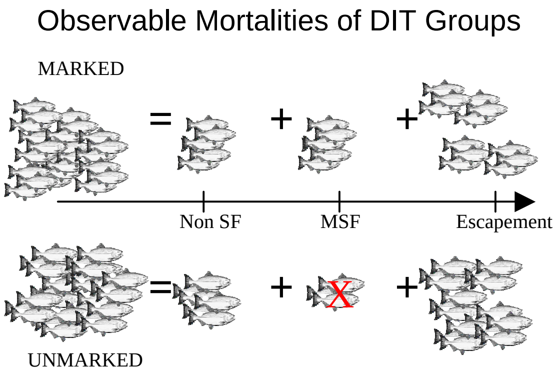


Fig 3. Observable recoveries of Double Index Tag Releases

With DIT, CWT recovery programs for fisheries and spawning escapements now must sample both marked and unmarked fish, and there must be provisions for recovering CWTs in both mark-selective and non-mark selective fisheries on the same stock. In theory, differences in recovery patterns between the DIT pairs would be used to assess the effect of mark-selective fishing.

DIT effectively doubles tagging costs for indicator stocks because now two groups of fish would need to be tagged. The number of fish in each group could not be reduced because of increased uncertainty surrounding recovery statistics.

In addition to differential patterns of fishery impacts on marked and unmarked fish, mass marking also poses an additional problem with the capacity of the CWT system to provide the data necessary to evaluate impacts of mark-selective fisheries and other fisheries. Prior to the advent of mass marking, the adipose fin clip had long been sequestered to indicate the presence of a CWT so sampling programs could efficiently identify fish with CWTs for analysis. With mass marking, the number of fish with missing adipose fins would increase many times over, so electronic tag detection (ETD) has been developed to identify fish containing a CWT. ETD equipment detects the presence of the CWT as magnetized wire. Two main types of ETD equipment are used: a hand-held wand and a tube. Wands are designed for use by field samplers who inspect fish in catches and escapements. They are passed over the head of a fish and a beep identifies the detection of metal. With a tube, the entire fish is passed through and the presence of a tag detected. Tubes are designed to be employed in high-volume installations such as hatcheries and processing plants. ETD technology must be used by trained samplers and employed throughout the migratory range of the stocks to recover the CWTs required for cohort analysis.

Fig. 4. Wand Detector and Tube Detector

Some jurisdictions that do not conduct mark-selective fisheries, however, continue to rely upon the missing adipose fin as the potential indicator of a CWT. Agreement to deploy ETD has not been reached in some areas because of increased cost of equipment and sampling plus unresolved technical or operational concerns. Consequently, since many mass-marked fish migrate to areas where there are no plans to employ ETD, CWT recoveries, particularly for unmarked DIT releases, will be incomplete, resulting in biased estimates of exploitation rates.[2] For many natural stocks, particularly, those listed under the ESA with jeopardy standards tied to exploitation rates, such bias can be problematic since accurate, unbiased estimates of exploitation rates are essential to monitor compliance and evaluate the effectiveness of fishery management measures.

Even with ETD and DIT, however, the capacity to generate the stock-age-fishery specific exploitation rates needed to preserve the viability of the CWT system as a means to estimate fishery impacts on natural stocks remains uncertain. The Selective Fishery Evaluation Committee (SFEC) established by the Pacific Salmon Commission in 1998, noted that no methods had yet been found to generate reliable estimates of mark-selective fishing impacts on unmarked fish when more than one mark-selective fishery impacts, particularly in the presence of substocks[3].

The potential impact of mass marking and mark-selective fishing is situational, depending on the biological characteristics of the stocks involved and the location and intensity of the mark-selective fishery. Under certain circumstances, mass marking and mark-selective fishing could seriously and adversely affect the future utility of the CWT system, which currently serves as the foundation for stock and fishery assessments of Chinook and coho salmon.

<u>Effectiveness of mass marking and mark selective fisheries have not been demonstrated</u>

Despite their “common sense” appeal, mass marking and mark-selective fisheries have not been shown to be an effective management tool to constrain impacts on natural stocks of Chinook and coho salmon to allowable levels. The effectiveness of mass marking and mark-selective fishing has not been evaluated prior to widespread application, and has instead, been blindly accepted as a matter of faith.

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[2] For a given stock, if mark selective fisheries occur in pre-terminal fishing areas, CWTs of unmarked DIT groups will not be recovered in non-selective fisheries that do not employ ETD; consequently, impacts of mark selective fisheries cannot be estimated by differences in exploitation patterns between marked and unmarked DIT pairs.

[3] Substocks are portions of a larger population that have different migratory patterns, for example, some coho originating in Puget Sound may reside in Puget Sound, while other portions migrate to the ocean. It is not possible to know in advance which fish will migrate to a given area. In the absence of mark-selective fisheries, the presence of substocks does not matter because marked and unmarked fish are subjected to the same fishing patterns. But when substocks are subjected to different mark-selective fishing patterns, fishery-specific impacts of mark-selective fisheries on unmarked fish cannot be readily estimated.

Management targets have not been adjusted to compensate for increased uncertainty

Statistical uncertainty surrounding CWT-based estimates has two general components, precision and bias. Precision relates to the amount of variability in the estimates, while bias concerns the accuracy of the estimates. Mass marking and mark-selective fisheries increase uncertainty and introduce additional bias in estimates of fishery impacts on unmarked fish due to the necessity to rely upon assumptions (e.g., release mortality rates) that cannot be readily validated. Current management regimes do not adjust allowable exploitation rates on natural stocks to compensate for this increased uncertainty; therefore, the risk that management objectives for natural stocks will not be achieved is increased, and the risk is an added burden on the viability of natural stocks.

Mass marking and mark-selective fishery have increased the cost of the CWT data collection system

DIT, changes in sampling requirements, requirements for ETD, and the need for sampling all fish in all fisheries and escapements greatly increases the cost of maintaining the CWT system. There is a potential for budget pressures resulting from the costs of mass marking and mark-selective fishery to reduce the amount of funding that agencies have available to operate other aspects of their program responsibilities.

The Pacific Salmon Commission's CWT Workshop

Since the early 1980's, the CWT system has served as the foundation for Chinook and coho salmon management in the Pacific Northwest and the scientific basis for the Pacific Salmon Treaty. Concerns over statistical uncertainty, the adequacy of reliance upon hatchery stock surrogates for associated natural stocks, and the impact of mass marking and mark-selective fisheries have been building in recent years. Taken together, these concerns have generated questions regarding the continuing utility of the CWT and associated sampling regimes and analytical tools that the Pacific Salmon Commission has relied upon for decades. As a result, the ability of the CWT system to continue to serve in that capacity is now very much in doubt.

As more and more of the fishing mortality on natural stocks is accounted for by non-landed catch (e.g., shaker loss, drop off, release and non-retention), the capacity of the CWT system to provide the data necessary for stock and fishery assessments is being increasingly challenged. Requirements to constrain exploitation rates on depressed natural stocks are increasing. Although reliable estimates of total mortalities are being demanded, the information systems necessary to provide the required data are deteriorating. Estimates of mortalities on natural stocks are becoming ever more dependent upon assumptions, inferences, and methods that cannot be readily validated, as well as programs for sampling and tag recovery in natural spawning populations whose accuracy is unknown. In June 2004, the Pacific Salmon Commission convened an expert panel to develop recommendations for addressing emerging concerns over the future of the CWT system. The Panel's report is scheduled for release this fall.

Other Considerations

There are other potential adverse impacts of mass marking and mark-selective fisheries, including:

a. the high costs associated with mass marking and sampling could reduce funding available to agencies to perform other program functions;
b. the implementation of fisheries that target the harvest of hatchery fish may reduce the motivation to protect the quantity and quality of habitat for production of natural fish;
c. the potential for agencies to try to increase production of hatchery fish could result in increased interactions that can reduce the survival of naturally produced fish.

Summary and Discussion

The effectiveness of mass marking and mark-selective fisheries as a management tool to constrain impacts on natural stocks to levels that effectively conserve natural populations has not been operationally demonstrated. Instead, that effectiveness in general has been accepted blindly. This change in management effectiveness is completely contrary to the management successes evident during the 1980s when coded-wire tag analyses provided reliable information for the coastwide management and assessment of coho and Chinook salmon populations.

Mass marking and mark-selective fisheries increase uncertainty and bias in the estimates of fishery impacts on natural stocks. Increased uncertainty resulting from different fishing pressures on hatchery and natural stocks, coupled with less than complete coverage of electronic tag detection throughout the migratory ranges of stocks, can substantially reduce the ability to monitor and evaluate fishery impacts on natural stocks. While these problems will exist to some extent in the presence of any mass marking and mark-selective fishery, their severity will vary among different salmon stocks, depending on the location, timing, and intensity of the mark-selective fishery.

Increased costs of implementing mass marking and mark-selective fisheries can adversely affect the ability of agencies to fulfill other responsibilities. In some quarters, there is concern that reliance on mass marking and mark-selective fisheries to sustain fisheries can lead to reduced protection of habitat and survival rates of natural fish. If hatchery production is increased to support mark-selective fishery, there are additional concerns that the accompanying increases in hatchery-wild interactions (competition, interbreeding) will adversely affect the future viability of natural stocks.

The issues associated with mass-marking and mass-mark selective fisheries are technical in nature and can be difficult for the public to appreciate; i.e., what could be wrong with selectively removing hatchery fish while reducing harvest impacts on naturally produced salmon that require increased conservation actions? What seems very logical in words, however, does not guarantee that the desired outcome will be reached. Fundamentally, mass marking and mark-selective fishing together represent a trade-off from what we can now measure and assess versus what we hope will be the case based on largely untested assumptions. The issue is further complicated because the level of concern over mass marking is dependent upon the application and magnitude of the mark-selective fishery. Even though a small, localized, terminal mark-selective fishery will likely have minimal increase in uncertainty, the scale of mass marking being conducted is not consistent with a plan for limited use of mark-selective fishing. Large-scale mass marking and mark-selective fisheries will substantially compromise the technical bases that have been established to assess and manage Chinook and coho salmon. In the presence of mass making and mark selective fisheries, how would an agency assess the role of harvest in the continued decline in abundance of a listed ESU? Will it be adequate to assume that 1) unvalidated values for the incidental mortality rates (e.g., release mortality rates) are accurate and known without error, 2) the incidence of multiple catch-and-release events is inconsequential, and 3) the physiological impact of multiple catch-and-release on reproductive potential of spawning fish is negligible? Will reduced levels of harvest impacts to natural stocks be assumed and risks ignored?

Although technical advisors working on CWT, mass-marking, and mark-selective fisheries have identified these concerns for several years now, the mass marking proceeds, and the benefit of mark-selective fisheries seems broadly accepted without thorough evaluation. These benefits may be realized in the end, but they have not been demonstrated to date.

Accurate, unbiased data are essential to decision-making and cooperative management approaches to conserve naturally spawning stocks of Chinook and coho salmon. In the 1970s and early 1980s, management actions to address declining Chinook salmon spawning escapements were frequently delayed because of uncertainty in the data and the lack of “proof” that particular user groups were contributing to a problem. Very few groups would have believed that total exploitation rates on Chinook salmon exceeded 80% and that many groups contributed to this over-fishing. Reliable CWT programs produced the “hard evidence” that allowed managers coastwide to resolve these issues and ultimately to agree on a coastwide management plan for rebuilding depressed populations of Chinook salmon in the Pacific Salmon Treaty.

In this period where stock rebuilding is given priority, increased uncertainty in outcomes should be explicitly accounted for in fishery regimes, management objectives, and assessment standards. Furthermore, technical debates over CWT data must NOT overshadow the three points noted previously under “Other Considerations.” As the ISAB explained in their Harvest Report, harvest is only one component of the impacts imposed on natural populations throughout their life cycle. If the issues associated with the other three H’s are ignored due to an assumption that mass marking and mark-selective fisheries will protect naturally spawning stocks, then natural populations may not recover. In addition, if mass marking and mark-selective fisheries continue to be promoted without adequate scientific evaluation, costs for assessments will have been substantially increased, critical information lost, and additional costs imposed on other users groups without obtaining the desired benefits. Resolution of the data concerns merits investment in studies to assess the validity of key assumptions involved in mass marking and mark-selective fishing. These issues will be further developed in the report of the Pacific Salmon Commission's Expert Panel report due in the fall, 2005.

Appendix E

Response to Comments on Version 2 Draft Hatchery and Supplementation Plan <insert date>, 2014