PacifiCorp Energy and Cowlitz County PUD No. 1

Fish Passage Monitoring and Evaluation Plan for the Lewis River

ACC Review Draft

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Acronyms and Abbreviations

ACC	Aquatics Coordination Committee
AER	Adult equivalent run
ATE	Adult trapping efficiency
C + E	Catch plus escapement
CE	Collection efficiency
CF	Correction factor
CI	Confidence Interval
CS	Collection survival
CWT	Coded-wire tag
DART	Data Access in Real Time
DIDSON	Dual-frequency Identification Sonar
FWS	U.S. Fish and Wildlife Service
HOR	Hatchery origin recruits
HPP	Habitat preparation plan
H&S Plan	Hatchery and Supplementation Plan
M&E	Monitoring and evaluation
NMFS	National Marine Fisheries Service
NOR	Natural origin recruits
ODS	Overall downstream survival
PME	Protection, mitigation and enhancement
RMIS	Regional Mark Information System
SAR	Smolt-to-adult survival rate
SASR	Smolt-to-adult survival ratio
SDF	Swift downstream facility

Services	US Fish and Wildlife Service and National Marine Fisheries Service
UPS	Upstream passage survival
Utilities	PacifiCorp and Cowlitz County PUD
WDFW	Washington Department of Fish and Wildlife
WDOE	Washington Department of Ecology
YOY	Young-of-the-year
ZOI	Zone of influence

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1.0 INTRODUCTION

This report is designed to meet the Monitoring and Evaluation (M&E) requirements outlined in the Lewis River Settlement Agreement (Settlement) entered into by state, federal and local governments, various resource interest groups and the Lewis River Project hydropower licensees (PacifiCorp and Cowlitz PUD 2004).

As described in the Settlement, the M&E Plan shall provide the approach to:

> *"…monitor and evaluate the effectiveness of aquatic PM&E Measures and to assess achievement of the Reintroduction Outcome Goals. The M&E Plan shall address the tasks, and the methods, frequency and duration of those tasks, necessary to accomplish the monitoring and evaluation items…"* [Section 9.1]

The items to be monitored and evaluated are described primarily in sections 4 and 9 of the Settlement. The intent of the M&E Plan is to determine the success of constructed fish passage systems, and the overall success of the reintroduction effort as defined by the reintroduction outcome goal which is to:

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

However, it needs to be noted that the metrics for determining whether the Reintroduction Outcome Goal is being met have yet to be developed[1]. Because these metrics were not available at the time this plan was drafted, the M&E Plan focuses on those studies needed to determine when the performance standards outlined in Section 4 of the Settlement are achieved. A definition of each performance standard and its benchmark value are presented in Table 1.

The M&E Plan also provides the methods to be used to monitor and evaluate adult spawning escapement, passage facility hydraulic performance, flow and ramping rates, resident and anadromous fish interactions, bull trout and kokanee populations, and M&E needed for the implementation of Lewis River Hatchery and Supplementation Plan (H&S Plan) (PacifiCorp Energy and Cowlitz PUD 2006). Monitoring related to Clean Water Act Section 401 certification will be identified in the Final Water Quality Management Plan which is due 90 days after issuance of the FERC licenses. PacifiCorp and Cowlitz PUD will provide an annual report to FERC, the ACC and the TCC and WDOE on or about April of each year. The report will contain results of all monitoring activities included in the M&E Plan plus all water quality, and terrestrial monitoring results from the previous year.

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[1] The time frame for the Services (NMFS and FWS) to identify this metric is described in Section 3.1.1 of the Settlement.

Table 1. Performance standard definitions and benchmark values.

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

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

Because the M&E Plan will be updated approximately every five years, this initial plan emphasizes the methods for evaluating the Swift Downstream Facility (SDF) and the Merwin Upstream Transport Facility[3].

[2] Species designated in Section 4.1.7 of the Settlement Agreement are spring Chinook, winter steelhead, coho, bull trout and sea-run cutthroat trout.

[3] The Settlement states that the licensees shall consult with the ACC as necessary, but not less than every five years (section 9.1).

The standards shown in Figure 1 will be used to determine not only the success of the SDF but also provide the justification for making improvements to this facility over time.

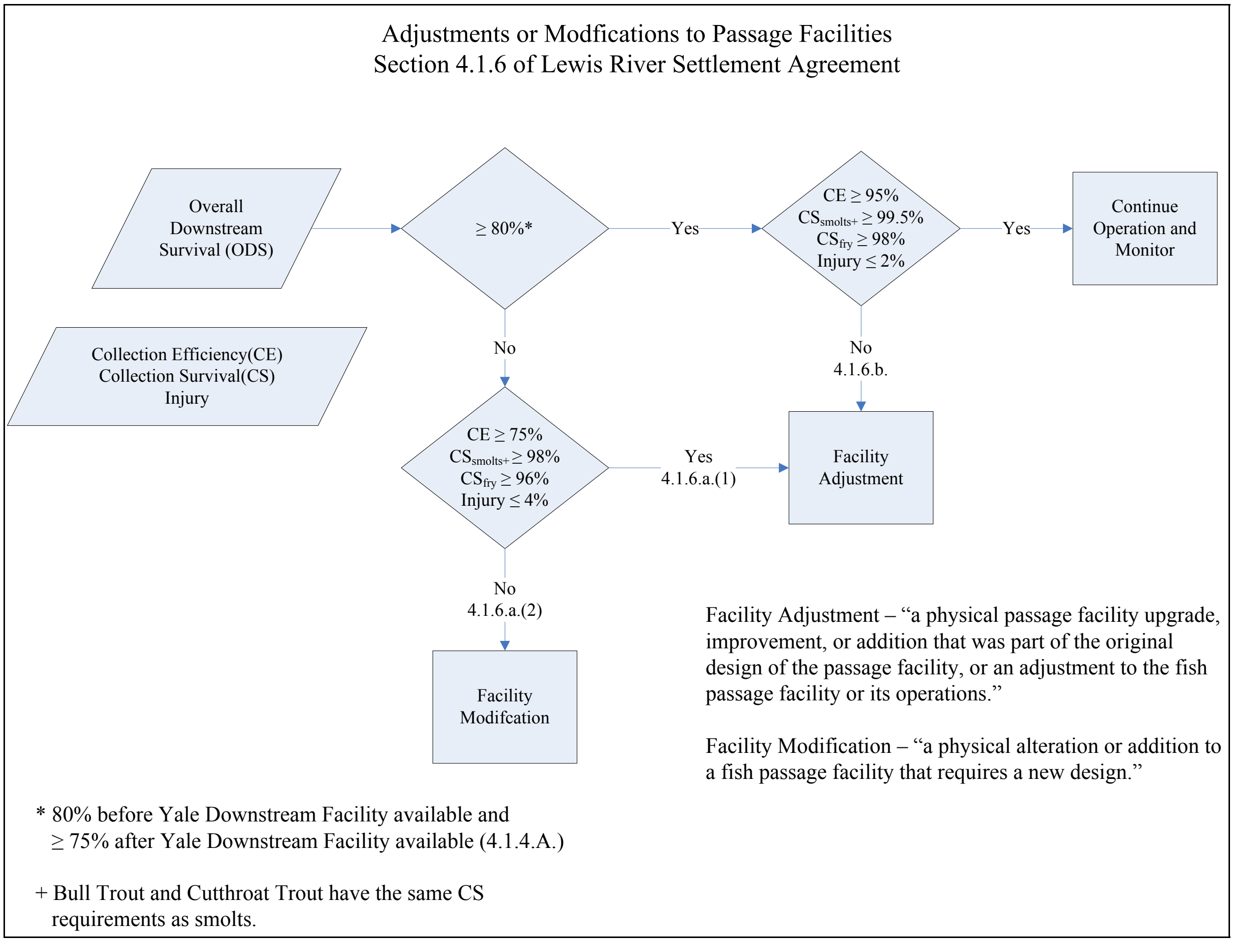

Figure 1. Swift Downstream Facility decision flow chart.

The lessons learned from studies undertaken to evaluate these facilities will be applied to new passage facilities proposed for Yale and Merwin starting in year 13 and completed in year 17 of the new FERC licenses.

Finally, the need for updating the M&E Plan will be determined as part of the comprehensive periodic review as outlined in the Settlement (see Sections 8.2.6 and 9.1 of the Settlement). This review will occur within 5-years after the reintroduction of anadromous fish above Swift No. 1 Dam, Yale Lake and also Lake Merwin. The periodic review will be repeated every 10 years from that point forward.

2.0 MONITORING AND EVALUATION OBJECTIVES

The M&E Plan has been designed to achieve 20 objectives. The objectives are as follows:

Objective 1	Quantify overall juvenile downstream survival (which includes reservoir survival, transport survival and survival at the release ponds)
Objective 2	Estimate SDF collection efficiency
Objective 3	Determine the percentage of juveniles available for collection that are not captured by the SDF and that enter the turbines
Objective 4	Estimate juvenile and adult bull trout collection survival
Objective 5	Determine juvenile injury and mortality rates during collection at the SDF (includes injury and mortality of adult bull trout, adult sea-run cutthroat, and steelhead kelts)
Objective 6	Quantify the number, by species, of juvenile and adult fish collected at the SDF
Objective 7	Estimate the number of juveniles entering Swift Reservoir
Objective 8	Determine Juvenile migration timing
Objective 9	Quantify adult upstream passage survival
Objective 10	Estimate adult trap efficiency at each upstream fish transport facility (emphasizes analysis of the Merwin Adult Trapping Facility)
Objective 11	Quantify the number, by species, of adult fish being collected at the projects (emphasizes Merwin Dam)
Objective 12	Develop estimates of ocean recruits
Objective 13	Determine performance measures for index stocks
Objective 14	Determine upstream and downstream passage facilities compliance with hydraulic design criteria
Objective 15	Determine spawn timing, distribution and abundance of transported anadromous adults
Objective 16	Evaluate lower Lewis River wild fall Chinook and chum populations
Objective 17	Monitor bull trout populations
Objective 18	Determine interactions between reintroduced anadromous salmonids and bull trout

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

Objective 20 Determine when reintroduction outcome goals are achieved

For each objective, the tasks, methods, frequency and duration of sampling, assumptions, results and reporting are discussed.

Although not explicitly repeated for each objective, the fish handling and facility operations listed in the Incidental Take Statements for the Project will be strictly followed. The Incidental Take Statements can be found in Section 9 of the National Marine Fisheries Service (NMFS) Biological Opinion for the Projects (NMFS 2007) and page 145 of the U.S. fish and Wildlife Service (FWS) Biological Opinion for the Projects (FWS 2006). The required Post-Season Monitoring and Evaluation Form required by NMFS is attached as Appendix A. This post-season report will be included in the M&E Plan report submitted to the Aquatics Coordination Committee (ACC) each year.

2.1 OBJECTIVE 1: QUANTIFY OVERALL JUVENILE DOWNSTREAM SURVIVAL

The Settlement requires that the Utilities achieve an overall downstream survival (ODS) rate of 80%[4]. ODS is defined in the Settlement (Settlement Agreement Section 4.1.4) as:

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

In other words, ODS is the percentage of the fish entering the Project that migrate, or are transported to the lower Lewis River (i.e. below Merwin Dam) and released successfully (i.e. alive).

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

Initially, ODS will be measured from the head of Swift Reservoir to the exit of the Release Ponds located below Merwin Dam[5] (Figure 2). Estimates of ODS will be developed for coho, spring Chinook, steelhead and sea-run cutthroat trout. ODS estimates for sea-run cutthroat trout will be delayed until data indicate that this cutthroat life history is present in the upper Lewis River basin and that the number of juveniles produced is sufficient for experimental purposes.

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

[5] Estimates of ODS will be developed for fish collected at Yale and Merwin dams once downstream passage facilities are constructed.

Radio-tags and direct enumeration of fish collected and transported from the SDF will be used to develop estimates of ODS.

Consistent with the Settlement, juveniles passing Swift Dam either through the turbines or spill will not be counted toward meeting the ODS standard as they are unlikely to survive passage through multiple dams and reservoirs not equipped with passage facilities[6].

2.1.1.1 Methods

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

- Test fish will be obtained from the SDF[7] as they represent assumed migrants. This approach is consistent with fish passage survival studies performed by the NMFS throughout the Columbia River Basin (Axel et al. 2007).
- Fish captured at the SDF will be identified to species, measured for length and tagged with a radio-tag.
- The test fish will be transported and released at the head of Swift Reservoir. Releases will be made weekly throughout the major part of the migration season (April-June). A total of 44 fish of each species will be released each week for six weeks (i.e. 264 tags per species tested) (See Appendix B for rationale).
- The test fish will be held for 24-hours prior to release to insure that fish retain the radio-tags, that the tags are functioning, and to quantify handling mortality.
- A control group will be held in small circular raceways throughout the study to quantify tag failure and decay rate and also to determine post-release mortality.
- Boat surveys (1 per week) will track the radio-tagged fish as they migrate through the reservoir to determine if fish actively migrate through or rear in the reservoir.
- Antennae arrays will be located at Swift Dam, Swift tailrace, the SDF, and at the exit of the Release Ponds to generate the detection histories necessary to estimate ODS and fish behavior.
- The SDF, transport trucks and release ponds will be examined daily by biologists to determine radio-tag loss during the handling and transport processes. Dead tagged fish found in the SDF and release ponds would be assigned to collection loss (S_{COL}) and transport loss (S_{TRAN}), respectively.
- 50 dead fish with live radio-tags will be released into the SDF over the course of the season as a check on the accuracy of the biologists to detect and recover dead

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[6] The Settlement states that fish passing through turbines at Swift Dam can be ignored if they are not expected to contribute substantially to ODS.

[7] According to the Settlement Agreement, the Modular Surface Collector built at Swift No. 1 Dam will be referred to as the Swift Downstream Facility. It is to be operational within 6-months of the 4th anniversary of the issuance of the new license for the Swift No. 1 or 2 Project, whichever is later.

fish. If recoveries are less than 100%, estimates of ODS will be adjusted based on the calculated error rate.

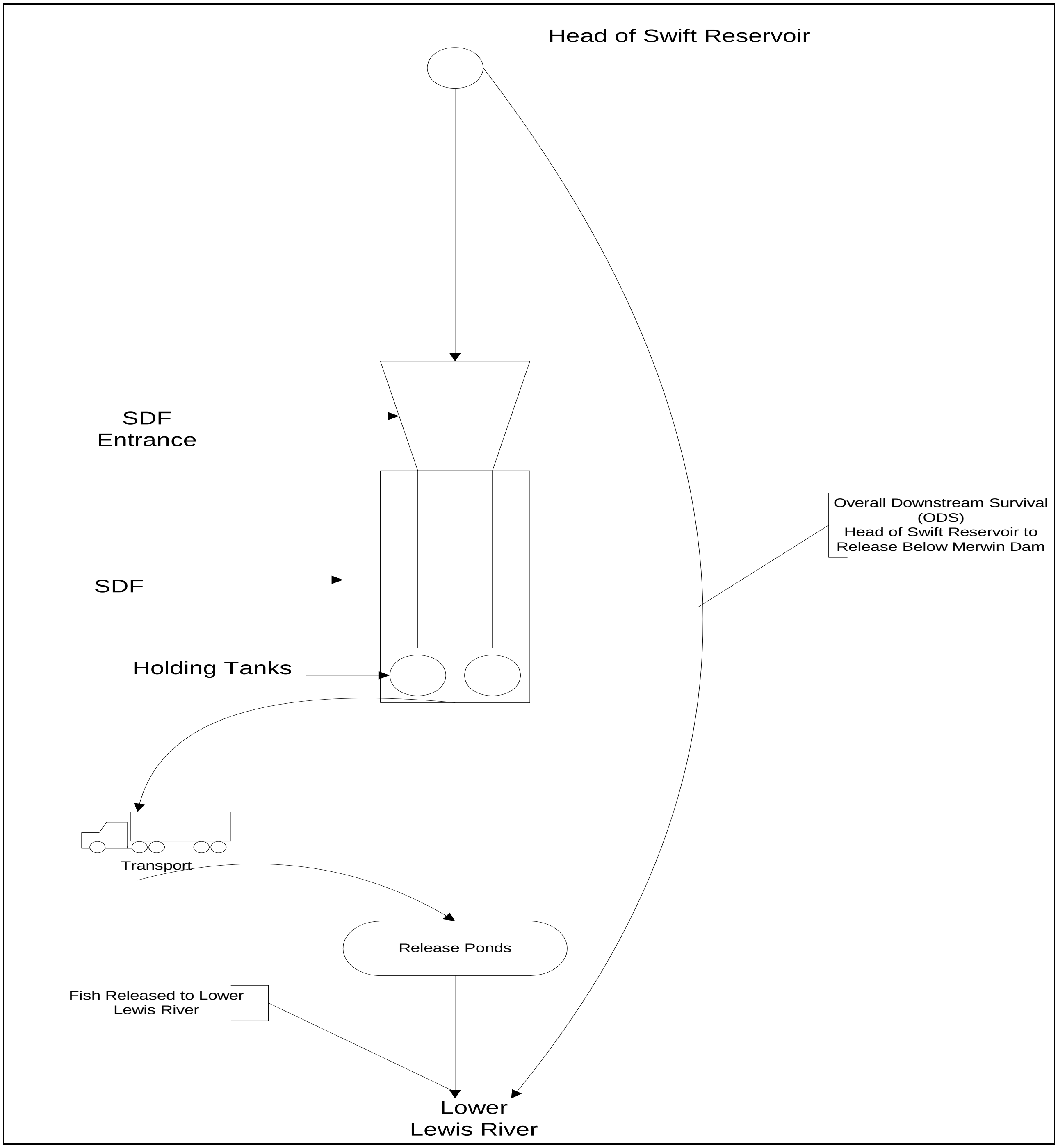


Figure 2. Schematic showing ODS measurement range and associated facilities.

The single release-recapture model will be used to estimate the probability of surviving passage to the lower Lewis River (Appendix B).

ODS will be calculated as:

$ODS = (S_{RES} * P_{COL}) * (S_{COL} * S_{TRAN})$

Where

S_{RES} = survival probability through reservoir,

P_{COL} = proportion of fish arriving at Swift Dam that enter the surface collector

S_{COL}= survival probability through the collector,

S_{TRAN} = survival probability through the smolt transport system.

A diagram of each of these four parameters (S_{RES}, P_{COL}, S_{COL} and S_{TRAN}) is shown in Figure 3.

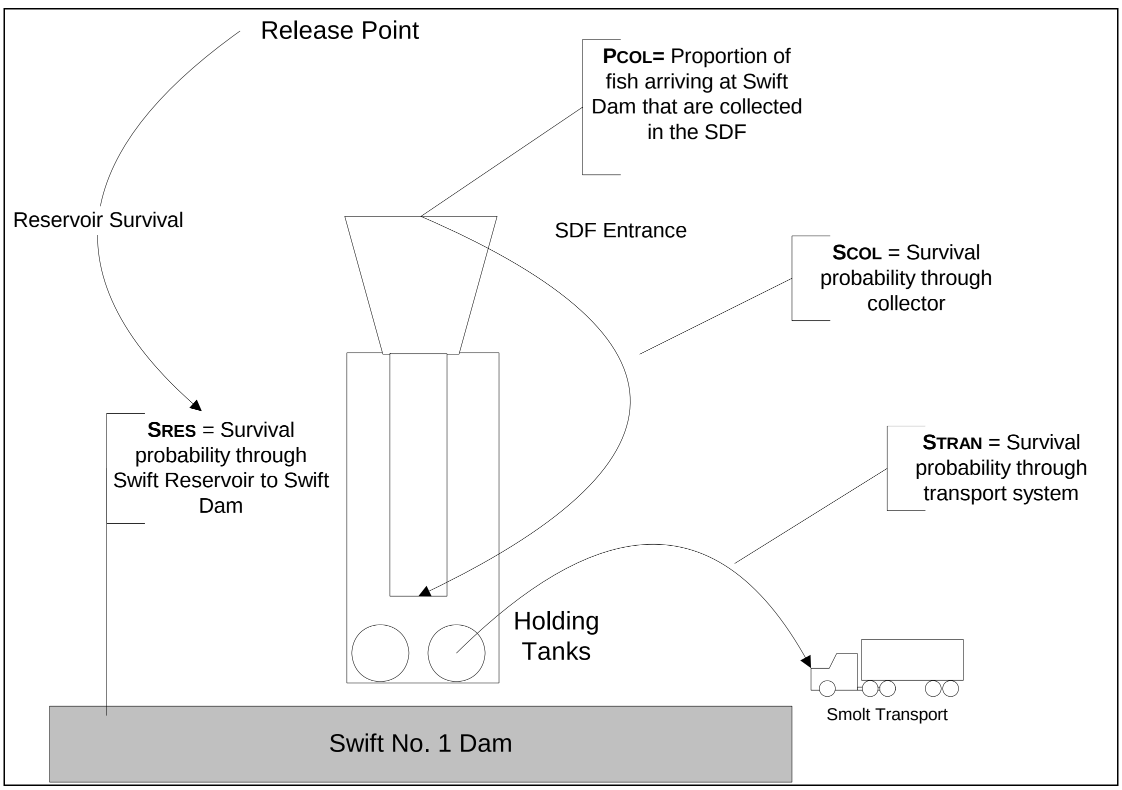


Figure 3. Schematic showing evaluation parameters for calculating ODS.

The ODS estimate will be based on the pooling of release–recapture data over the season. Whether the ODS 80% standard is achieved will be based on an asymptotic Z-test at *a* of 0.10 (Appendix B).

2.1.1.2 Frequency and Duration

ODS estimates will be developed weekly throughout the major portion of juvenile migration season, which is expected to vary by species. Releasing fish on a weekly basis will also help to identify whether changing environmental conditions (river flow, temperature, etc.) impact resulting ODS estimates. The study will be performed yearly until such time as study results show that the 80% ODS standard has been achieved for each species.

2.1.1.3 Assumptions

Assumptions associated with conducting the analysis include:

1. All fish act independently,
2. Release size is known without error,
3. There is no post-release handling mortality, tag failure or loss, or the loss/failure can be accounted for.
4. Downstream detection is conditionally independent of detection upstream.
5. Tagged fish are uniquely identifiable at all detection sites.
6. Fish passing through spill and turbine discharge at Swift Dam will not count toward meeting the ODS standard (i.e. these fish will be considered mortalities).

Of the six assumptions listed, number 3 is the most likely to be violated. Tagging and transporting juvenile salmonids can be stressful and result in some mortality both pre- and post release. To quantify this mortality, a control group will be established as part of the experimental design. These fish will be tagged and handled in an identical fashion as the test fish. However, instead of being released into the reservoir, the fish will be held in small raceways, and then observed over time to determine both mortality rate and also to quantify radio-tag failure rate and loss. This information would then be used to adjust survival rates for the test fish, if needed.

2.1.1.4 Results and Reporting

The results of the study will be reported in text and tabular format in the annual M&E report. An example of the type of table that would be presented in the report is shown in Table 2.

Table 2. Example table of weekly estimates of ODS for juvenile coho, Chinook and steelhead released at the head of Swift Reservoir

Date	Coho	Chinook	Steelhead
Week 1			
Week 2			
Week 3			
Week 4			
Week 5			
Week 6			
Season*			

* A weighted average of the weekly ODS estimates may be used for the seasonal estimate dependent on whether the weekly estimates prove to be heterogeneous.

2.2 OBJECTIVE 2- ESTIMATE SDF COLLECTION EFFICIENCY (P_{CE})

The radio-tagged fish released at the head of Swift Reservoir will also be used to measure the juvenile collection efficiency (P_{CE}) of the SDF. Section 4.1.4 of the Settlement defined collection efficiency as:

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

In this study, a juvenile that is available for collection is one that is found (detected) within the zone of influence (ZOI) of the SDF entrance[8]. As stated in the Settlement, the performance standard for P_{CE} is 95% or greater for smolts.

Additionally, estimates of the proportion of fish encountering the SDF (P_{ENC}), SDF fish entrance efficiency (P_{ENT}) and SDF retention efficiency (P_{RET}) will also be collected as part of this analysis using radio-tag detections and a DIDSON (Dual-frequency Identification Sonar) camera. Collecting this data will give biologists the ability to determine where improvements in the design or configuration of the SDF may be needed to meet the collection efficiency, and ODS standards. The importance of each parameter in diagnosing SDF operations are as follows:

- P_{ENC} – A low encounter value indicates that few fish arriving at Swift Dam were detected within the zone of hydraulic influence of the SDF. These data may indicate that the collector may need adjustment, or flows into the collector increased to better attract juvenile migrants.

[8] The Zone of Influence is the area in front of the SDF entrance where all flow lines lead to the collector.

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

- P_{RET} - Fish that enter the SDF may also swim back out of the system, resulting in low SDF retention efficiency (P_{RET}). Low SDF retention efficiency may be the result of water velocities through the SDF that are too slow to trap the fish. This condition could be alleviated by increasing flow through the collector or changing screen openings or baffles to increase water velocities.

2.2.1 Task 2.1- Estimate SDF Collection Efficiency (P_{CE})

2.2.1.1 Methods

The same technology proposed for measuring ODS (Section 1.1.1) will be used for estimating SDF collection efficiency.

Radio-tagged juveniles released at the head of Swift Reservoir and surviving reservoir passage will be detected at a set of antennae arrays located at the SDF (Figure 4). The first antennae array (A) will be located at the entrance of the SDF; the second, (B), near or within the holding tanks, depending on operational constraints of the facility.

Antennae array (A) will be tuned such that it detects fish within the ZOI of the surface collector. The ZOI is the area in front of the collector where all flow lines lead to the entrance of the SDF. The actual area of the ZOI will be determined by measuring flow velocities and direction in front of the SDF at the start of each field season.

The collection efficiency of the SDF (P_{CE}) will be estimated as:

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

Where

a_1 = number of unique tagged fish identified in the ZOI of the surface collector

a_2 = number of unique tagged fish identified in the fish holding tanks

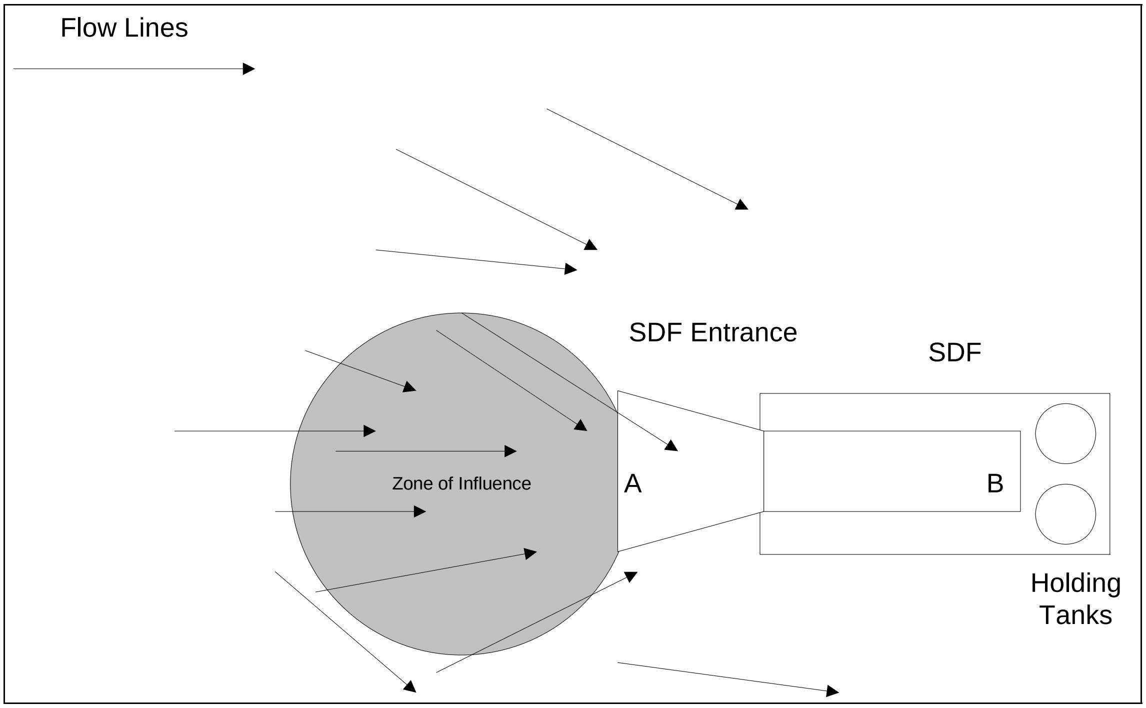


Figure 4. Schematic of SDF and associated antenna arrays (A and B).

2.2.1.2 Frequency and Duration

SDF collection efficiency will be quantified weekly for approximately 6 weeks around the expected peak migration period for each species. The study will continue yearly until either the collection efficiency standard is met, or it is determined by the ACC and the Services (FWS and NMFS) that improvement in collection efficiency is not possible. Under either outcome, studies to estimate collection efficiency will be repeated every 5-years to document SDF compliance with the standard.

2.2.1.3 Assumptions

All of the assumptions associated with the single release-recapture model described previously apply here as well. In addition, it is assumed that the second antennae array will have 100% detection efficiency.

2.2.1.4 Results and Reporting

The results of the study will be reported in tabular format in the annual M&E report. An example table is shown below as Table 3.

Table 3. Example table for weekly estimates of SDF collection efficiency for coho, Chinook and steelhead.

Date	Coho	Chinook	Steelhead
Week 1			
Week 2			
Week 3			
Week 4			
Week 5			
Week 6			
Season*			

* A weighted average of the weekly collection efficiency estimates may be used for the seasonal estimate depending on whether the weekly estimates prove to be heterogeneous.

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

2.2.2.1 Methods

The number of juveniles (smolts) encountering the SDF will be determined by tracking releases of radio-tagged fish as they arrive at Swift Dam. Antennae arrays will be placed across the face of Swift Dam to detect radio-tagged fish arriving at the dam. Arrays will be located near the spillway and on the earthen embankment both upstream and downstream of the SDF. Actual array locations will be developed once a final design for the SDF has been completed[9].

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

$$P_{ENC} = DET_{SDF} / DET_{SWIFT}$$

Where

DET_{SDF} = number of juveniles detected at antenna array A and/or B on the SDF

DET_{SWIFT} = number of juveniles detected at Swift Dam and the SDF

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

2.2.2.2 Frequency and Duration

P_{ENC} estimates will be developed until the collection efficiency standard is achieved.

[9] Antennae arrays will be tested to determine the detection range of each array. This action will ensure that fish outside of the SDF, for example, are not counted in collection estimates, etc.

2.2.2.3 Assumptions

Antenna array A can be tuned to detect fish only within the zone of influence of the SDF.

2.2.2.4 Results and Reporting

Results will be reported in the annual M&E Report. Data will be presented in tabular format similar to that shown in Table 3.

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

2.2.3.1 Methods

Juvenile entrance (P_{ENT}) and retention efficiency (P_{RET}) will be estimated using DIDSON acoustic cameras positioned at two locations on the SDF (Figure 5). The DIDSON cameras located at D1 (Entrance) and D2 (Retention Zone) will be used to determine P_{ENT} and P_{RET}, respectively.

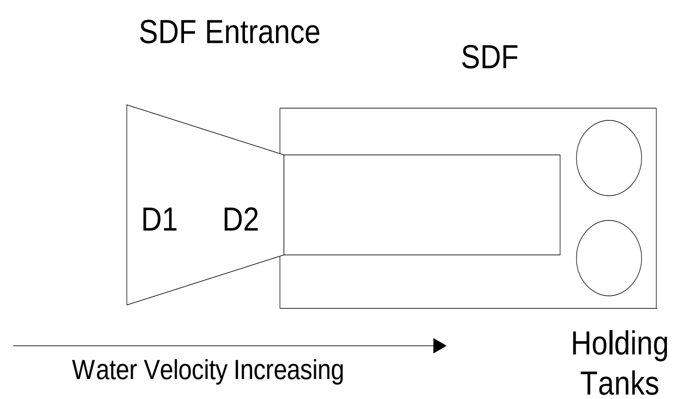


Figure 5. Location of DIDSON cameras on SDF (D1 and D2).

The cameras will be operated during the peak migration period for each species. Because the camera cannot identify fish by species, sampling will occur when catch at the SDF indicates that the capture population is dominated by a single species. Sampling will occur both during daylight and nighttime hours to determine if fish behavior varies depending on light conditions.

Video taken from each camera location will be analyzed by a biologist to qualitatively determine fish behavior at the two locations.

P_{ENT} will be calculated as:

P_{ENT} = number of fish exiting entrance area/ number of fish that entered and exited

P_{RET} will be calculated as:

P_{RET} = number of fish exiting capture zone / number of fish that entered and exited capture zone

The estimates will be considered qualitative due to the subjectivity associated with viewer interpretation, and from the fact that the ultimate fate of any fish seen on a camera is not known. For example, a fish may enter and leave each area multiple times before actually passing into the SDF. If any fish happens to be radio-tagged, the tendency to pass multiple times can be determined on a limited basis.

2.2.3.2 Frequency and Duration

DIDSON camera evaluations will be terminated once results show that juvenile fish readily enter and are captured by the SDF.

2.2.3.3 Assumptions

Key assumptions of the analysis include:

- Qualitative estimates of fish behavior are sufficient for management and testing purposes
- Ability to determine fish behavior by species is not critical for evaluation purposes

2.2.3.4 Results and Reporting

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

2.4 OBJECTIVE 3- DETERMINE THE PERCENTAGE OF JUVENILES AVAILABLE FOR COLLECTION THAT ARE NOT CAPTURED BY THE SDF AND THAT ENTER THE TURBINES

The proportion of fish entering Swift No. 1 Dam turbines will not be quantified until downstream collection systems are installed at Yale and Merwin dams. Once these systems are operational, the M&E Plan will be updated to include study protocols designed to determine turbine entrainment and loss.

2.5 OBJECTIVE 4- ESTIMATE JUVENILE AND ADULT BULL TROUT COLLECTION SURVIVAL (CS)

The objective of this task is to quantify survival from the time the fish (smolt, fry and adult bull trout) enter the SDF to their release below Merwin Dam[10]. This survival rate is defined in the Settlement as collection survival (CS). The CS standard varies by fish size and species as shown below:

- Chinook, coho, steelhead, and sea-run cutthroat smolts = 99.5%

[10] Bull trout survival estimates will also be made for other release sites identified by the FWS.

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

The radio-tag data collected to estimate ODS can be used to estimate CS for smolts, but not for fry. Fry are too small to tag with a radio transmitter and therefore calculating survival for this size fish requires that fish mortality be measured directly. The calculations for estimating smolt collection and transport survival using the radio-tag results are presented in Appendix B.

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

Estimates of CS, S_{COL} and S_{TRAN} will be developed for coho, Chinook, steelhead, sea-run cutthroat trout (if a run is established) and bull trout captured in the SDF[11].

2.4.1 <u>Task 4.1- Estimate Fish Collection and Transport Survival Rates</u>

2.4.1.1 Methods

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

Determine Fish Survival through the Collection System (S_{COL})
Survival estimates for juvenile fish collected at the SDF (S_{COL}) will be developed daily by subsampling fish prior to their entry into the transport system. Subsampling will be accomplished through the use of gates located on the SDF that can be programmed to automatically divert fish to the subsample tanks. The diverted fish will be physically examined to determine the proportion of fish that die from collection activities. Consequently, estimates of S_{COL} will be based on binomial sampling with the estimator:

$S_{COL} =$ $Fish_{SUB} / Fish_{EX}$

$Fish_{SUB} =$ *number* of fish found dead in subsample

$Fish_{EX} =$ number of fish examined in subsample

Determine Survival through the Transport System (S_{TRAN})
Juvenile survival, from the time they enter the transport system until they exit the release ponds located below Merwin Dam, is defined as S_{TRAN}.

[11] Survival estimates will be developed for both juvenile and adult bull trout. The adult bull trout CS standard is 99.5%. Unless large numbers of bull trout juveniles are collected at the SDF, testing will not be performed.

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

- Healthy uninjured smolts and fry will be marked and released directly into the transport tanks located on the SDF on a weekly basis (1 test per week). The test fish used for these releases will be collected from the SDF subsample tanks.

- Test fish releases will be made such that these fish spend a similar amount of time in the holding tanks as the fish that were diverted to the tanks through the SDF.

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

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

- To test the ability of biologists to identify and collect dead fish from the release ponds, a known number of marked dead fish will be released into the system each month. The results of this test will be used to develop a correction factor to account for less than 100% detection of dead fish.

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

S_{TRAN} will be calculated using the formula:

S_{TRAN} = $(Fish_{DEAD}/Fish_{REL})$ * CF

$Fish_{DEAD}$ = number of marked fish found dead in release ponds

$Fish_{REL}$ = number of marked fish released in transport system

CF = Correction factor for missed marked fish based on dead fish

An estimate of S_{TRAN} will be developed for coho, Chinook, steelhead, sea-run cutthroat trout and bull trout (adults and juveniles) captured in the SDF. It should be noted that S_{TRAN} values for bull trout adults will be based on observed mortalities during transport and release at all release sites identified by the FWS.

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

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

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

2.4.1.2 Frequency and Duration

Collection survival estimates will be developed daily until it is proven that the collection standards have been met. Once met, survival estimates will be developed monthly to document compliance with the collection survival standard.

2.4.1.3 Assumptions

The major assumptions inherent in the proposed methods include:

1. The subsample fish are representative of the population being collected and transported.

2. Diversion of juvenile fish into the subsample system does not bias mortality estimates.

3. Fish handling protocols for determining S_{TRAN} do not bias juvenile mortality estimates.

4. Biologists will be able to identify and collect dead fish from the release ponds.

2.4.1.4 Results and Reporting

Results of the analysis will be presented in tabular format as shown in Table 4. The CS standard will be assumed met if the calculated confidence interval (CI) spans the target survival rate of smolts, fry and adults.

Table 4. Daily and seasonal estimates of S_{COL}, S_{TRAN} and CS, with associated 95% CI for coho salmon collected and transported from the SDF.

	Collection Survival	**Transport Survival**	**Collection + Transport (CS)**	
Week	S_{COL}	S_{TRAN}	CS	95% CI
Day 1				
Day 2				
Day 3				
Season				

2.5 OBJECTIVE 5- DETERMINE JUVENILE INJURY RATES DURING COLLECTION AT THE SDF

The objective of this analysis is to determine the injury rate for fish collected at the SDF. The Settlement establishes a SDF design performance objective for injury of less than or equal to 2% for all fish examined.

Injury is defined in Settlement Table 4.1.4 as:

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

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

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

2.5.1.1 Methods

Estimates of P_{CINJ} will be determined by closely examining a subsample of the total juvenile population collected each day. Sample fish will be diverted (through the use of automatic gates on the SDF) into small holding tanks where they will be anesthetized and examined for injury. Injured smolt and fry will be classified into the categories shown in Table 5.

Table 5. Categories used for documenting visible injury at the SDF collection and transport system.

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

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

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

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

2.5.1.2 Frequency and Duration

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

2.5.1.3 Assumptions

The major assumptions for measuring P_{CINJ} include:

1. The subsample fish are representative of the population being collected.

2. Diversion of juvenile fish into the subsample system does not bias estimates of injury.

3. Fish handling protocols do not result in an increase in fish injury.

2.5.1.4 Results and Reporting

Results of the injury analysis will be summarized in tabular format similar to that shown in Table 6.

Table 6. The injury type and number of juvenile coho injured during collection and transport operations of the SDF.

	Date		
Data/Injury	5/22/07	5/23/07	5/24/07
Number Examined			
Number Injured (Visible)			
Hemorrhaging			
Open Wound (No Fungus)			
Open Wound (Fungus)			
Gill Damage			
Bruising 0.5 cm diameter			
Bruising ≤ 0.5 cm diameter			
Loss Of Equilibrium			
Descaling > 20%			
Descaling ≤ 20%			

2.6 OBJECTIVE 6- QUANTIFY THE NUMBER, BY SPECIES, OF JUVENILE AND ADULT FISH COLLECTED AT THE SDF

The objective of this analysis is to quantify the number of juvenile and adult fish collected at the SD by species.

The number of juvenile fish entering the SDF will be calculated through subsampling and the use of a VAKI Electronic Bioscanner (Bioscanner) that will automatically count all fish passing through the SDF. A combination of these two methods was chosen for estimating this parameter as it is currently unknown how accurate the VAKI system will be at enumerating small juvenile salmonids. System reliability is especially uncertain during periods of high debris load which may trigger a reading thereby biasing estimates upwards.

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

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

2.6.1.1 Methods

A diversion gate on the SDF will be used to subsample fish entering the system. Diverted fish will be anesthetized, enumerated, checked for marks and identified to species. The number of fish collected each day in the SDF (SDF_{COL}) will be calculated as follows:

$$SDF_{COL} = N_{SUB} * (SDF_{OP} / S_{SUB})$$

Where

N_{SUB} = # of fish sub-sampled each day

SDF_{OP} = # of hours the SDF was operated each day

S_{SUB} = # of hours the diversion gate was operated each day

The total number of fish (by species) entering the SDF each year will be calculated by summing the daily totals for each sample year.

2.6.1.2 Frequency and Duration

Daily counts of the number of fish entering the SDF will continue for as long as the facility is operational. Subsampling rates will be developed over time as more is learned about facility effectiveness and total basin fish production.

2.6.1.3 Assumptions

The major assumption inherent in the methodology is that the subsample fish are representative of the general population.

2.6.1.4 Results and Reporting

The results of the analysis will be presented in tabular format and included in the annual M&E report.

2.6.2 <u>Task 6.2- Calculate Juvenile and Adult Collection Numbers Using VAKI Bioscanner</u>

2.6.2.1 Methodology

Bioscanners will be located at both the subsample and adult holding tanks on the SDF. According to the manufacturer, the Bioscanner has an accuracy of > 99% (http://www.vaki.is/Vaki/Products/Bioscannerfishcounter/).

To test the accuracy of this system, physical counts of fish collected in the fry and smolt subsample tanks and adult holding tanks will be compared to the fish counts produced from the Bioscanners. Testing will be conducted monthly throughout the migration season to determine if system accuracy varies by species, size and environmental condition present at the SDF.

For each system test, fish will be subsampled hourly over a single 24-hour period. All fish diverted will be counted by hand, identified to species, and measured for length. The number of fish enumerated through the hand count will be compared to the count produced from the Bioscanner for each sample taken.

2.6.2.2 Frequency and Duration

Daily counts of the number of fish entering the SDF will continue for as long as the facility is operational.

2.6.2.3 Assumptions

A key assumption is that the Bioscanner juvenile counts are not biased due to species composition, fish size or environmental condition present at the SDF.

2.6.2.4 Results and Reporting

The results of the analysis will be presented in tabular format by day and included in the annual M&E report.

2.7 OBJECTIVE 7- ESTIMATE THE NUMBER OF JUVENILES ENTERING SWIFT RESERVOIR

Estimating the number of juveniles entering each reservoir is stipulated in Section 9.2.1 of the Settlement[12]; however, the Settlement does not ascribe a rationale for why these data are needed or provide any information on the level of precision required for the estimate. Because the data are not needed to quantify any of the performance standards agreed to in the Settlement and will be difficult to measure, it is suggested that the ACC revisit the need for this information as part of their review of this draft report.

2.7.1 Task 7.1– Estimate the Number of Juveniles Entering Swift Reservoir using the SDF

The proposed method for estimating the number of juveniles entering Swift Reservoir from data collected at the SDF is presented below.

2.7.1.1 Methods

Total juvenile production would be calculated using the following formula:

$$N_{JUV} = SDF_{COLW} / P_{DET}$$

Where

N_{JUV} = number of fish entering Swift Reservoir

SDF_{COLW} = number of juveniles collected weekly in the SDF

12 Section 9.2.1 defines juveniles as Chinook, steelhead, coho, bull trout and sea-run cutthroat trout.

P_{DET} = Proportion of radio-tags released weekly at the head of Swift Reservoir detected at Swift Dam, SDF and/or the tailrace

These weekly estimates of juvenile production will be combined to calculate the total number of fish entering the reservoir each migration season.

2.7.1.2 Frequency and Duration

Estimates of the number of juveniles entering the reservoir will be conducted weekly for at least one year. At that time, the ACC will be consulted to determine the usefulness of this type of data. If still needed, it is likely that the juvenile abundance estimates would be conducted on the same schedule as the SDF collection efficiency tests.

2.7.1.3 Assumptions

Key assumptions inherent in the analysis are:

1. Estimates of fry abundance are not needed for management decisions.

2. Juvenile survival rate from small tributaries in the reservoir to the SDF are similar to those for tributaries upstream of Swift Reservoir.

2.7.1.4 Results and Reporting

Trapping results will be summarized in the annual M&E report. An example of a table that may be used to present juvenile production estimates developed from fish captured at the SDF are shown in Table 7.

Table 7. SDF estimates of the number of juvenile coho entering Swift Reservoir

	Swift Downstream Facility	
Sample Period	**Number of Coho**	**95% CI (+/-)**
Week 1		
Week 2		
Week 3		
Week 4		
Season Summary		

2.8 OBJECTIVE 8- DETERMINE JUVENILE MIGRATION TIMING

Juvenile migration timing will be determined by tracking juvenile abundance at the SDF each migration season.

2.8.1 Task 8.1- Operate SDF to Develop Juvenile Migration Timing Index

The methods, analysis and assumptions required for using the SDF to develop a juvenile migration timing index are presented in the following section.

2.8.1.1 Methods

An index of juvenile migration timing will be developed by tracking the number of fish captured each day at the SDF and then plotting this information over time.

The number of fish collected each day at the SDF (SDF_{COL}) will be calculated as follows:

$$SDF_{COL} = N_{SUB} * (SDF_{OP} / S_{SUB})$$

Where

N_{SUB} = Number of fish sub-sampled each day

SDF_{OP} = number of hours the SDF was operated each day

S_{SUB} = number of hours the diversion gate was operated each day

Fish counts from the Bioscanners also will be used to generate a run-timing index for juvenile fish.

2.8.1.2 Frequency and Duration

Juvenile migration timing will be collected each year that the SDF is operational.

2.8.1.3 Assumptions

The major assumptions inherent in this analysis are:

1. The run-timing estimate is an index that applies to fish arriving at the SDF.

2.8.1.4 Results and Reporting

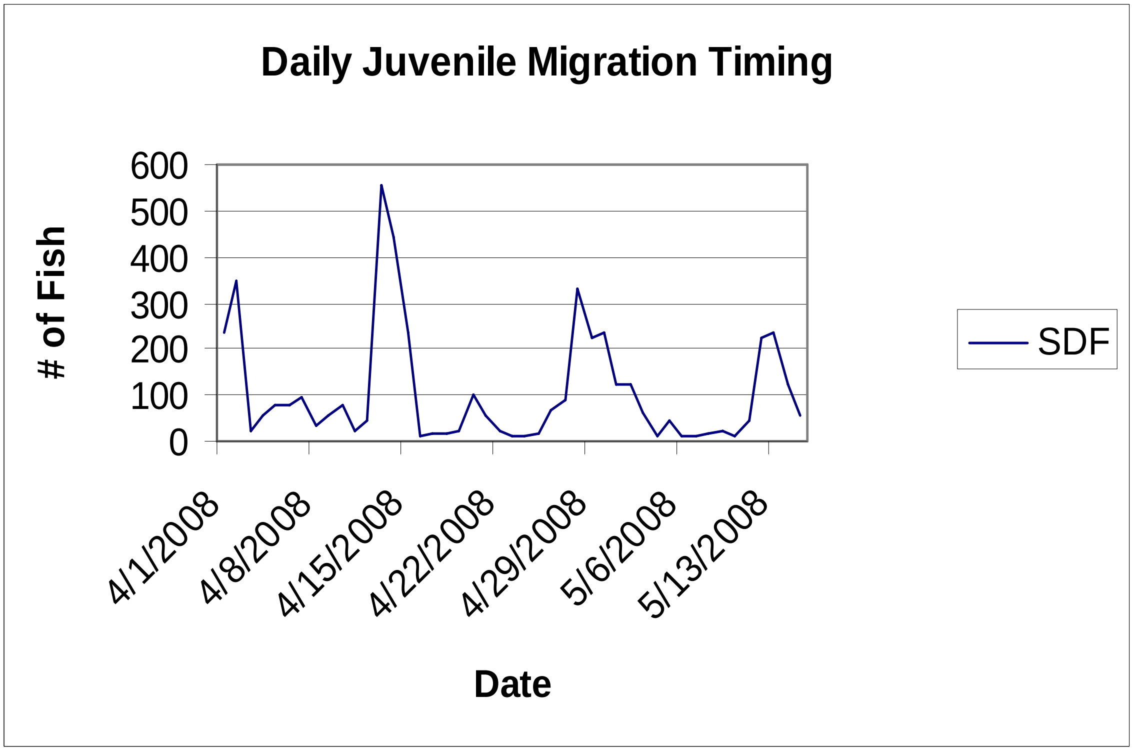
Migration timing results will be presented as shown in Figure 6. Trapping results will be summarized in the annual fish monitoring and evaluation report.

2.9 OBJECTIVE 9 - QUANTIFY ADULT UPSTREAM PASSAGE SURVIVAL

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

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

The Settlement requires the Utilities to achieve a UPS for all species of 99.5%. Given the UPS definition, it is assumed survival is measured from the point of collection to the point of release. The UPS standard will be considered achieved when the point estimate (mean) is $\geq$ 99.5%.



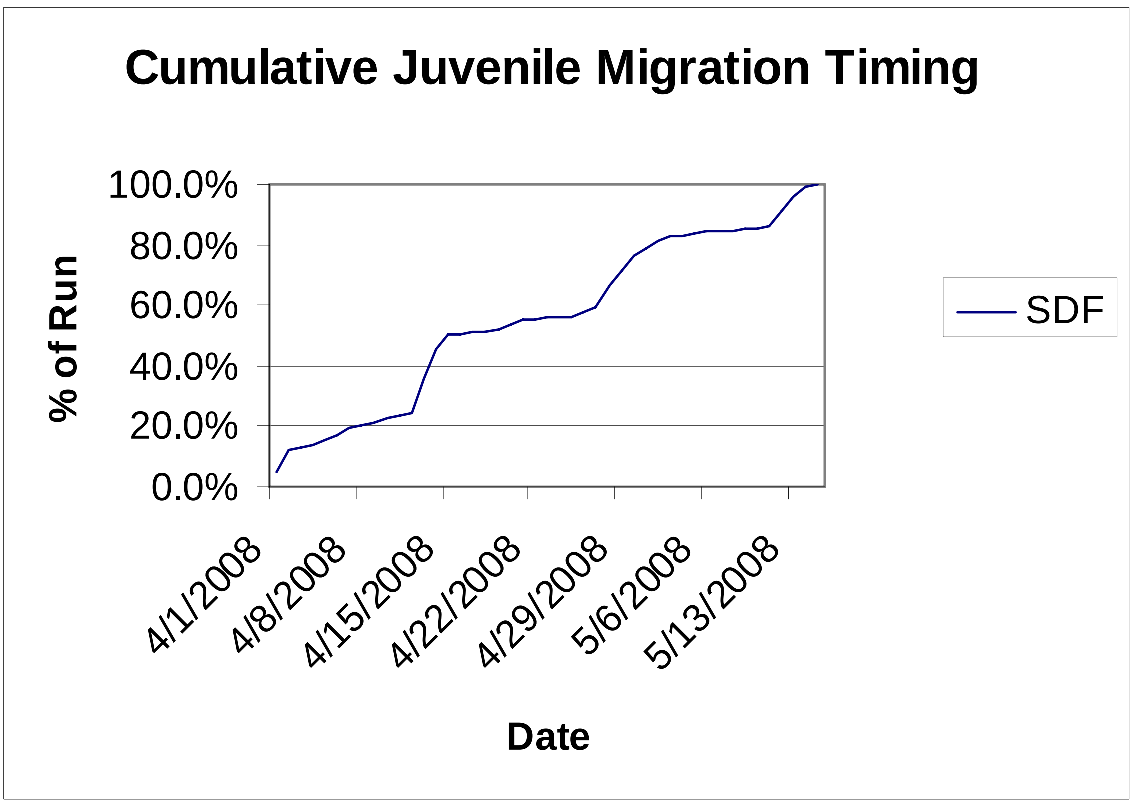


Figure 6. Example of juvenile migration timing graphs.

2.9.1 Task 9.1- Quantify Upstream Passage Survival

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

2.9.1.1 Methods

The UPS will be measured through the direct enumeration of adult fish at the Merwin Upstream Transport Facility and at transport release sites. Any dead fish recovered at trapping or release sites will be identified to species and examined for signs of physical injury, to the extent possible.

UPS will be calculated as follows:

$$UPS = 1-((AD_{TRAP}+AD_{REL}) / N)$$

Where

N =	number of live adults loaded into the transport truck
AD_{TRAP} =	number of dead adults in trap
AD_{REL} =	number of dead adults at release site

An estimate of UPS will be calculated for each day fish are collected and/or transported from the Merwin Upstream Transport Facility. The daily estimates will be summarized to produce a single estimate of UPS for the year.

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

Temperature- Water temperatures at the Merwin Adult Trapping Facility, in the transport truck and release site will be collected each day. Transport truck water temperature will be collected during fish loading and at the time of release. Stream temperature will be recorded for each release group.

Dissolved Oxygen- Measurements of dissolved oxygen will be collected in the transport truck at initial loading and release.

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

Species Mix- The number of fish by species will be recorded for each load of fish.

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

2.9.1.2 Frequency and Duration

An estimate of UPS will be calculated for each day fish are collected and/or transported from the Merwin Upstream Transport Facility.

2.9.1.3 Assumptions

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

2.9.1.4 Results and Reporting

Results will be presented in tabular format by species as shown in Table 8.

Table 8. Estimated adult UPS for coho captured and transported from Merwin Dam.

Date	Number Loaded Alive	No. Dead Release Site	% Survival
4/01/12			
4/02/12			
4/03/12			
4/04/12			
4/05/12			
4/06/12			
4/07/12			
Season Total			

2.10 OBJECTIVE 10- ESTIMATE ADULT TRAP EFFICIENCY AT EACH UPSTREAM FISH TRANSPORT FACILITY

Adult trap efficiency (ATE) is defined in the Settlement as:

> *The percentage of adult Chinook, coho, steelhead, bull trout and sea-run cutthroat that are actively migrating to a location above the trap and that are collected by the trap.* [See Settlement Table 4.1.4]

Currently there is no ATE standard identified for the Project. The Settlement calls for the licensees to consult with the resource agencies and the ACC to develop such a standard as soon as practicable. For now, it is assumed that the objective is to achieve an ATE of 95%.

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

The primary goal of this monitoring effort is to: 1) provide information on fish behavior in the tailrace including areas both around and away from the trap entrance, 2) information useful for assessing the need for future trap modifications, and 3) the initial data for SA trap monitoring needs. Specific study objectives follow.

1) Determine trap effectiveness based on: a) trap attractiveness, b) the rate of entry for the trap, c) trap ladder passage time, d) number of entries that lead to capture, e) trap rejection, and f) trap capture rate, and,
2) Determine the condition of fish that are captured by the trap. Specifically address descaling and injury.

2.10.1.1 Methods

This effort involves monitoring the migratory behavior of adult coho salmon, Chinook salmon and winter steelhead via radio telemetry as they move through the Merwin Tailrace. A fixed telemetry array is proposed with coverage in the tailrace that will facilitate obtaining information on the fish attraction to the trap, coverage in the trap that will provide information to assess trap effectiveness. The data from tagged fish will be assumed to be representative of the corresponding fish populations and will inform us of fish behavior as they enter the tailrace, locate the fish trap and are captured.

Fish Collection and Tagging

Approximately 150 adult fish from each of three species/stocks (coho salmon, winter steelhead, spring Chinook salmon) will be collected out of the Merwin Dam fish trap. We will attempt to tag fish on location at the Merwin sorting facility and immediately haul them for release at the Merwin boat ramp. Our goal would be to tag three groups of up to 50 fish on three separate days across the run. If we are unable to tag fifty fish during each tagging episode we will increase the number of tagging events to result in a total of 150 fish tagged. We will attempt to use the electro-anesthesia (EA) system incorporated into the trap to anesthetize fish prior to tagging. Tags will be gastrically implanted and tagged fish immediately placed into a transport truck. Based on the 2005 study, the time from net capture in the pond to release in the truck is anticipated to take less than one minute per fish.

Fish will be implanted with a tag similar to Lotek MCFT-3A digitally coded transmitters. These tags are 16 mm in diameter, 46 mm in length and weigh 16 g in air and 6.7 g in water. With rates of 2.5 bursts per seconds these tags should last as long as 394 days. After all fish from a release group are tagged, they will be transported to the Lewis River for release at the Merwin Boat ramp. Tagged fish will be released via the transport truck pipe directly into the water. Tagging personnel will monitor each release; regurgitated tags and tag mortalities will be collected.

Telemetry Array

The radio telemetry array will be designed to provide coverage around the perimeter of the tailrace and within the new fish ladder and trap. A total of 22 (17 to 22) fixed antennae will be used in this study creating 14 distinct detection zones. Fourteen antennas, including 2 aerial and 15 underwater antennas will be located within the tailrace proper (Figure 1). Six underwater dipole antennas (Grant Engineering Systems) will be used to create six distinct detection zones along the powerhouse and control room walls (Figure 1, Zones 1-6). One underwater antenna, comprised of stripped coax cable will be used to monitor the aft bay behind the powerhouse (Zone 7). Two aerial antennas will be located on the access bridge and will cover the right and left edges of the tailrace (Zones 8-9).An additional eight (2-8) underwater antenna, comprised of striped coaxial cable, will be used to create a grid below the access road bridge (Zone 10) that provides coverage across the tailrace and from the water's surface to the bottom (or to 20m, as depth is unknown at this time). This array was designed to provide coverage of the perimeter of the tailrace and to inform us regarding time fish spend in the tailrace proper as well as about fish swimming and holding patterns along the right and left banks and the powerhouse wall.

To help understand behavior of fish in the new trap, three underwater dipole antennas (#18, 19, and 20) will be located within fish trap. The furthest downstream will be the vicinity of ladder slot 2 (Zone 11). A second will be further upstream in the ladder in the vicinity of ladder slot 3 (Zone 12). A third antenna will be located upstream of the weir inside the trap proper (Zone 13).

Four fixed detection zones will be established downstream of the Merwin tailrace (Figures 2, 3). Zone 14 will be generated by two parallel fixed aerial antennas (#21 and 22) located just downstream of the large pool immediately below the tailrace (Figure 2). The water in this area is relatively shallow and we can obtain complete coverage of the water column using aerial antennae. Two antennas are paired at this location to provide information on direction of movement and thus should allow us to determine when a tagged fish has entered or exited the tailrace.

The exact locations of each of these antennas will be modified to obtain the best coverage given the width of the river and water depth at each location. Dummy tags will be dragged through the detections zones during installation of the array to define the boundaries of distinct detection zones and calibrate the telemetry equipment. The associated receiver's gain and blank levels will be adjusted at the time of installation to ensure adequate coverage and within the tailrace proper to prevent overlap between detection zones. If a number of fish leave the array and are unaccounted for, periodic mobile surveys will be conducted within the Lewis River to try and determine the disposition of these fish.

Table. Relationship between radio telemetry antennas and detection zones.

Location	Antenna	Detection Zone
Tailrace: trap entrance	1	1
Tailrace: downstream of trap	2	2
Tailrace: downstream of trap	3	3
Tailrace: along powerhouse wall	4	4
Tailrace: along powerhouse wall	5	5
Tailrace: along powerhouse wall	6	6
Tailrace: gallery behind dam	7	7
Tailrace: right bank	8	8
Tailrace: left bank	9	9
Tailrace: below bridge	10-17	10
Trap: near slot 1	18	11
Trap: near slot 2	18	12
Trap: upstream of weir	20	13
Lewis River holding pool downstream of powerhouse access bridge	21-22	14

Analyses

Within the release groups, the behavior of individual tagged fish moving through the 10 detection zones in the tailrace will be analyzed. Tagged fish will be selected as the unit of replication for the following reasons: 1) individuals with substantially greater numbers of detections will dominate the analysis if the number of detections aggregated across all fish is analyzed; 2) there are individual behavioral differences among fish, and we want to incorporate this variability; 3) analysis will be completed on the data as it is measured, rather than on an average or summed quantity to avoid obscuring individual fish behavior.

Objective 1. Determine trap effectiveness based on: a) trap attractiveness, b) the rate of entry for the trap, c) trap ladder passage time, d) total number of entries, e) trap rejection, and f) trap capture rate.

a) Trap attractiveness (A)will be determine by the number of tagged fish the are detected in Zone 1 (T_1) divided by the number of tagged fish that are detected in Zone 10 (T_{10}). $A=T_1/T_{10}$.

b) The rate of trap entry will provide information on how effectively fish enter the trap once they have located it. Trap entry rate (E) will be calculated as the sum of unique detections in Zone 11 (D_{11}) divided by the total time spent in Zone 1 (T_1). This rate will be compared to expected values (based on 2005 data) to determine if tagged fish readily enter the trap. $E=\sum D_{11} / \sum T_1$.

c) Trap ladder passage time (P) will be calculated for individual fish by summing the total time in trap zones 11, 12, and 13 and will be compared to an expected passage time of less than 3 hours. If these times exceed an average of 3 hours, we will analyze time within and transitions among ladder and trap detection zones to isolate any problem area within the ladder. $P= \sum T_{11} + \sum T_{12} + \sum T_{13}$.

d) We will enumerate the fish with unique detections in the three ladder and trap detections zones. Successful entries will include tagged fish that are detected in the trap entrance zone (11) and continue to move through the ladder to the trap (zone 13). In addition, any fish detected in Zone 13 only, even if they were missed in Zones 11 and/or 12, will be included as successful entries. The number of successful entries can be compared to the number of trap rejections to help evaluate trap effectiveness.

e) The number of trap rejections (defined as tagged fish that enter but then leave the trap and return to the tailrace) will be enumerated based on directional transitions between Zone 1 and Zones 11-13. Given the location of Merwin Dam within the lower Lewis River and Lower Columbia River basins we cannot know if all tagged fish were destined for the upper Lewis River fish. In fact, a recent literature review indicated that fish from several of the nearby rivers including the Cowlitz, Kalama, and the Washougal rivers have been shown to stray into the Lewis River (Quinn 2005, Pascual et al 1995, Quinn and Fresh 1984). Rates of straying for hatchery fish have been estimated as high as 22.2% for returns to the Lewis River Hatchery (Quinn and Fresh 1984). Given this information, it is reasonable to assume that some level of trap rejection will likely occur at Merwin Dam. Trap rejection rate during the 2005 study were consistently around 25% for multiple species. A reduction of trap rejection to 20% would be a reasonable goal.

f) Trap capture rate will be calculated for each species/stock of tagged fish as the number of tagged fish detected in the trap Zone 13 divided by the number of tagged fish detected outside the trap in Zone 1.

These parameters will be considered in concert to evaluate the effectiveness of the trap at attracting and capturing the three species of salmonids that are destined to be transported upstream.

Objective 2. Determine the condition of fish that are captured by the trap, as a function of rates of descaling and injury.

All fish collected for radio tagging will be assessed for injury and descaling after tagging and prior to release, and then again during collection in the trap. In addition a random sample of approximately 100 run of the river fish from each run should be anesthetized and examined for descaling and injury to correlate levels seen in test fish with the overall migratory population.

2.10.1.2 Frequency and Duration

ATE tests will be conducted on each species until such time as the ATE standard is met for that species, or the Services are of the opinion that no further improvements in ATE are possible or needed.

2.10.1.3 Assumptions

Key assumptions inherent in the analysis include:

1. Using fish collected at the Merwin trap for testing does not bias resulting estimates of ATE or fish behavior.

2. Fish handling protocols do not substantially affect fish survival or behavior after release.

2.10.1.4 Results and Reporting

Study results will be provided in the annual M&E Report.

2.11 OBJECTIVE 11- QUANTIFY THE NUMBER, BY SPECIES, OF ADULT FISH COLLECTED AT THE PROJECTS

The accurate enumeration of adults arriving at Merwin Dam is important not only for determining the success of the anadromous reintroduction program, but is also needed to make changes to the program as defined in the Settlement. For example, when natural origin adult production exceeds the abundance targets shown in Table 9, hatchery production levels may be decreased on a fish-for-fish basis (1:1)[13].

Table 9. Natural origin adult abundance numbers governing modifications to hatchery production targets.

	Spring Chinook	Steelhead	Coho	Total
Natural Production Threshold for Hatchery Reduction	2,977	3,070	13,953	20,000

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

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

2.11.1.1 Methods

All fish arriving at Merwin Adult Trapping Facility will be anesthetized, enumerated and identified to species. Adult fish will be counted by species and recorded on a data entry form. The definition of adult for each species of interest is as follows:

[13] The surplus abundance of one species cannot be used to reduce the number of hatchery fish of another species.

Bull trout: ≥ 13 inches

Chinook: ≥ 22 inches

Coho: ≥ 18 inches

Sea-run cutthroat trout: ≥ 13 inches

Steelhead: ≥ 20 inches

The number of live and dead adults captured at Merwin Dam will be summarized on a daily basis. The daily counts will be combined to quantify totals adults captured by species for the year.

2.11.1.2 Frequency and Duration

The number of adult fish entering the facility will be calculated for each day the facility is operated.

2.11.1.3 Assumptions

The primary assumption of this analysis is that biologists working the adult trap will be able to accurately count and identify all captured fish to species.

2.11.1.4 Results and Reporting

Results of this analysis will be reported in tabular format similar to that shown in Table 10 in the annual monitoring report.

Table 10. The number of adult coho, Chinook, steelhead, bull trout and sea-run cutthroat trout captured at the Merwin Adult Trapping Facility in 2012.

Date	Coho	Chinook	Steelhead	Bull Trout	Sea-run Cutthroat	Daily Total
4/01/12						
4/02/12						
4/03/12						
4/04/12						
Season Total						

2.12 OBJECTIVE 12- DEVELOP ESTIMATES OF OCEAN RECRUITS

According to the Settlement, a juvenile tagging program is needed to determine when the hatchery and natural adult production targets identified in Table 11 are achieved.

Table 11. Hatchery and natural production adult threshold levels (ocean recruits) for spring Chinook, steelhead and coho.

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

These targets are referred to in the Settlement as Ocean Recruits[14]. This parameter is defined as:

> *"… total escapement (fish that naturally spawned above Merwin and hatchery fish) plus harvest (including ocean, Columbia River, and Lewis River Harvest)."* [Section 8.1]

The Settlement does not however, define (1) if the species specific values are averages, or the time frame over which they must be observed to invoke a possible change in hatchery production.

For this analysis the average ocean recruits for five consecutive brood years will be used to determine if and when hatchery production levels should be altered.

2.12.1 Task 12.1- Calculate Ocean Recruits

2.12.1.1 Methods

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):

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 the harvest management activities affecting the species.

The formulas used to calculate each of the three ocean recruits estimates are presented in Appendix C. The indices that will be used to calculate this parameter by species is shown in Table 12.

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

Table 12. Methods used for estimating ocean recruits by species.

Stock	Age 2	AER	C+E[1]
Spring Chinook Hatchery	✓	✓	✓
Spring Chinook Natural	✓	✓	✓
Coho Hatchery	✓	✓	✓
Coho Natural	✓	✓	✓
Steelhead Hatchery			✓
Steelhead Natural			✓

[1] Because steelhead are not harvested in large numbers in ocean fisheries, the H&S Plan recommended that only C+E be used for estimating ocean recruits for this species.

Calculating ocean recruits requires that Lewis River origin fish be marked such that they are distinguishable in fisheries, traps and on the spawning grounds. Test fish will be marked using a combination of coded-wire-tags (CWTs) and fin-clips. The mark used for each index group will be consistent with the marking designations presented in Table 13.

Table 13. Juvenile marking program for supplementation, hatchery, and natural origin spring Chinook, coho and steelhead.

Location	Fish Origin	Spring Chinook	Steelhead*	Coho
Lewis River Hatcheries	Hatchery Double Index Group	1) AD removed, 150,000 CWT (Nose) 2) AD present, 150,000 CWT (Nose)	1) AD removed	1) AD removed, 150,000 CWT (Nose) 2) AD present, 150,000 CWT (Nose)
Swift	Natural	AD intact, 34,000 CWT (Right Cheek)	AD intact, 16,700 CWT (Right Cheek)	AD intact, 21,000 CWT (Right Cheek)
	Supplementation	AD intact, 100% RV clipped and CWT	AD intact, 100% RV clipped and CWT	AD intact, 100% RV clipped and CWT
Yale	Natural	AD intact, 34,000 CWT (Left Cheek)	AD intact, up to 16,700 CWT (Left Cheek)	AD intact, 21,000 CWT (Left Cheek)
	Supplementation	AD intact, 100% LV clipped and CWT	AD intact, 100% LV clipped and CWT	AD intact, 100% LV clipped and CWT
Merwin	Natural	None	None	None
	Supplementation	None	None	None

* CWTs may be coded or blank dependent on the harvest sampling program in net fisheries. In addition, the decision to use CWTs, or another tag type for upper basin wild production will be coordinated with the resource agencies.

Note: AD =adipose fin clip; RV = right ventral fin clip

The number of fish to be tagged by species and stock is also shown in Table 13. Sample sizes for fish released from Lewis River hatcheries are based on historical practices. Sample sizes for natural origin fish are based on the smolt-to-adult survival rates (SAR) presented in the H&S Plan. The release size for each group was designed to produce 1,000 marked adults, on average, for each brood year (Table 14). Sample sizes would be adjusted in the future as data become available on SARs for each species.

Table 14. Release size, SAR and expected adult production for marked natural origin spring Chinook, coho and steelhead.

Species	Release Size	SAR	Number of Adults
Spring Chinook	34,000	3%	1,000
Coho	21,000	4.8%	1,000
Steelhead	16,700	6%	1,000

Calculating Sample Sizes

A portion of the natural origin fish entering the SDF will be diverted to the subsample tanks for marking. Here the fish will be anesthetized, tagged, allowed to recover and then transported and released below Merwin Dam. The formula for calculating the number of tagged natural origin fish released below Merwin Dam is:

N = number of fish tagged at SDF - number lost due to tagging and transport

Hatchery origin fish will be tagged at basin hatcheries and then released according to protocols in place at each hatchery. Sample size (N) for these groups equals:

N= number of total fish tagged - number of fish found dead before release

Supplementation fish destined for release above Swift Dam will be tagged at the Lewis River hatcheries, transported and released into the upper watershed (either streams or acclimation ponds).

The number of tagged supplementation fish caught in the SDF will be determined using the protocols described in Section 2.6. The formula for calculating the number of supplementation fish released below Merwin Dam is:

N= number of tagged fish collected in SDF - number lost due to collection and transport

Tagged Lewis River origin fish captured in ocean and freshwater fisheries, as well as the spawning grounds and at hatcheries will be collected by those agencies responsible for monitoring these areas. PacifiCorp will also recover tagged fish during any spawning surveys they conduct in the Lewis River basin both below and above Merwin Dam. CWT recoveries will be reported to the Regional Mark Information System (RMIS) where the data will be stored (http://www.rmpc.org/).

Adjusting Hatchery Production

The Settlement allows the Utilities to reduce hatchery production on a 1:1 basis after the natural production target for each species shown in Table 11 is achieved. The calculations used for adjusting spring Chinook, coho and steelhead hatchery production is as follows:

$H_{JUV} = N_{OR} – (N_{PTH} / H_{SUR})$

Where:

H_{JUV} = Number of hatchery juveniles eliminated

N_{OR} = Natural ocean recruits (five brood year running average)

N_{PTH} = Natural production threshold

H_{SUR} = Hatchery survival rate (five brood year running average)

The hatchery survival rate (H_{SUR}) is calculated:

$H_{SUR} = (H_{OR} / H_{REL})$

Where:

H_{OR} = Hatchery ocean recruits (five year running average)

H_{REL} = Number of hatchery fish released (five year running average)

The need for hatchery production adjustment will be determined every five brood years. An example hatchery production adjustment for spring Chinook is shown in Table 15. In this example, hatchery spring Chinook production would be reduced by 55,471 fish.

Table 15. Spring Chinook hatchery adjustment example.

Brood Year	N_{OR}	N_{PTH}	Difference	H_{SUR}
1	3,500	2,977	523	1.0%
2	4,500	2,977	1,523	2.0%
3	6,900	2,977	3,923	4.0%
4	1,500	2,977	-1,477	0.5%
5	3,200	2,977	223	1.0%
Average	3,920	2,977	943	1.7%
Adjustment (H_{JUV}) (Calculated: 943 / 1.7%)	55,471			

2.12.1.2 Frequency and Duration

Estimates of ocean recruits will be developed for each brood year and species throughout the term of the licenses.

2.12.1.3 Assumptions

Key assumptions inherent in completing the analysis include:

1. Sample sizes provide sufficient precision for making management decisions.
2. Tagged fish can be readily identified in ocean and freshwater fisheries, on the spawning grounds and at trapping facilities.
3. Recovered CWT data will be reported to RMIS in a timely manner.

2.12.1.4 Results and Reporting

The results of the ocean recruits analysis will be documented in the annual M&E report. The data will be presented in tabular format similar to that shown in Table 16.

Table 16. Estimates of ocean recruits for coho, Chinook and steelhead using three different indices.

		Age 2	AER	C+E
Species	**Stock**	**Ocean Recruits**	**Ocean Recruits**	**Ocean Recruits**
Spring Chinook	Natural			
	Hatchery			
	Supplementation			
Coho	Natural			
	Hatchery			
	Supplementation			
Winter Steelhead	Natural	N/A	N/A	
	Hatchery	N/A	N/A	
	Supplementation	N/A	N/A	

2.13 OBJECTIVE 13- DETERMINE PERFORMANCE MEASURES FOR INDEX STOCKS

The H&S Plan recommended that other Lower Columbia River stocks be used as index groups to determine whether the success or failure of the Lewis River reintroduction program is the result of in-basin or out-of-basin factors. This would be determined by comparing the survival rates of hatchery and natural origin fish produced in basins such as the Cowlitz River with releases made in the Lewis River. The methods that will be used to calculate juvenile to adult survival rates are presented below.

2.13.1 <u>Task 13.1- Develop Estimates of Survival for Lower Columbia River Fish Stocks</u>

2.13.1.1 Methods

Two different juvenile to adult survival estimates will be developed for marked test groups. These are:

- Smolt-to-adult Survival Ratio (SASR): Represents the total number of fish caught in fisheries, on the spawning grounds and at hatcheries. The SASR is equivalent to C+E described in Section 2.12.1.1.

- Smolt-to-adult Survival Rate (SAR): Measures the number of adults that return to the basin at a pre-defined point. For this analysis, SAR will be measured at the Merwin Dam upstream trap and/or Lewis River Hatchery ladder.

For almost all hatchery stocks, SASR is tracked on the Data Access in Real Time (DART) web site (http://www.cbr.washington.edu/cwtSAR/)[15]. DART uses data from RMIS to calculate both SASR and a standard error for CWT fish released in the Columbia River Basin.

The DART system will be used to develop and contrast survival rates for index stocks and fish released in the Lewis River. All hatchery and natural stocks located below Bonneville Dam will be used as index stocks as recommended in the H&S Plan so long as data are available for comparison. This M&E plan does not propose to initiate a tagging program for those lower river fish stocks that are not currently marked.

The SAR for each tagged group of fish originating from upper basin origin juveniles will be determined by sampling fish at Merwin Dam[16]. Hatchery SARs will be based on tag recoveries at both Merwin and Lewis River hatcheries. SAR will be calculated as:

SAR = number of tagged fish recovered / number tagged fish released

Scale samples will be collected on upper basin origin tagged fish to determine age and assign tags to the correct brood year[17]. Results from this analysis will be checked against tags and scales recovered on the spawning grounds. The additional step of reading scales is needed because it is currently unknown what proportion of the upper basin spawners will be sampled as part of the spawning surveys described in Section 2.14. The inability of biologists to access some spawning areas may result in few CWT fish being recovered during survey work, making it difficult to accurately assign adult returns to the correct release year based on CWTs alone[18].

Finally, SAR estimates will also be developed for unmarked natural origin adults returning to Merwin Dam. The SAR for this group of fish will be calculated as follows:

SAR= number of unmarked adults/ number of unmarked juveniles released below Merwin Dam

The estimated number of unmarked juveniles released below Merwin comes from the analysis described in Section 2.6 of this report.

[15] Note: this web site uses the abbreviation SAR in presenting data for what they refer to as the smolt-to-adult ratio. The abbreviation was changed to SASR in this report to eliminate confusion with the more well known smolt-to-adult survival rate (SAR) used in the fisheries literature.

[16] Upper basin origin fish collected at the Lewis River hatcheries would also be included in SAR calculations.

[17] Although the vast majority of coho are three-year old fish, scale samples will be collected on this species until such time as data indicate that no or few 4+ fish return to the basin.

[18] Scale sampling will be eliminated if sufficient numbers of CWT are recovered during spawning surveys.

2.13.1.2 Frequency and Duration

Survival estimates will be developed for each brood year throughout the term of the licenses.

2.13.1.3 Assumptions

Key assumptions inherent in completing the analysis include:

1. Sample sizes provide sufficient precision for making management decisions.
2. Tagged fish can be readily identified in ocean and freshwater fisheries, on the spawning grounds, hatcheries and at trapping facilities.
3. All unmarked fish arriving at Merwin Dam originated from upstream reaches.
4. Scale samples accurately identify fish age.
5. Recovered CWT data will be reported to RMIS in a timely manner.

2.13.1.4 Results and Reporting

The results of the SAR analysis will be documented in the annual M&E report. The data will be presented in tabular format similar to that shown in Table 17. Results of SAR analysis for index stocks developed by others will be provided in a similar table (if available).

Table 17. Estimated SAR for hatchery and natural origin Lewis River coho, Chinook and steelhead.

Species	Stock	Brood Year	SAR	Standard Error

Results of the SASR analysis will be downloaded from the DART site and presented in a similar manner.

2.14 OBJECTIVE 14: DETERMINE COMPLIANCE OF UPSTREAM AND DOWNSTREAM PASSAGE FACILITIES WITH HYDRAULIC DESIGN CRITERIA

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

2.14.1 Task 14.1- Confirm SDF System Compliance with Hydraulic Design Criteria

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

2.14.1.1 Methods

Both acoustic Doppler and hand-held water velocity meters will be used to determine the hydraulic performance of the SDF. The two systems will collect data on flow velocity and direction at the following locations (see Figure 7 for SDF schematic):

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

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

2.14.1.2 Frequency and Duration

Flow measurements required to document compliance with design criteria will be conducted until it is proven that these criteria have been achieved. After that time, flow measurements within the SDF will be made yearly to ensure that the system continues to perform as designed.

2.14.1.3 Assumptions

Key assumptions inherent in completing the analysis include:

- Measurement points are readily accessible to staff.

2.14.1.4 Results and Reporting

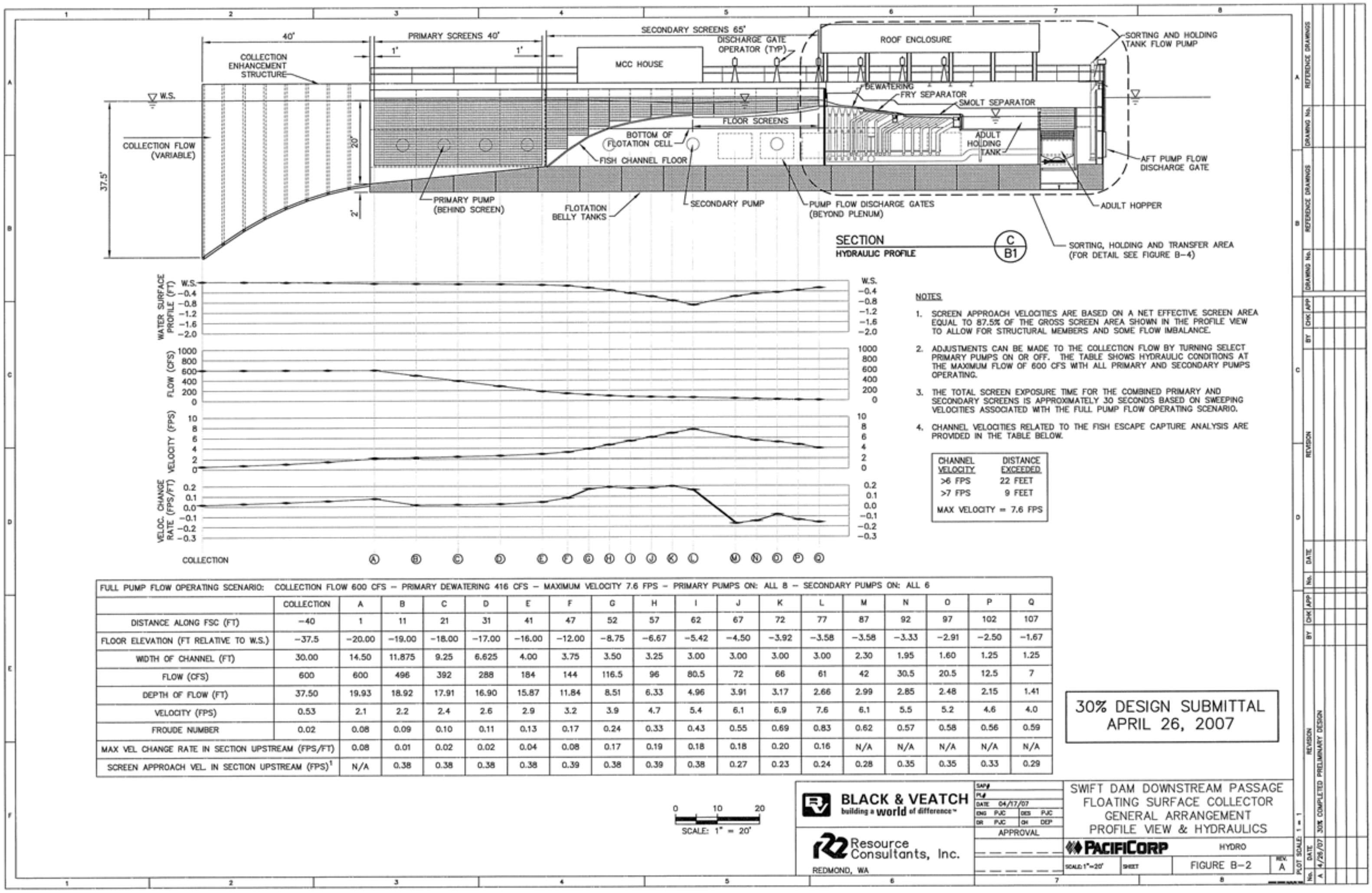
The results of the SDF hydraulic evaluation will be presented in a stand-alone report developed upon completion of the study. Yearly monitoring results will be reported in the annual M&E report.

2.14.2 Task 14.2- Confirm Compliance of Merwin Upstream Transport System with Design Criteria

The method used for determining that the Merwin upstream transport system is operating as designed is presented below.

2.14.2.1 Methods

To be determined after facility design is complete.



FULL PUMP FLOW OPERATING SCENARIO: COLLECTION FLOW 600 CFS – PRIMARY DEWATERING 416 CFS – MAXIMUM VELOCITY 7.6 FPS – PRIMARY PUMPS ON: ALL 8 – SECONDARY PUMPS ON: ALL 6

	COLLECTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
DISTANCE ALONG FSC (FT)	−40	1	11	21	31	41	47	52	57	62	67	72	77	87	92	97	102	107
FLOOR ELEVATION (FT RELATIVE TO W.S.)	−37.5	−20.00	−19.00	−18.00	−17.00	−16.00	−12.00	−8.75	−6.67	−5.42	−4.50	−3.92	−3.58	−3.58	−3.33	−2.91	−2.50	−1.67
WIDTH OF CHANNEL (FT)	30.00	14.50	11.875	9.25	6.625	4.00	3.75	3.50	3.25	3.00	3.00	3.00	3.00	2.30	1.95	1.60	1.25	1.25
FLOW (CFS)	600	600	496	392	288	184	144	116.5	96	80.5	72	66	61	42	30.5	20.5	12.5	7
DEPTH OF FLOW (FT)	37.50	19.93	18.92	17.91	16.90	15.87	11.84	8.51	6.33	4.96	3.91	3.17	2.66	2.99	2.85	2.48	2.15	1.41
VELOCITY (FPS)	0.53	2.1	2.2	2.4	2.6	2.9	3.2	3.9	4.7	5.4	6.1	6.9	7.6	6.1	5.5	5.2	4.6	4.0
FROUDE NUMBER	0.02	0.08	0.09	0.10	0.11	0.13	0.17	0.24	0.33	0.43	0.55	0.69	0.83	0.62	0.57	0.58	0.56	0.59
MAX VEL CHANGE RATE IN SECTION UPSTREAM (FPS/FT)	0.08	0.01	0.02	0.02	0.04	0.08	0.17	0.19	0.18	0.18	0.20	0.16	N/A	N/A	N/A	N/A	N/A	
SCREEN APPROACH VEL. IN SECTION UPSTREAM (FPS)[1]	N/A	0.38	0.38	0.38	0.38	0.39	0.38	0.39	0.38	0.27	0.23	0.24	0.28	0.35	0.35	0.33	0.29	

Figure 7. SDF Schematic.

2.14.2.2 Frequency and Duration

Compliance activities will be conducted yearly.

2.14.2.3 Assumptions

To be determined after facility design is complete.

2.14.2.4 Results and Reporting

Results will be presented in a stand-alone report developed upon completion of the study. Yearly evaluations to document that the facility continues to operate as designed will be reported in the annual M&E Report.

2.15 OBJECTIVE 15- DETERMINE SPAWN TIMING, DISTRIBUTION AND ABUNDANCE OF TRANSPORTED ANADROMOUS ADULTS

Article 9.2.2 of the Settlement Agreement requires the Licensees to identify the spawning timing, distribution, and abundance for transported anadromous species that are passed upstream. This is to be done by monitoring a statistically valid sample of each stock. The primary objective of this task is to identify preferred spawning areas in order to (i) inform revisions to the H&S Plan and the Upstream Transport Plan and (ii) guide the ACC in determining how to apply monies from the Aquatics Fund.

To fulfill this requirement, the Licensees will conduct annual spawning ground surveys for Chinook, coho, and winter steelhead in the mainstem Lewis River and selected tributaries located upstream of Swift Dam.

2.15.1 <u>Task 15.1: Conduct Mainstem and Large Tributary Spawning Surveys</u>

2.15.1.1 Methods

The mainstem and large tributary spawning survey reaches listed in Table 18 will be intensively surveyed for redds, carcasses, and live fish, once every two weeks, throughout each species' spawning period using traditional spawning survey techniques. The spawning surveys will begin in Year 3 of the new licenses (following introduction of adults upstream of Merwin) and continue for a minimum of 5 years, when the need for these on-the-ground surveys will be re-evaluated by the ACC. During the spawning surveys, biologists will work in pairs, walk in an upstream direction on opposite sides of the stream bank, at a pace adapted to weather and viewing conditions. It is anticipated that crews will be able to walk two to three miles during each survey day; however, some of the more remote sites may require more time to survey (due to difficult access conditions). Surveyors may also elect to float selected mainstem reaches in rafts or kayaks during periods of higher flows. To minimize stress on pre-spawning salmonids, surveyors will move carefully and quietly through holding and spawning areas. Surveys will not be conducted in a given reach if the streambed is obstructed from view due to high flows or turbid conditions.

Table 18. Mainstem and large tributary reaches targeted for spawning ground surveys.

Reach Name	Survey Reach Length[1]	Migration Barrier Location
North Fork Lewis River	RM 59.1 to RM 72.2	RM 72.2
Pine Creek	RM 0 to RM 3.2	RM 8.0
Muddy River	RM 0 to RM 6.0	RM 13.8
Clear Creek	RM 0 to RM 5.1	RM 12.3
Clearwater Creek	RM 0 to RM 5.2	RM 5.2
Smith Creek	RM 0 to RM 3.7	RM 5.7

[1]It should be noted that these reach lengths are preliminary and may be adjusted (shortened or lengthened) based on initial survey results or access concerns; however, any modification would be made in consultation with the ACC.

While moving upstream or floating downstream surveyors will count redds and collect basic biological and physical data including live fish and carcasses counts. Carcasses will also be sampled for coded-wire tags, scales and examined to determine egg retention and spawning success. After examination, all sampled carcasses will have the tails removed to prevent re-sampling during subsequent surveys. Individual redds or groups of redds will be flagged, documented and the GPS location recorded. Each flag will be marked with the date, location of redd, redd number for the survey, fish species observed near the redd, and the surveyors initials. The color of the flagging will be changed for each survey and the number of days between the survey when a redd was first marked and when it was no longer visible will define the period of "redd life" for that redd. Because all redds will be marked, they represent a total count in a given reach[19].

Using the above redd count information, the total number of redds dug in the mainstem Lewis River or large tributary reach, in each spawning season, will be estimated. The total salmon and steelhead escapement to the upper watershed will be determined from adult counts at Merwin Dam.

In addition to these traditional "on-the-ground" spawning surveys, PacifiCorp may conduct a series of annual aerial spawning ground surveys. Low elevation helicopter or fixed-wing flights will be made over the accessible reaches of each stream listed in Table 18 during the peak spawning period of each species. The aerial surveys will also begin in Year 3 of the new licenses (following introduction of adults upstream of Merwin) and continue for a minimum of 5 years, when the need for these aerial surveys will be re-evaluated by the ACC. The objective of these surveys is to document the full extent of spawning distribution of each species in the upper basin as needed to refine (lengthen or shorten) the preliminary index reach lengths listed in Table 18. The aerial surveys will also help to determine the best access into those streams located in remote areas of the basin (i.e. the upper Muddy River, Smith Creek, and Clearwater Creek).

During these aerial counts, fisheries biologists will count and record the number of fish and redds observed in each survey reach (Table 18). To facilitate counts, the pilot will maintain the slowest airspeed possible at an altitude that will provide the best possible view of the streambed. All flights will be scheduled to minimize sampling error by avoiding periods of turbid flow and inclement weather. The direction of the surveys (upstream or downstream) will be dictated by local wind and visibility conditions. When

[19] All flagging used to mark redds will be removed at the conclusion of each field season.

necessary, the pilot will hover or circle over areas with a large number of redds or large schools of fish to assist with the counting. Hand-held GPS units and digital cameras will be used to record areas of peak spawning activity and to refine index reach demarcations.

In general, the accessible reaches of large tributaries will be surveyed until they begin branching into numerous small tributaries, or until the vegetation canopy or canyon walls limit the ability of observers to count fish.

2.15.1.2 Frequency and Duration

Surveys of mainstem and large tributaries will be conducted every two weeks throughout the defined spawning season (Table 19).

Table 19. Proposed schedule for the mainstem and large tributary spawning surveys upstream of Swift Creek Reservoir.

Species	Dates*	Frequency	Activity
Winter Steelhead	March 15 through June 30	Every two weeks	Spawning surveys
Chinook	September 1 through October 31	Every two weeks	Spawning surveys
Coho	October 15 through December 31	Every two weeks	Spawning surveys

* Preliminary schedule is based on spawning periodicity observed in the Lewis River downstream of Merwin Dam. These dates may be modified in consultation with the ACC as more information becomes available.

2.15.1.3 Assumptions

The major assumptions associated with this study include:

1. Biologists are able to accurately determine the presence of redds, and identify redds to species.

2. Spawning occurs during the time frames identified in Table 19.

2.15.1.4 Results and Reporting

Study results will be provided in the annual M&E Report.

2.15.2 Task 15.2- Conduct Supplemental Small Tributary Spawning Surveys

2.15.2.1 Methods

In addition to the mainstem and large tributary reach surveys described above, PacifiCorp biologists will conduct supplemental spawning ground surveys during peak spawning periods, in up to 9 randomly selected small tributaries not visited during the mainstem and large tributary reach surveys (Table 20). The supplemental surveys will be conducted during the peak spawning period of each species and will be designed to further define the extent of spawning activity in the upper basin. Methods used for this work will be the same as described for the mainstem and large tributaries.

Table 20. Small tributary reaches targeted for supplemental spawning ground surveys.

Reach Name	Survey Reach Length	Migration Barrier Location
Swift Creek	RM 0 to RM 0.3	RM 0.3
Range Creek	RM 0 to RM 0.7	RM 0.7
S10	RM 0 to RM 0.4	RM 0.4
Drift Creek	RM 0 to RM 1.6	RM 1.6
S15	RM 0 to RM 1.3	RM 1.3
P1	RM 0 to RM 0.9	RM 0.9
P3	RM 0 to RM 1.0	RM 1.0
P7	RM 0 to RM 1.1	RM 1.1
P8	RM 0 to RM 4.2	RM 4.2
P10	RM 0 to RM 0.3	RM 0.3
U8	RM 0 to RM 0.3	RM 0.3
Pepper Creek	RM 0 to RM 0.4	RM 0.4
Rush Creek	RM 0 to RM 1.7	RM 1.7
Little Creek	RM 0 to RM 0.3	RM 0.3
Big Creek	RM 0 to RM 0.3	RM 0.3
Spencer Creek	RM 0 to RM 0.6	RM 0.6
Cussed Hollow Creek	RM 0 to RM 0.3	RM 0.3
Chickoon Creek	RM 0 to RM 0.3	RM 0.3

2.15.2.2 Frequency and Duration

The supplemental small tributary surveys will occur once a year for each species during the peak spawning period of each species.

2.15.2.3 Assumptions

Major assumptions associated with this study include:

1. Biologists are able to accurately determine the presence of redds, and identify redds by species.

2. Spawning occurs during the time frames identified in Table 19.

3. A single survey in small tributaries adequately captures data needed for management.

2.15.2.4 Results and Reporting

Study results will be provided in the annual M&E Report.

2.16 OBJECTIVE 16: EVALUATE LOWER LEWIS RIVER WILD FALL CHINOOK AND CHUM POPULATIONS

Section 9.3 of Lewis River Settlement Agreement also calls for the continued monitoring of wild fall Chinook and chum populations in the Lewis River below Merwin Dam (including juvenile tagging). To meet this obligation, PacifiCorp will either (i) fully reimburse WDFW to conduct juvenile Chinook monitoring activities, or (ii) provide at least one biologist with an adequate boat for 5 days (reimbursing WDFW half of the cost to conduct the activities)[20].

2.16.1 Task 16.1- Tag Lower Lewis River Wild Fall Chinook Juveniles

2.16.1.1 Methods

In May or early June of each year, staff will collect fall Chinook young-of-the-year (YOY) from rearing areas in the Lewis River using stick seines. YOY fish will be collected from just above Colvin Creek (RM 16.5) to upstream of the county road bridge in Woodland (RM 6.6). The goal will be to collect and CWT tag approximately 100,000 YOY fall Chinook each year. Fish less than 47 mm in length will not be tagged. All tagged fish will also have their adipose fin removed.

2.16.1.2 Frequency and Duration

Wild YOY fall Chinook will be tagged each year throughout the term of the new license.

2.16.1.3 Assumptions

Key assumptions of the analysis include:

1. Chinook captured in the lower river are fall Chinook and not juvenile spring Chinook.
2. Fish handling and tagging does not bias study results.
3. Failing to tag fish less than 47 mm does not bias study results or interpretation.

2.16.1.4 Results and Reporting

The results of this work will be summarized in the annual M&E report.

2.16.2 Task 16.2- Conduct Fall Chinook and Chum Spawning Surveys in Lower Lewis River

2.16.2.1 Methods

Starting in September and continuing through January, staff will perform weekly spawning and carcass recovery surveys for fall Chinook and chum on the lower Lewis River. Surveys will include all reaches extending from just below Merwin Dam to just downstream of Eagle Island.

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[20] It should be noted that juvenile tagging is not being required for chum until technological improvements make such tagging practicable.

To better accommodate redd counts and fish carcass data collection, PacifiCorp will reduce river flows below Merwin Dam to approximately 1,200 cfs once weekly starting in November. PacifiCorp will coordinate with crews conducting this survey work to the best of their ability depending on runoff conditions.

Field crews will count carcasses and collect length and sex data on a subset of the carcasses found. The snout of any carcass missing an adipose fin will be sampled with a wire detector wand to determine if it has a CWT. Snouts with CWTs will be sent to a lab for tag removal and submittal to RMIS. The tails of sampled carcasses will be cut off so they will not be counted in future surveys.

Counts of both live fish and redds will be made for all reaches where spawning is observed. A mark recapture study using tagged carcasses will be conducted every five years to verify sample rates and escapement estimates.

2.16.2.2 Frequency and Duration

Fall Chinook and chum spawning and carcass surveys will be conducted yearly throughout the term of the new license.

An annual report that estimates run size and population demographics for the Lewis River will be developed in coordination with WDFW. The tagging information is provided to the Pacific States Marine Fisheries Commission.

2.16.2.3 Assumptions

The key assumptions of the analysis include:

1. Surveyors can identify fall Chinook and chum carcasses and redds.
2. Historic areas sampled are representative of the spawning area below Merwin Dam for each species.
3. Fall Chinook carcasses and redds can be distinguished from spring Chinook.

2.16.2.4 Results and Reporting

Study results will be provided in the annual M&E report.

2.17 OBJECTIVE 17- MONITOR BULL TROUT POPULATIONS

As described in Section 9.6 of the Settlement Agreement, the Utilities have agreed to include in this M&E Plan a series of measures designed to monitor bull trout populations in the Lewis River basin for the duration of the new Licenses[21]. Specifically, Sections 9.6.1 and 9.6.2 of Settlement Agreement direct the Utilities to continue their annual bull trout net-and-haul program in the Yale and Swift No. 2 tailraces or as designated by the Bull Trout Annual Monitoring Plan (in the absence of anadromous fish passage). In addition, they are to monitor and evaluate protection, mitigation and enhancement (PM&E) measures relating to bull trout using tagging, snorkel surveys, or other methods.

[21] In the event that bull trout are found by FWS to no longer warrant protection under the ESA, then the Licensees and FWS will reevaluate the need to continue the bull trout monitoring program.

The information gathered during these monitoring activities may then be used by the ACC to prioritize expenditures from the Aquatics Fund.

2.17.1 Task 17.1- Develop Estimate of Swift Reservoir Bull Trout Spawner Population

As noted in PacifiCorp (2004), radio tracking studies conducted in 1990, 1991 and 1994 revealed a pre-migrant congregation of bull trout at the confluence of the North Fork Lewis River and Swift Reservoir. The studies further indicated that all tagged bull trout migrated into either Rush or Pine Creeks. These behavioral patterns have allowed the use of a Peterson estimator to document the annual number of adult spawners ascending the Lewis River from Swift Reservoir.

2.17.1.1 Methods

In May and June of each year, pre-migrant bull trout will be captured at the head of Swift Reservoir using gear as specified in the Annual Plan. Bull trout longer than 14 inches captured during seining will be “marked” with a Floy® tag and released back to the stream. A different colored Floy® tag will be used each year to distinguish adults by release date. No more than 60 bull trout will be tagged each year to minimize impacts to this ESA listed fish.

Snorkel surveys will be conducted in established survey areas of Rush and Pine creeks to determine the number of "recaptures" as required by the Peterson model. Surveys may also be conducted in the mainstem Lewis River. Snorkel surveys will be conducted on alternate weeks in Rush and Pine creeks from August through September. The average of the weekly adult abundance estimates will be used as the measure of population abundance for each year.

The size of the population (N) will be calculated each sampling period as:

$$N = (M*N)/m)$$

Where
M= number of marked fish
N= number of marked + unmarked fish caught in the second sample
m= number of marked fish recaptured

2.17.1.2 Frequency and Duration

The frequency and duration of bull trout tagging and survey work is shown in Table 21.

Table 21. Frequency and duration of bull trout marking and survey activities in the Upper Lewis River.

Dates	Frequency	Activity
May 1 to July 1	Weekly	Capture, mark, and release pre-migrant bull trout at the head of Swift Reservoir
August 1 to September 30	Weekly	Conduct snorkel surveys in Rush and Pine creeks to enumerate bull trout

2.17.1.3 Assumptions

Key assumptions of the study include:

- Surveyors are able to identify marked and unmarked fish to species.
- Variable environmental conditions do not affect accuracy of snorkel counts.

2.17.1.4 Results and Reporting

Study results will be provided in the annual M&E Report.

2.17.2 Task 17.2- Conduct Bull Trout Trapping in Yale Tailrace and Swift Bypass Channel

The objective of this task is to collect adult bull trout arriving at the Yale tailrace and Swift bypass channel and transport them upstream to Cougar Creek and Swift Reservoir, respectively.

2.17.2.1 Methods

Adult bull trout will be captured using tangle nets and hook-and-line at the Yale tailrace and Swift Bypass Reach (or as directed by the FWS). The Utilities will also continue to investigate the use of alternative methods to capture bull trout. If more effective collection methods are identified, and the FWS concurs, those methods will be implemented.

2.17.2.2 Frequency and Duration

Until permanent upstream passage facilities are constructed at Swift and Yale dams, PacifiCorp and Cowlitz PUD will continue their net-and-haul programs following the schedule presented in Table 22. PacifiCorp and Cowlitz PUD will also continue to investigate the use of alternative methods to capture bull trout.

Table 22. Proposed schedule and frequency for Yale tailrace and Swift Bypass Reach bull trout collection and transport.

Dates	Frequency	Activity
July 15 - August 31	Weekly	Netting and Transportation of bull trout in the Yale tailrace and Swift bypass

2.17.2.3 Assumptions

The key assumptions inherent in the study include:

1. All adults captured are migrating to spawning grounds.
2. Fish captured at Yale Dam are destined for Cougar Creek.
3. Fish captured in the Swift Bypass Reach are destined for streams above Swift Reservoir.

2.17.2.4 Results and Reporting

The results of this study will be presented in tabular format in the annual M&E report.

2.17.3 Task 17.3- Describe Fish Utilization of Constructed Channels and Mainstem Lewis River Bypass Reach

Water discharged from the Swift No. 1 Project has been flowing into the bypass reach since May 2002. The presence of water attracts bull trout as well as other fish species into this reach which extends from Swift Dam to Yale Reservoir. Fish can also enter the bypass reach from either the Swift No. 2 canal wasteway or the Swift No. 1 Project spillway. When completed, the upper and lower constructed channels will also create additional resident and anadromous salmonid habitat. To document fish presence in the bypass reach and constructed channels, the Utilities will conduct quarterly snorkel surveys to describe fish utilization of these areas.

2.17.3.1 Methods

Snorkel surveys will be used to describe juvenile and adult fish use of stream habitat in both the constructed channels and mainstem Lewis River below Swift Dam.

Snorkel survey methods will be consistent with the protocols outlined in "Underwater Methods for Study of Salmonids in the Intermountain West" (Thurow 1994). Day snorkel surveys will be conducted when water temperatures in the survey area are generally greater than 9°C. At water temperatures below 9°C, most juvenile salmonids hide during the day, and therefore night surveys are likely to be more effective (O'Neal 2007). However, due to the risk of spill in the winter, surveys in the bypass reach will not be conducted during the flood season (Nov.1 to March 31) for safety reasons.

Surveys crews will collect data on fish species present, their size and location. The crews will also identify any redds observed and spawning activity by species, if possible.

In addition to these snorkel surveys, the Utilities will conduct spawning surveys (redd surveys) in the bypass reach and constructed channels once every two weeks from September 15th to November 15th and from February 1st to May 31st. These surveys will be conducted during the years listed in Table 23 and follow the same general protocols described in Section 2.15.

2.17.3.2 Frequency and Duration

Consistent with Ecology's Section 401 Certification for the Swift No. 1 Project (WDOE 2006), PacifiCorp and Cowlitz PUD's proposed snorkel surveys will follow the schedule and survey frequency presented in Table 23.

Table 23. Schedule for conducting snorkel surveys in Swift Bypass Reach and constructed channels.

Start Date	Frequency	Rationale
Beginning after the first full year of operation of both constructed channels.	Quarterly for one full year	Waiting one full year after both release points and channels become operational will allow the aquatic ecosystems to become established.
Beginning after the fourth full year of operation of both constructed channels.	Quarterly for one full year	Surveying in the fourth year will determine fish response to the combined flow schedule described in the Settlement Agreement.
Beginning one year after any change in the Settlement's combined flow schedule (made in consultation with the ACC).	Quarterly for one full year	Survey after any changes in the flow regime will determine any fish response to the modified habitat conditions.
Beginning one year after the reintroduction of anadromous fish into Yale Lake (likely in Year 13).	Quarterly for one full year	Surveying one year after the reintroduction of anadromous fish into Yale Lake (likely in Year 13) will determine anadromous fish use in the bypass reach and constructed channels.
Beginning one year after the construction of upstream fish passage facilities at the Swift projects.	Quarterly for one full year	Will determine anadromous fish use in the bypass reach and constructed channels after the construction of upstream fish passage facilities at the Swift projects.

2.17.3.3 Assumptions

Major assumptions associated with this task include:

- Biologists are able to correctly identify fish utilization by species of the stream areas being surveyed.
- Redds can be identified to species.

2.17.3.4 Results and Reporting

Study results will be presented in tabular format in the annual M&E report.

2.17.4 Task 17.4- Conduct Spawning and Migration Barrier Surveys in Cougar Creek

Since 1979, PacifiCorp biologists, along with various state and federal agencies, have conducted annual surveys to estimate kokanee and bull trout spawning escapement and identify migration barriers in Cougar Creek. This work will continue under the new licenses.

2.17.4.1 Methods

Before spawning or snorkel surveys are conducted, biologists will walk Cougar Creek to determine if there are any barriers that may prevent fish from accessing the creek. Blockages will be reported to the WDFW and FWS for corrective action.

Kokanee and bull trout spawning surveys will be conducted yearly in Cougar Creek in the fall of each year. Spawning surveys will performed by two biologists walking upstream, each enumerating the number of kokanee and bull trout observed in the creek (PacifiCorp 2004 and PacifiCorp Energy 2006). The entire length (1.5 miles) of Cougar Creek will be surveyed. Fish are counted rather than redds due to the large number of kokanee that spawn in the creek, making the identification of individual redds difficult. Estimates of kokanee and bull trout abundance will be based on the average of the two observer counts.

The field crew will also conduct snorkel surveys in this creek to assist in enumerating the number of bull trout present in the stream. Snorkel surveys will be performed yearly consistent with the methods presented in Thurow (1994).

2.17.4.2 Frequency and Duration

The number of snorkel surveys conducted each year will depend on the number of fish present in the creek. It is anticipated that during the month of October, weekly surveys will be conducted, as this is the peak spawning period. During non-peak periods (September and November), bi-weekly surveys will be performed. A single migration barrier survey will be conducted in late July or August (Table 24).

Table 24. Proposed schedule and sampling frequency for Cougar Creek bull trout and kokanee spawning and migration barrier surveys.

Dates	Frequency	Activity
July/August	Once	Preliminary survey to identify migration barriers
September	Bi-weekly (every 2-weeks)	Includes both bull trout snorkel surveys and kokanee foot surveys
October	Weekly	Includes both bull trout snorkel surveys and kokanee foot surveys
November	Bi-weekly	Includes both bull trout snorkel surveys and kokanee foot surveys

2.17.4.3 Assumptions

The key assumption of the study is:

- Biologists can accurately identify and enumerate bull trout and kokanee spawners.

2.17.4.4 Results and Reporting

Study results will be presented in the annual M&E Report.

2.18 OBJECTIVE 18: DETERMINE INTERACTIONS BETWEEN REINTRODUCED ANDROMOUS SALMONIDS AND BULL TROUT

As called for in Section 9.7 of the Settlement, PacifiCorp will monitor the interaction between reintroduced anadromous salmonids and resident fish species. Of specific interest to the Settlement parties was the possible effect resident trout released in Swift Reservoir may have on reintroduced salmonids and the effect of anadromous fish introductions on the kokanee populations in Yale Lake. Additionally, concern was expressed that anadromous fish may impact the health of ESA listed bull trout populations. The methods proposed for addressing these concerns are presented separately below.

2.18.1 Task 18.1- Develop Qualitative Estimates of the Number of Juvenile Anadromous Fish Consumed by Stocked Resident Trout.

Currently, 60,000 rainbow trout (3 fish per pound) are released each year into Swift Reservoir to provide fish for harvest in sport fisheries. Although smaller rainbow trout feed primarily on aquatic insects, amphipods, aquatic worms, and fish eggs; they are know to become increasingly pisciverous at sizes greater than 250 mm (Beauchamp 1990; Wydoski and Whitney 1979). However, in the case of the Lewis River, it appears the diets of larger rainbow trout in Swift and Yale are primarily invertebrates (PacifiCorp 2007). Still these planted rainbow trout have the potential, due to their size, to prey on anadromous juvenile coho, Chinook and steelhead. Therefore, the objective of this task is to develop qualitative estimates of the number of juvenile anadromous fish consumed by the planted rainbow trout.

2.18.1.1 Methods

Stocked rainbow trout will be sampled monthly from April 1st to July 1st for one year using hook-and-line techniques and as part of bull trout netting efforts at Eagle Cliff. The sampling period was chosen to coincide with the expected juvenile migration period for coho, Chinook and steelhead[22]. Sampling would begin the first year after the SDF becomes operational.

[22] Sampling will be conducted throughout the summer and early fall as it is anticipated that spring Chinook sub-yearlings may migrate into Swift Reservoir during this time frame as a result of decreasing river flow.

Sampling will be conducted at the following locations in the Upper Lewis River[23]:

- Head of Swift Reservoir
- Mouths of small Swift Reservoir tributaries
- Near the Entrance of the SDF
- SDF sub-sample tanks (bull trout should be lavaged in these)
- Within Swift Reservoir

As many fish as possible will be collected at each location (up to 25 at each location) during each monthly sample period. The rainbow trout stomach contents will be removed for analysis using a standard gastric lavage technique[24]. After removal, the contents of each stomach will be immediately placed into a vial filled with ethanol and labeled (species, fish length, capture date and location). The vials will then be sent to a lab for content analysis.

The lab will report the number and estimated weight of anadromous juveniles by species (if possible), as well as any other prey items found in each stomach sample. The data collected for each month's sampling will be combined to develop and overall estimate of the number of juveniles consumed by the stocked trout. The estimate will be considered qualitative in that it is not possible to determine the total stocked rainbow population size at any given time due to removal of fish by recreational anglers and natural mortality.

2.18.1.2 Frequency and Duration

The study will be conducted for 12 months starting one year after installation of the SDF. If study results show high predation rates, as defined by the ACC, the study may be repeated the following year.

2.18.1.3 Assumptions

Major assumptions associated with this task include:

1. Stocked hatchery fish are easily identified and will not be confused with wild fish.

2. Lab staff will be able to identify, to species, anadromous fish found in the stomach samples.

[23] Sample sites may be abandoned if it is found that few rainbow trout are present in an area.

[24] It is assumed that the stocked rainbow trout can be distinguished from wild trout due to coloration, size, condition and frayed fins. If not, during the year the study is being conducted, the rainbow trout will be ad-clipped prior to their release.

2.18.1.4 Results and Reporting

Study results will be presented as a separate report and submitted to the ACC for review. If additional work is conducted in future years, results will be reported in the annual M&E Report.

2.18.2 Task 18.2- Determine Spawning Competition in Rush, Pine and Cougar Creeks

Reintroduced coho salmon have the potential to compete with bull trout for limited spawning habitats in the upper Lewis River basin as a result of their similar spawning period and generally comparable spawning habitat preferences. Steelhead and Chinook salmon spawn prior to bull trout in the Lewis River and therefore do not pose a risk of competition for spawning sites (FWS 2006). Potential negative effects on bull trout can include redd superimposition and associated increases in egg and alevin mortality. The objective of this task therefore is to determine if coho spawners compete with bull trout for spawning areas in the identified streams.

2.18.2.1 Methods

Following implementation of the upper Lewis River basin Habitat Preparation Plan (HPP), but before the start of the formal reintroduction effort above Swift Dam (i.e. the completion of the downstream passage facilities), PacifiCorp will work with in close coordination with the FWS and WDFW to evaluate potential bull trout redd superimposition by coho salmon in Pine Creek. An evaluation in Cougar Creek will begin as soon as the HPP is implemented in the Yale Lake reach (likely 8 years after license issuance).

During the bull trout spawning surveys described previously, survey crews will mark each clearly defined bull trout redd with a piece of rebar or a wooden dowel driven into the streambed so that bull trout redds can continue to be identified after potential superimposition by coho (ODFW 2005).

For each bull trout redd, the combined length of the pocket and mound, maximum depth of the pocket, and maximum width of the mound will be measured and recorded. Spawning substrate size will also be determined by counting gravel along a 0.5 meter length of each pocket and mound of selected redds.

After each bull redd is located and marked, they will be revisited twice per month during the coho spawning period to determine whether spawning coho superimpose their redds on bull trout redds. Superimposition of redds will be defined as overlapping redd pits or tailspills resulting from construction of multiple redds in the same area. Estimates of the percent of each bull trout redd affected by coho spawning and the total number of redds superimposed will be determined for each tributary for each sample period.

2.18.2.2 Frequency and Duration

Surveys will be performed every two weeks starting in September and continuing until January, weather and access permitting. The study may be repeated for up to 5-years. Study termination would be determined in consultation with the ACC.

2.18.2.3 Assumptions

- Biologists are able to correctly identify redds to species.

2.18.2.4 Results and Reporting

Study results will be summarized in the annual M&E Report.

2.18.3 Task 18.3 - Determine if Salmon and Steelhead Prey on Juvenile Bull Trout

The task objective is to determine if reintroduced salmon and steelhead prey on ESA listed bull trout.

2.18.3.1 Methods

The initial study proposes to collect stomach samples from age 1+ Chinook, coho and steelhead juveniles inhabiting stream reaches within and below Rush and Pine creeks and the mainstem Lewis River above Swift Reservoir. Sampling will be performed weekly from February through late May. A total of 25 samples will be collected from each species each sample period.

To minimize potential impacts on juvenile bull trout, snorkeling will be used to locate schools of salmon and steelhead that will then be collected using an electrofisher or seine. The stomachs of these collected salmon and steelhead juveniles will then be lavaged for content analysis. Similar to the rainbow trout stomach analysis study, each stomach will be placed in a vial filled with ethanol and labeled (species, fish length, capture date and location) and the vials will be sent to a lab for content analysis. The lab will report the number and estimated weight of consumed bull trout juveniles, as well as any other prey items found in each stomach sample.

2.18.3.2 Frequency and Duration

Stomach samples will be collected each week for each species from February through May. The study will be conducted for 12 months starting one year after installation of the SDF. If study results show high predation rates, as defined by the ACC, the study may be repeated the following year.

2.18.3.3 Assumptions

A major assumption associated with this task is that lab staff will be able to identify, to species, fish found in the stomach samples.

2.18.3.4 Results and Reporting

Study results will be presented in both text and graphic formats in the annual M&E report

2.18.4 Task 18.4 – Determine if Anadromous Fish Introductions are having a Detrimental Effect on Kokanee Populations in Yale Lake.

As described in Section 2.17.4, kokanee and bull trout spawning surveys will be conducted yearly in Cougar Creek throughout the spawning period of each species. The entire 1.5 miles of Cougar Creek will be surveyed for adult fish. It is anticipated that during the month of October, weekly surveys will be conducted, as this is the peak kokanee and bull trout spawning period. During non-peak periods (September and November), bi-weekly surveys will be performed (Table 24). Following reintroduction of anadromous into Yale Lake, the licensees will review this annual kokanee abundance information consultation with the ACC to inform adaptive management of the reintroduction program and to help guide the operation of the passage facilities.

2.18.4.1 Assumptions

The key assumption of the study is:

- Biologists can accurately identify and enumerate kokanee spawners.

2.18.4.2 Results and Reporting

Study results will be presented in the annual M&E Report.

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

As stipulated by Section 6 of the Settlement Agreement and the WDOE Section 401 Certifications for Swift No. 1 and Merwin Hydroelectric Projects (WDOE 2006), PacifiCorp has agreed to document project flow, ramping rate and flow plateau requirements of the new Licenses for the Project. The monitoring locations will be at the Ariel Gage located in the Lower Lewis River, and at two sites in the Lewis River bypass reach below Swift No. 1 Dam.

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

2.19.1.1 Monitoring Locations

Currently minimum stream flow values for the Lewis River are measured at the USGS Gage No. 14220500 (Ariel Gage) located below the Merwin Dam. This gage is the official compliance point for minimum stream flow releases below Merwin Dam.

Flow into the Swift Bypass Reach will be measured in two locations in accordance with Section 6.1 of the Settlement Agreement. These locations are the “Upper Release Point” in the upper end of the bypass reach, and at the Canal Drain located approximately one-third the length of the canal downstream of the Swift No. 1 tailrace. [25]

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

2.19.1.2 Rating Tables and Gage Station Maintenance

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

2.19.1.3 Data Management and Publication

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

Ariel Gage

Real-time 15-minute provisional data from the Ariel gage will be logged by PacifiCorp and/or and qualified contractor to monitor daily average flow and hourly ramping rates below Merwin Dam. A quarterly report of daily mean stream flow values (measured at the Ariel gage) will be submitted to FERC and the ACC. These reports will be included in the Annual M&E Report.

Swift Bypass Reach: Upper Release Point

Fifteen-minute data from the Swift Bypass Reach Upper Release Point will be logged by PacifiCorp and/or a qualified contractor to monitor daily average flow. Mean daily stream flow values measured at the Upper Release Point will be published in the Annual M&E Report. All reviewed and published records will be archived by PacifiCorp or a qualified contractor.

In the event of a planned or unplanned interruption to flow from the upper release point, PacifiCorp will provide flow via the spill gates (or other means) to allow at least the minimum flow into the upper bypass reach. During this particular scenario, flow will be calibrated by PacifiCorp or a qualified contractor at the most suitable point downstream of the spillway to verify that the temporary flow release is equal to the flow required by the 401 Certification. The spill gates will be adjusted until such time as the appropriate minimum flow is achieved and the spill gates fixed to this opening. In addition, PacifiCorp will send a notice by electronic mail to WDOE and the ACC members within 48 hours after each adjustment or change to the flows in the Bypass Reach (unless the Parties and WDOE agree upon an alternate method of notification). PacifiCorp will also notify WDOE and the ACC of the occurrence, duration, and magnitude of any spill within 10 business days after a spill from Swift No. 1 or the Swift No. 2 canal.

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

Swift Bypass Reach: Canal Drain

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

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

2.19.1.4 Flow and Ramp Rate Monitoring and Excursion Reporting

Flow Monitoring and Excursion Reporting

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

Ariel Gage and Swift Bypass Reach Upper Release

PacifiCorp will review mean daily flow data for compliance with the minimum stream flow requirements in the new license (Table 25). Excursions from minimum stream flow requirements will be reported to FERC, WDOE, and the ACC as soon as practical after verifying the excursion. Notification will include a detailed explanation of why the event occurred and corrective actions implemented.

These initial notifications will be distributed via electronic mail (email), and will describe the location, time, duration, magnitude, and cause of the event; what immediate corrective actions were taken; and any long-term plans to prevent recurrence.

PacifiCorp will describe minimum flow excursions as measured at Ariel gage in quarterly Ariel gage reports to FERC and the ACC. Minimum flow excursions measured at the Upper Release site will be described in the annual report.

Swift Bypass Reach Canal Drain

PacifiCorp will review mean daily stage data on a quarterly basis for compliance with the minimum stream flow requirements in the new license (Table 25). Following review of these quarterly data, any excursions from minimum (stage) stream flow requirements will be reported to FERC, WDOE and the ACC as soon as practical after verifying the excursion. Notification will include a detailed explanation of why the event occurred and corrective actions implemented.

These initial notifications will be distributed via electronic mail (email), and will describe the location, time, duration, magnitude, and cause of the event; what immediate corrective actions were taken; and any long-term plans to prevent repetition.

PacifiCorp will describe minimum flow excursions measured at the canal drain in the annual report.

Ariel Gage Ramp Rate and Plateau Operations Monitoring and Excursion Reporting

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

PacifiCorp will review hourly Ariel gage stage data to ensure compliance with project ramping rate restrictions and plateau changes below Merwin Dam[26]. Stage will be measured in inches per hour, and will be calculated using available 15 minute Ariel gage flow data to calculate an hourly average.

Stage height will be converted from feet (in hundredths) to inches and rounded to the nearest tenth of an inch. The ramping rates will then be compared with the License required ramping rate and flow plateau requirements on an hourly basis.

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

Table 25. Minimum flow releases in the Lewis River below Merwin Dam and the Swift Bypass Reach required by the Settlement Agreement and Section 401 Certification.

Lewis River Below Merwin Dam	
Date	**Minimum Flow (cfs)**
October 16 through October 31	2,500
November 1 through December15	4,200
December 16 through March 1	2,000
March 2 through March 15	2,200
March 16 through March 30	2,500
March 31 through June 30	2,700
July 1 through July 10	2,300
July 11, through July 20	1,900
July 21 through July 30	1,500
July 31 through October 15	1,200
Swift Bypass Reach*	
Date	**Minimum Flow (cfs)**
January	65
February	89
March	90
April	90
May	90
June	68
July	68
August	68
September 1-23	68
September 24-30	69
October	75
November 1-15	90
November 16-30	70
December	65

* Flow levels were taken from the WDOE 401 Certification for the Swift No. 1 Hydroelectric Project (WDOE 2006) and are the "Combined Flow Schedule" for the required stream flow releases from the "Upper Release Point" and the "Canal Drain."

The requirements are as follows:

1. PacifiCorp will limit the up-ramping rate below Merwin Dam to 1.5 feet per hour for all periods when flows below Merwin Dam are at or less than the hydraulic capacity of the Merwin Project turbines.
2. PacifiCorp will limit the down-ramping rate to 2 inches per hour below Merwin Dam for all periods when flows below Merwin Dam are at or less than 8,000 cfs.

From February 16 through June 15, no down-ramping shall occur (1) commencing one hour before sunrise until one hour after sunrise and (2) commencing one hour before sunset until one hour after sunset.

3. PacifiCorp will further restrict daily flow fluctuation below Merwin from February 16 through August 15 of each year by maintaining flow plateaus (periods of near-steady discharge) as described in Section 6.2.2 of the Settlement Agreement.

Excursions from hourly ramp rate requirements or plateau changes will be reported to FERC and the ACC as soon as practical after verifying the excursion. Notification will include a detailed explanation for why the event occurred and corrective actions implemented.

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

PacifiCorp will describe ramping rate and plateau operation excursions as measured at the Ariel gage in annual reports to FERC and the ACC.

Swift Spill Monitoring and Reporting

As per the Section 4.2(7) of the WDOE 401 Certification for the Swift No.1 Hydroelectric Project, spill from Swift Dam into the Swift Bypass Reach will be calculated and documented for every gate change opening. PacifiCorp will log, download, and report daily mean spill from Swift No. 1 in an annual report to WDOE.

High Run-Off Procedure Monitoring and Reporting

Pending approval by FERC and the U.S. Army Corps of Engineers of PacifiCorp's High Run-Off Procedure and as described in the Settlement Agreement in Section 12.0, PacifiCorp may monitor and report compliance with these procedures in the annual report to FERC and the ACC.

2.20 OBJECTIVE 20 - DETERMINE WHEN REINTRODUCTION GOALS ARE ACHIEVED

The Settlement Agreement notes:

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

Although the responsibility of the Services, the Utilities are interested in playing a significant role in putting forth viable approaches for the Services to consider in establishing the Evaluation Methodology. The H&S Plan (PacifiCorp Energy and Cowlitz PUD 2006) provides some ideas as to what type of information should be considered in determining program success. In general the H&S Plan suggests:

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

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

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

Methods

Methods for conducting each of the three analyses are presented in different sections of this M&E Plan. Currently missing is a numeric adult goal that dictates when run-size is sufficient for achieving both recovery and harvest goals. Until the Services develop numeric goals, the natural adult abundance targets presented under Objective 11 (Ocean Recruits) will be used as the benchmarks for determining the success of the reintroduction effort.

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Appendix A

Incidental Take Statement

Post-Season Monitoring and Evaluation Form
Scientific Research Plan
Annual Report

Date: ___________

Plan Name: _____________ **Evaluator's Name:** ____

Contact Name: ___________________ **Contact Email:** __________________________ **Contact Phone #:** __________________
(Contact = person submitting report)

Study Number and Title (if applicable): ____
Provide separate tables for each study.

Part I: This is an example of how to fill out the table. **Replace all red text with the information in the plan. Replace all blue text with the actual results of your activities.**

ESU/Species and population group if specified in your permit	Life Stage	Origin	Take Activity	Number of Fish Authorized for Take	Actual Number of Listed Fish Taken	Authorized Unintentional Mortality	Actual Unintentional Mortality	Evaluation Location	Evaluation Period
Lower Columbia River (LCR) Chinook	Juvenile	Naturally Produced	Capture, mark, release	100	90	5/100	4/90	Columbia River, Oregon	January – February
LCR Chinook	Adult	Artificially Propagated	Capture, handle, release	10	9	1/10	0/9	Bonneville Dam	June
LCR Chinook	Adult	Naturally Produced	Intentional mortality	20	15	N/A	N/A	Bonneville Dam	June
Oregon Coast Coho	Juvenile	Naturally Produced	Observe / Harass	500	400	N/A	N/ A	Nehalem River	October

Appendix B

Radio-Tag Recapture Design

RADIO-TAG RELEASE-RECAPTURE DESIGN AT SWIFT DAM

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11 JULY 2007

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INTRODUCTION

This report describes the design and analysis of the 2012 radio-tag release-recapture study at Swift Dam No. 1. Mark-recapture models will be used to estimate survival through the Swift reservoir and project. This report describes the release and detection locations used in the proposed study along with the recommended data analyses. Specific objectives of the tagging study include the following:

1. Estimate the joint probability of smolt surviving through the reservoir and entering the surface collector.
2. Estimate entrance efficiency and retention efficiency of the surface collector.
3. Estimate smolt survival through the transport system.

These goals will be accomplished using one or more groups of tagged fish.

RELEASE-RECAPTURE DESIGN

Releases of the radio-tagged fish at the top of the Swift reservoir will be used to estimate passage survival through the project. Survival through the Swift No. 1 project can currently be conceptualized by the equation

$$S_{PROJ} = S_{RES}\left[P_{COL} \cdot S_{COL} \cdot S_{TRAN} + P_{TIT} \cdot S_{TIT} + \left(1 - P_{COL} - P_{TIT}\right) S_{SP}\right] \quad (1)$$

where

S_{RES} = survival probability through reservoir,

S_{PROJ} = total project passage survival,

P_{COL} = proportion of fish arriving at Swift Dam that enter the surface collector,

P_{TIT} = proportion of fish arriving at Swift Dam that enter the turbine intake tower,

S_{COL} = survival probability through the collector,

S_{TIT} = survival probability through the turbine intake tower,

S_{SP} = survival probability through the spillway,

S_{TRAN} = survival probability through the smolt transport system.

Currently it is assumed that $S_{TIT} = S_{SP} = 0$, in which case

$$S_{PROJ} = S_{RES} \cdot P_{COL} \cdot S_{COL} \cdot S_{TRAN}. \quad (2)$$

A single release-recapture model will be used to estimate joint probability

$$S_{RES} \cdot P_{COL} = S_1 \quad (3)$$

Independent sampling of fish known to have entered the collector in will be used to estimate the probability of surviving through the collector and the transport system, i.e.,

$S_{COL} \cdot S_{TRAN} = S_2$. The product $\hat{S}_1 \cdot \hat{S}_2$ will therefore provide an estimate of overall project passage survival with associated variance

$$\text{Var}\left(\hat{S}_1 \cdot \hat{S}_2\right) = S_1^2 \cdot \text{Var}\left(\hat{S}_2\right) + S_2^2 \cdot \text{Var}\left(\hat{S}_1\right) + \text{Var}\left(\hat{S}_1\right) \cdot \widehat{\text{Var}}\left(\hat{S}_2\right)$$

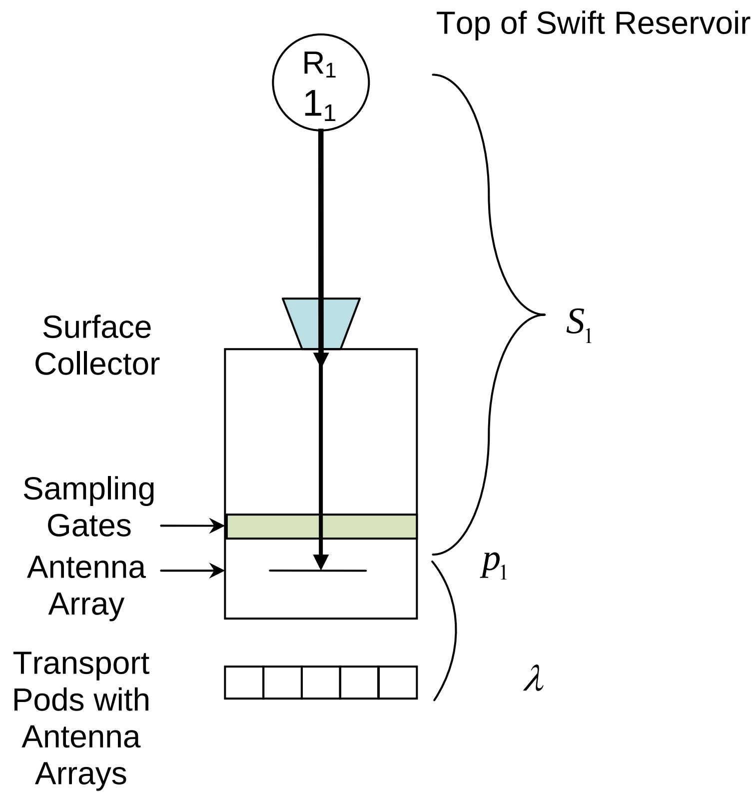
and estimated variance

$$\widehat{\text{Var}}\left(\hat{S}_1 \cdot \hat{S}_2\right) = \hat{S}_1^2 \cdot \widehat{\text{Var}}\left(\hat{S}_2\right) + \hat{S}_2^2 \cdot \widehat{\text{Var}}\left(\hat{S}_1\right) - \widehat{\text{Var}}\left(\hat{S}_1\right) \cdot \widehat{\text{Var}}\left(\hat{S}_2\right).$$

2.1. Estimating Survival through the Reservoir to the Surface Collector

Fish known to be active migrants will be collected in the surface collector and subsequently used in estimating project passage survival. Fish gathered from the surface collector, tagged, and transported back to the top of the Swift reservoir will be released to estimate reservoir survival and entry into the surface collector (S_1, Fig. 2.1).

Figure 2.1. Schematic of release-recapture design used in estimating survival through the reservoir and into the surface collector (S_1).



The single release-recapture model will be used to estimate the joint probability of surviving the reservoir and entering the surface collector to the point of the sampling gates. Two detection arrays, one in the collector just below the "point of no return" and another set in the collection pods will be used to generate the capture histories necessary to estimate the survival parameter S_1.

With 2 detection arrays, there are $2^2 = 4$ possible capture histories, and the following likelihood model:

$$L = \binom{R_1}{\underset{\sim}{n}} \left(S_1 p_1 \lambda_1\right)^{n_{11}} \left(S_1 p_1 \left(1-\lambda_1\right)\right)^{n_{10}} \left(S_1 \left(1-p_1\right)\lambda_1\right)^{n_{01}} \cdot \left(\left(1-S_1\right) + S_1\left(1-p_1\right)\left(1-\lambda_1\right)\right)^{R-n_{11}-n_{10}-n_{01}}, \tag{4}$$

where

R_1 = number of tagged fish released above Swift reservoir;
n_{ij} = number of fish with capture history *i* (0,1 detected or not at first array) and *j* (0,1 detected or not at second array);
S_1 = joint probability $S_{RES} \cdot P_{COL}$;
p_1 = probability of being detected at first collection array;
λ = joint probability of surviving between arrays 1 and 2 and being detected at second array.

Survival is then estimated by the quantity

$$\hat{S}_1 = \frac{\left(n_{10} + n_{11}\right)\left(n_{01} + n_{11}\right)}{R_1 n_{11}} \tag{5}$$

with associated variance

$$\text{Var}\left(\hat{S}_1\right) = S_1^2 \left[\frac{(1-\lambda)(1-p_1)^2}{R_1 \lambda S_1 p_1} + \frac{(1-\lambda)^2 p_1 (1-p_1)}{R_1 \lambda (1-\chi_1)} + \frac{\chi_1}{R_1 (1-\chi_1)}\right] \tag{6}$$

where

$$\chi_1 = \left(1-S_1\right) + S_1\left(1-p_1\right)\left(1-\lambda\right).$$

The other model parameters are estimated by

$$\hat{p}_1 = \frac{n_{11}}{n_{01} + n_{11}}, \tag{7}$$

$$\hat{\lambda} = \frac{n_{11}}{n_{10} + n_{11}}. \qquad (8)$$

Assumptions associated with the single release-recapture model include the following:

1. All fish act independently.

2. Release size is known without error.

3. There is no post-release handling mortality or tag loss.

4. Downstream detection is conditionally independent of detection upstream.

5. Tagged fish are uniquely identifiable at all detection sites.

2.2. Estimating Collector and Transport Survival

Survival through the surface collector and subsequent transport process to re-release will be estimated using a conceptual release group of fish that were known to have entered and were retained in the collector. Antenna at the sampling gate (Fig. 1) will identify fish known to have entered the collector (i.e., both alive and dead). These collected fish will then enter the transport system and eventually be transported to the recovery ponds prior to re-release. Two antenna arrays in the release channel will monitor fish as they exit the holding facilities (Fig. 2). All visual mortalities in the recovery pond will be collected to compare against known fish entering the transport system. A single release-recapture model analogous to Eq. (1) will be used to estimate smolt survival from the vicinity of the sampling gate to the release channel (Fig. 2.2).

To assure all dead tagged fish are properly identified and adjusted for in the statistical model, a known release of 50 dead tagged fish will be monitored through the system from the sampling gate to the antenna array in the release channel. If all known tagged fish are identified and recovered before the release channel, no adjustments to the release-recapture model would be necessary. If, on the other hand, some of the known dead tagged fish are detected at the recovery channel antenna, the likelihood model will need to be adjusted for the observed rate of false positives. In which case, the likelihood can be rewritten as follows:

$$L = \binom{R_2}{\underset{\sim}{m}} \left[\left(S_2 + (1 - S_2)(1 - p_d) \right) p_2 \lambda_2 \right]^{m_{11}}$$

$$\cdot \left[\left(S_2 + (1 - S_2)(1 - p_d) \right) p_2 (1 - \lambda_2) \right]^{m_{10}}$$

$$\cdot \left[\left(S_2 + (1 - S_2)(1 - p_d) \right) (1 - p_2) \lambda_2 \right]^{m_{01}}$$

$$\cdot \left[\left(S_2 + (1 - S_2)(1 - p_d) \right) \left(\lambda_2 + p_2 (1 - \lambda_2) \right) \right]^{R_2 - m_{11} - m_{10} - m_{01}}$$

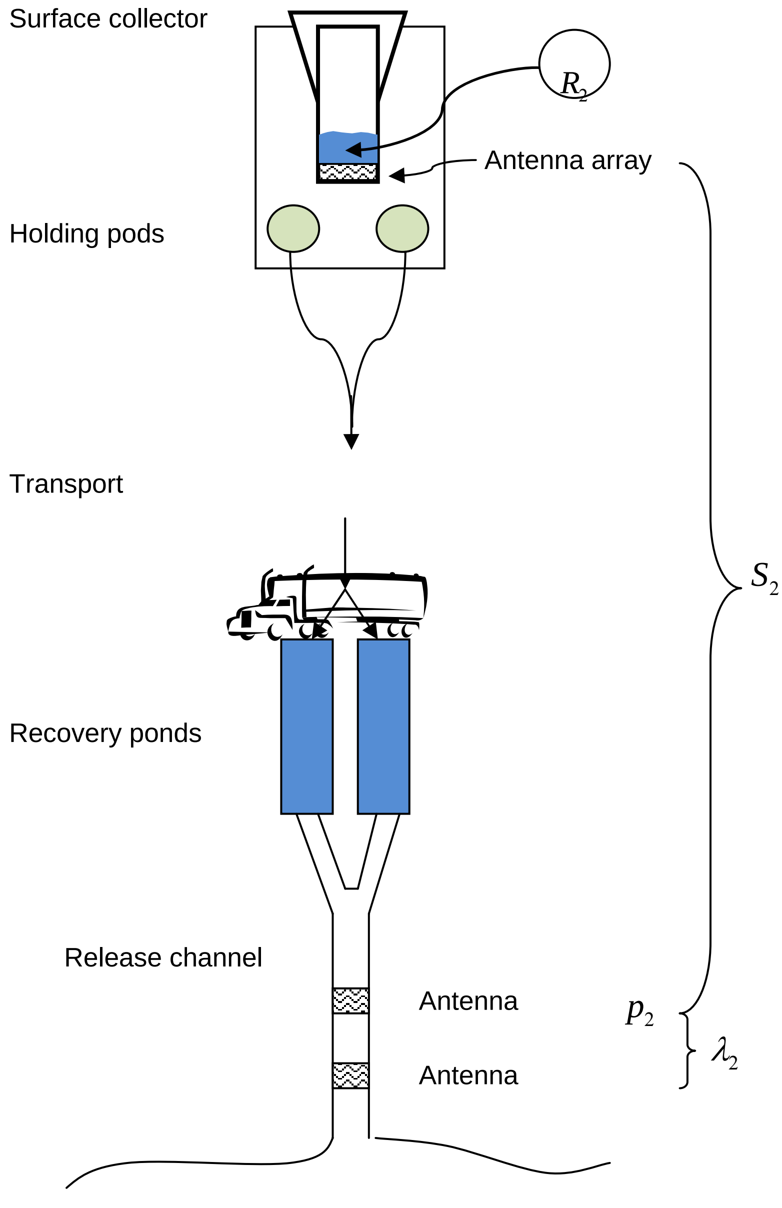
$$\cdot \binom{D}{d} (p_d)^d (1 - p_d)^{D-d}, \qquad (9)$$

where

D = number of dead tagged fish released into collector system,
d_2 = number of dead tagged fish retrieved before exiting recovery ponds,
p_d = probability a dead fish is recovered in the transport/handling facilities.

In a similar vein, a tag-life study will be performed to construct a tag-failure curve to adjust perceived survival rates (S_1 and S_2) for rates of tag failure during outmigration. This adjustment will be based on the methods in Townsend et al. (2006) to account for any negative bias due to tag failure during the course of the release-recapture study.

Figure 2.2. Schematic of release-recapture design used in estimating survival through collector, transport system, and recovery ponds (S_2). Release group (R_2) composed to tagged fish known to have arrived at the sampling gates in the surface collector.



2.3. Test of Seasonal Performance

Overall dam survival $\left(S_1 \cdot S_2\right)$ will be compared to a desired project goal of 0.80 or greater using an asymptotic Z-test of the form

$$Z = \frac{\hat{S}_1 \cdot \hat{S}_2 - 0.80}{\sqrt{\hat{\text{V}}\text{ar}\left(\hat{S}_1 \cdot \hat{S}_2\right)}},$$

testing the null hypotheses

$$\text{H}_\text{o}\text{:} S_1 S_2 \geq 0.80$$

vs.

$$\text{H}_\text{a}\text{:} S_1 S_2 < 0.80$$

(at an $\alpha = 0.10$)

Should the estimate of $S_1 S_2$ be significantly less than 0.80, H_o will be rejected, and it will be concluded survival goals have not been achieved. The estimate of $\hat{S}_1 \hat{S}_2$ will be based on pooling the release-recapture data over the season. Should weekly estimates of $\hat{S}_1 \hat{S}_2$ prove to be heterogeneous, then a weighted average, weighted by an index of smolt migration, will be used to construct an annual estimate.

2.4. Estimating Collector Efficiency

Two sets of antennas will be used to estimate collector efficiency $\left(P_{CE}\right)$ at the surface collector (Fig. 2.3).

The first antenna array will be in front of the collector, identifying tagged fish within the vicinity of the entrance. The second antenna array will be in the holding pods, assumed to have a 100% detection efficiency. Then the overall collector will be estimated by the fraction

$$\hat{P}_{CE} = \frac{a_2}{a_1} \qquad (10)$$

with associated variance estimator

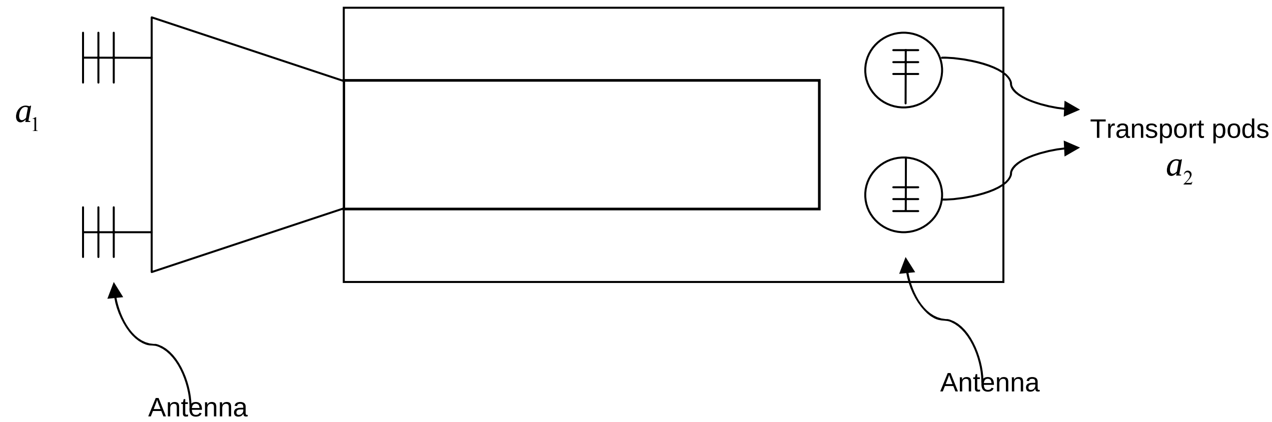
$$\hat{\text{V}}\text{ar}\left(\hat{P}_{CE}\right) = \frac{\hat{P}_{CE}\left(1 - \hat{P}_{CE}\right)}{a_1}, \quad (11)$$

where

a_1 = number of unique tagged fish identified in the vicinity of the surface collector,

a_2 = number of unique tagged fish identified in the fish collection pods.

Figure 2.3. Schematic of detection data used in estimating collector efficiency.



2.5. Release Schedule

Values of overall project survival and transport mortality might be expected to vary over the outmigration season due to changes in smoltification and ambient conditions. For these reasons, tag releases need to be distributed across the season in order to more accurately reflect intra-annual trends. Releases will be conducted weekly in order to represent average migrational conditions. Efforts will be coordinated to assure estimates of S_1 and S_2 will be paired over the same time frames in order to estimate overall project survival (i.e., $S_1 \cdot S_2$).

2.6. Sample Size Calculations

Using the single release-recapture model, sample size calculations were performed for precision defined as

$$P\left(\left|\hat{S}_1 - S_1\right| < \varepsilon\right) = 1 - \alpha ;$$

in other words, the absolute error in estimation $\left(\text{i.e.}\left|\hat{S}_1 - S_1\right|\right)$ being less than $\varepsilon, (1-\alpha)100\%$ of the time. For example,

$$P\left(\left|\hat{S}_1 - S_1\right| < 0.05\right) = 0.90 .$$

specifies that the absolute error in estimating *S* should be less than .05, 95% of the time. Here ε is equivalent to the half-width of a 90% confidence interval.

Required release sizes were calculated under alternative combinations of:

a. S_1 = 0.50, 0.60, 0.70, 0.80, 0.90

b. p_1 = 0.85, 0.90, 0.95, 0.98

c. $\lambda = 1$

d. ε = 0.05, 0.10

e. $1-\alpha$ = 0.90

Required release sizes are summarized in Table 1. For example, to be within ± 0.05 of the true survival value (S_1), 90% of the time when S_1 = 0.90, p_1 = 0.90, a total of 109 radio-tagged fish need to be released.

Table 1. Release sizes to estimate $S_1 = S_{RES} \cdot P_{COL}$ at the Swift reservoir for alternative values of survival and collection S_1, and detection probability (p_1) at the slide gates for a precision of ε = 0.05 or 0.10, $1-\alpha$ = 0.90 when λ = 1 at the holding pods.

		ε				ε	
S_1	p_1	0.05	0.10	S_1	p_1	0.05	0.10
0.50	0.85	285	72	0.80	0.85	197	51
	0.90	277	70		0.90	183	46
	0.95	272	69		0.95	176	44
	0.98	271	69		0.98	174	44
0.60	0.85	277	70	0.90	0.85	124	31
	0.90	267	67		0.90	109	28
	0.95	262	66		0.95	100	25
	0.98	261	65		0.98	98	25
0.70	0.85	248	62	0.95	0.85	79	20
	0.90	236	59		0.90	63	16
	0.95	230	58		0.95	55	14
	0.98	228	57		0.98	52	13

References

Townsend, R.L., Skalski, J.R., Dillingham, P., and Steig, T.W. 2006. Correcting bias in survival estimation resulting from tag failure in acoustic and radiotelemetry studies. Journal of Agricultural Biology and Environmental Statistics **11**(2): 183-196.

Appendix C

Ocean Recruits Analysis

There are three possible options for calculating Ocean Recruits for the H&S Plan:

1) Catch Plus Escapement (CPE)
2) Adult Equivalent Run Size (AER)
3) Age 2 Recruitment

The calculations used for completing each of the three analyses are performed as follows:

1. Catch plus escapement, $(C+E)_Y$, for brood year Y is computed as:

$(C+E)_Y = Xesc_Y + Xterm_Y + Xcol_Y + Xocean_Y$, where

$Xesc_Y, Xterm_Y, Xcol_Y, and\_Xocean_Y$ are brood year escapement, terminal, mainstem, and ocean harvest based on expanded CWT recoveries.

2. Adult equivalent return, $(AER)_Y$, for brood year Y is computed as:

$(AER)_Y = \sum_{age=1}^{NN} R_{Y,age}$, where

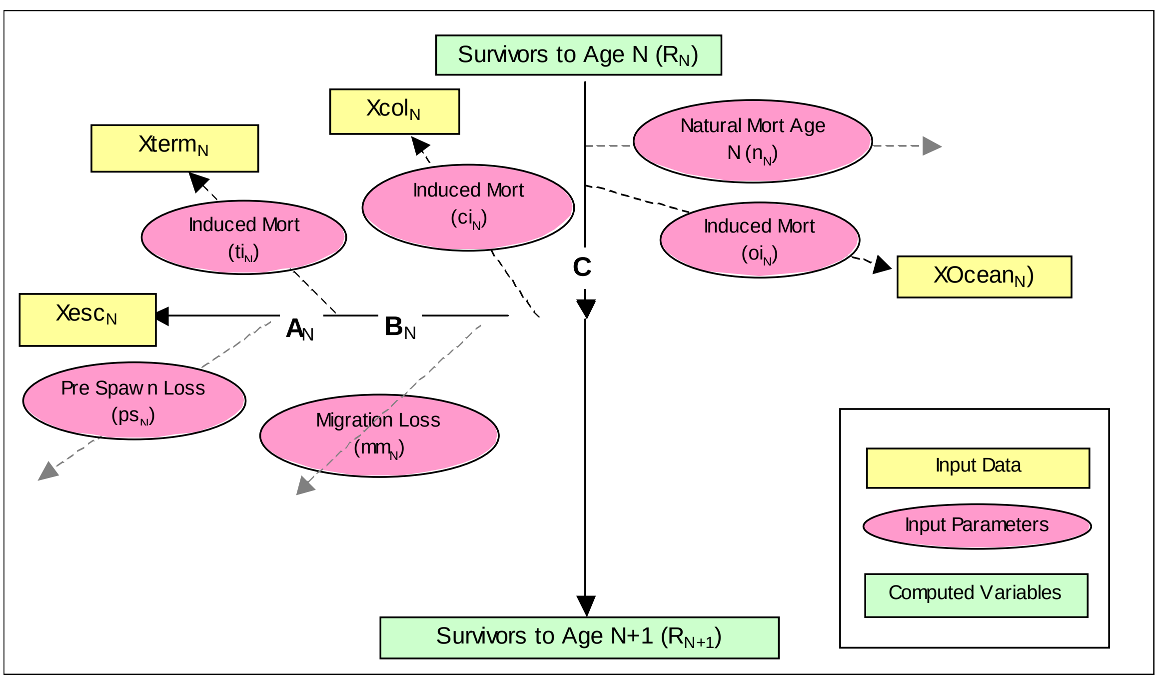
$R_N = C_N + Xocean_N(1+oi_N)(1-n_N)^{(na_N-1)}$, and

$C_N = R_{N+1} + B_N/(1-mm_N) + Xcol_N(1+ci_N)$, and

$B_N = A_N + Xterm_N(1+ti_N)$, and

$A_N = Xesc_N/(1-ps_N)$, and $R_{NN+1} = 0$

Symbols are defined in the chart below.



3. Age 2 recruitment, A2R, is computed as R_2 in AER equation above.

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