LEWIS RIVER FISH PLANNING DOCUMENT

Prepared for

PacifiCorp
and
Cowlitz PUD

April 2004

S. P. Cramer & Associates, Inc.
600 NW Fariss
Gresham, OR 97030
(503) 491-9577
www.spcramer.com

EXECUTIVE SUMMARY

The Fish Planning Document (FPD) is a culmination of several reports developed during 2002-2003 in conjunction with the collaborative re-license process for operation of Merwin, Yale, Swift 1, and Swift 2 hydroelectric facilities. This document reflects information and recommendations to assist in collaborative development of strategies regarding Lewis Basin fish management and reintroduction of fish populations in the upper Lewis Basin. A summary of key elements of these reports include:

- A conceptual foundation (Lichatowich, et al. 2003) provides the biological framework for fishery resource management strategies (Appendix G).
- The EDT model (Mobrand Biometrics, Inc. 2003) estimates historic (template), current (patient), and potential (PFC+) productivity of the Upper Lewis basin habitats. Estimates of both juvenile and adult production potential are made (Appendix E).
- The EDT data also displays miles of habitat and importance of specific habitat reaches for each species in the upper Lewis, lower Lewis, and East Fork Lewis.
- A Salmon PopCycle Model (SP Cramer 2002) was used to project future adult spawning populations above Swift, Yale, and Merwin dams.
- A comparison of Salmon PopCycle Model and the Lewis Fish Passage Assessment Model (LFPAM), which was developed by the ARG, showed little difference in results when the same life cycle mortality inputs were made.
- Three passage systems were compared for future anadromous production potential including; full volitional passage, trap and haul facilities at all dams, and trap and haul facilities to re-introduce fish above Swift Dam only.
- Steelhead and spring Chinook populations would be difficult to maintain at levels above significant risk in Yale and Merwin reservoirs, but coho populations could potentially be sustained at lower levels in these reservoirs.
- Salmon and steelhead populations introduced into Swift reservoir may be negatively affected by passage systems which include anadromous fish access to Yale and Merwin reservoirs.
- The Salmon PopCycle model is explained with instruction for use in Appendix B.
- The importance of passage, harvest, habitat, and supplementation limiting factors are addressed in a sensitivity analysis in Appendix C.
- A population goal of 86,000 adults was recommended and considered for management of an integrated Lewis River hatchery program and upper Lewis basin natural production program.

- A Lewis River Hatchery Review aimed at providing options to meet natural production objectives and provide for sustainable fisheries was completed (Appendix D)
- The Hatchery Review provides recommendations concerning species specific population goals, smolt production levels, harvest objectives, supplementation and reintroduction strategies, distribution plan for hatchery production, hatchery facility needs, monitoring and evaluation, and adaptive management plan.
- The Hatchery Review reflects current conceptual agreements regarding the hatchery and natural production programs.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LEWIS RIVER FISH PLANNING DOCUMENT (AQU 18) DEVELOPMENT OF FISH STUDY PLAN

BACKGROUND

At an Aquatic Resources Group (ARG) meeting on October 13, 2000, questions were raised that framed some of the issues related to fish management in the Lewis River basin.

At a follow-up meeting, the ARG conducted an analysis of fish management policy documents that were relevant to the Lewis River and determined that there was a need to analyze the implications of the sometimes overlapping policies. From that it was suggested that the ARG might want to produce a "guidance document" that would be used to develop a fish management plan for the Lewis River. This issue was raised again at the June 6, 2002, ARG meeting where the group requested that the utilities either fund the Washington Department of Fish and Wildlife (WDFW) and the Tribes to develop a fish management plan for the Lewis River or fund development of a Guidance Document that would: 1) address the issue of historic anadromous fish run sizes; 2) review the relicensing studies and any previous fisheries information available for the Lewis River basin and determine what, if any, data gaps remain. (Those data gaps should be addressed from the perspective of information needed to make settlement decisions or information that may be needed but not in the context of relicensing); and; 3) suggest elements that would be needed to develop a fish planning document for the basin. In addition, the ARG requested that this document address project effects as they relate to the aquatic resources in the Lewis River basin.

Jim Lichatowich, an independent fisheries consultant was contacted to develop a study plan to address these issues and to help develop a document that would provide the foundation for a Lewis River Fish Planning Document. Mr. Lichatowich suggested that, with the help of Mr. George Gilmour, he could take a conceptual foundation approach to address this issue. It is included in Appendix G.

A conceptual foundation is a scientific description of a biological system's structure and function. In this case, the "system" is the Lewis River and its fish populations. Structure refers to the physical habitat for fish in the Lewis River. Function refers to the ecological relationships and processes that lead to the production of fish. The conceptual foundation is a set of scientific theories, principles, and assumptions that are derived from a synthesis of existing information. The foundation determines how information is interpreted, what questions are relevant, and the range of management alternatives that are appropriate. Every management, mitigation, or restoration program is based on a conceptual foundation, however, in most cases the foundation is implied, not explicitly stated. Conflicts often arise over the interpretation of data or the choice of management alternatives that are, at their roots, conflicts between unstated and contradictory conceptual foundations. Those conflicts can remain intractable as long as the underlying frameworks from institutional policies remain hidden from view and not subject to evaluation.

Any attempt to identify, evaluate and implement research, management, or restoration alternatives must start with an explicitly stated foundation which will be based upon various guidance documents, as well as consultation with stakeholders. Where possible, the foundation should be a consensus statement among the parties. Legitimate alternative frameworks are a reality; however, in a debate over management and research issues it is critical that all the frameworks, if there is more than one, be explicitly stated.

The overall objective of this study is to develop a fish planning document that would provide and analyze alternatives for managing future fish populations and their habitats as well as hatchery facilities and operations under the new licenses in order to guide Settlement Agreement negotiations.

In assembling potential reintroduction and fish planning alternatives for fish of the Lewis River consultations should be given to 14 questions and responses from participating parties (See Appendix A). The purpose of this work is to:

1) Assemble fish population, habitat, and hatchery information for analytical purposes; estimate historical and current habitat condition, carrying capacity, fish life history diversity, and productivity for diagnostic species: spring/fall Chinook, coho, chum, summer/winter steelhead, and bull trout;
2) Analyze alternatives to use artificial propagation to recover and conserve naturally spawning populations of fish and support sustainable fisheries;
3) Identify critical uncertainties;
4) Document monitoring and evaluation needs identified by the Ecosystem Diagnostics and Treatment (EDT) and hatchery review processes;
5) Determine what policies and plans influence actions that can be taken in the basin relative to fish management, and;
6) Develop a Fish Planning document

The information synthesized in the final report is intended to help guide any fish planning-related decisions that are made in the course of negotiating new license conditions for the Lewis River projects.

The steps in developing a Fish Planning Document for the Lewis River basin are described as follows:

PHASE 1

Task I Review the published and unpublished information and studies conducted on the fish and aquatic habitat of the Lewis River. Incorporate information from the general literature and other river systems where appropriate. Review the relevant policies, statutes (i.e., laws, acts, etc., that provide the basis for development of policies, Forest Plans, etc.) and agreements that may constrain the choice of management alternatives as gathered by the ARG.

Task II Write a draft Conceptual Foundation document for distribution and review. The document will contain five major sections:

1) General background on the Lewis River, its aquatic habitat, and its fish populations.
2) Hypothesized description of historical structure and function of the fish populations and aquatic habitat (including inundated mainstem) in the Lewis River basin.
3) Description of the present day structure and function of fish populations and their aquatic habitat in the Lewis River basin.
4) Description of the legal and policy constraints on management and reintroduction alternatives.
5) Complete identification of hydro project effects on aquatic resources in the Lewis River.
6) Review the relicensing studies and any previous fisheries information available for the Lewis River basin and determine what, if any, data gaps remain.

PHASE 2

The information from the Conceptual Foundation document and other sources will be used to complete a Fish Planning document for the Lewis River Basin.

Task 1 Mobrand Biometrics, Inc. (MBI) will modify the EDT model previously developed for the Cowlitz River for use on the Lewis River and populate it with Lewis River data for diagnostic species: spring/fall Chinook, coho, chum, summer/winter steelhead, and bull trout. The Consultant will then use EDT to evaluate those alternatives.

Products: Use the EDT model to analyze alternatives, recommended to by the Negotiating Team Sub-Group for use in the Fish Planning Document. Anticipated information provided through the EDT model includes: Fish assemblage populations relative to available aquatic habitat and its condition; Aquatic habitat conditions and quality as it applies to specific fish life history stages, such as, rearing habitat for juvenile coho salmon; and, protection and restoration recommendations based on existing habitat conditions.

Based upon the EDT results the consultants would generate these supporting products:

Description of critical uncertainties.

Identification of need for monitoring and evaluation to support management of critical uncertainties and risks.

Task 2 Assimilate information from the Lewis River Hatchery Complex Evaluation and the Lower Columbia River Hatchery Scientific Review Group (HSRG) process. The Negotiating Group will seek to have Lewis River placed at a higher priority in the Lower Columbia HSRG.

The subgroup, designated by the Negotiating Group, will evaluate the preliminary alternatives for hatchery production funded by the Licensees to meet license responsibilities and make recommendations to the Consultant for inclusion in the fish planning document.

Product: Consultant will use Columbia River HSRG results or other appropriate evaluation tools to identify methodologies, facilities, and programs to support natural production objectives and provide for sustainable fisheries.

Task 3 The Consultant will develop a “Lewis River Fish Planning Document”.

Information from the Tasks 1 and 2 will be utilized to develop a Fish Planning Document. The Consultant will be responsible for drafting the document cooperatively with WDFW, the Tribes and other management agencies. If and where the need exists, these participants will be funded by the Licensees for this specific task. This work will utilize the EDT model to evaluate Lewis River fish life history diversity, productivity (which requires good knowledge of aquatic habitat conditions), and capacity. The Fish Planning Document will contain the following elements:

Identify basin fish population goals for species identified by the Negotiating Group;

Potential habitat restoration needs that support healthy populations of anadromous and resident fish;

Potential supplementation strategies as identified in Task 2;

Hatchery production needs for sustainable fisheries as identified in Task 2;

Critical uncertainties and risks, performance criteria for fish passage facilities, and;

Document monitoring and evaluation needs identified by the EDT and the hatchery review processes described in Phase II, Task 2.

- **Product: Develop a comprehensive "Fish Planning Document" through consultation with the Negotiating Group.**

- **Contingency**

If, at any point, time-sensitive sub-products of this study have not reached the identified targets, the Negotiating Group will evaluate the progress, and, if timely completion is not perceived, identify alternative approaches. The Negotiating Group should be kept apprised of AQU-18 progress on a weekly basis to ensure the success of this effort.

Sub-Product Tracking

Several products connected to the Lewis River fish planning process were developed between December 2002 and November 2003. These documents were constructed by consultants in a collaborative effort involving ARG members and with periodic policy direction from the Negotiating Group. The sub-product list is as follows:

December, 2002	• Draft Conceptual Foundation completed (Lichatowich, Gilmour, Dubé) • Draft Alternatives (Mediation Team) • Preliminary EDT analysis completed. (Malone, Mobrand)
January, 2003	• Fish Planning Document 1st draft. (Norman, Cramer)
February 2003	• Fish Planning Document Second Draft (Norman, Cramer)
March 2003	• EDT updated (Malone)
April 2003	• Comparison of LFPAM and Salmon PopCycle models (Beamesderfer) • Lewis River Population Goals (Norman, Rawding, AQU 18) • AQU 18 Work Group population goal presentation (AQU 18)
May 2003	• Negotiating Group direction for adult production goal
June 2003	• Lewis River Run Reconstruction Methods (Norman) • Conceptual Foundation Draft (Lichatowich, Gilmour, Dubé)
August 2003	• Hatchery Review First Draft (Norman, Underwood, Daigneault) • AQU 18 review of Hatchery Review
September 2003	• Draft Summary of FPD and Hatchery Review (Norman, Underwood) • AQU 18 review of Summary
October 2003	• Summary of key fish planning and hatchery review issues (Norman) • AQU 18 review of summary • Power point presentation of key fish planning issues to the Negotiating Group (Norman)
November 2003	• Status of fish planning issues- list of conceptual agreements and issues needing further discussion (Norman)
January 2004	• Final EDT report (Malone)
March 2004	• FPD and Hatchery Review Document final review drafts submitted (Norman)
April 2004	• Final fish planning and hatchery review documents submitted (Norman)

INTRODUCTION

The Lewis River Fish Planning Document (FPD) is intended to serve as a biological guide for formulating decisions on Project actions to manage anadromous and resident fish resources of the Lewis River basin. The FPD document focuses on biological considerations associated with salmonid reintroduction alternatives. The Hatchery Review (Appendix D) describes alternatives and makes recommendations which integrate hatchery and natural production objectives. The FPD document will describe technical methods used, identify critical uncertainties, and display an example of an adaptive management framework to aid in selecting among alternatives and the specific actions that compose them. There is an emphasis on biological measurements and population response initially, but the document expands to include other fish management elements which were addressed after completion of supporting tasks and additional input from the Negotiating Group, most notably comments on sub-group recommended adult population goals and a hatchery review.

The guidance provided in this document builds from the Conceptual Foundation for Management of the Lewis River Salmonid Populations established by Lichatowich, et al. (2003) (Appendix G). A primary consideration in adopting a Lewis River Fish Management Plan is integration of wild and hatchery management practices including reintroduction and supplementation of anadromous fish. However, as represented in the Conceptual Framework, managers must consider the loss of ecosystem connectivity associated with the construction of three dams that convert 39 miles of river into reservoirs. Managers should recognize that some historical pre-dam life histories are not likely to be restored, new life histories may now be supportable, and the ability to understand unique life histories suited to altered conditions through adaptive management is critical to the success of restoration efforts. Current habitat production potential, fish passage uncertainties, affect on existing wild populations, affect on current hatchery production, and affect on harvest are key elements to consider when making implementation choices.

Expected results and the standards for judging future progress toward objectives will be developed primarily from two analytical tools known as Ecosystem Diagnostic and Treatment (EDT) (Appendix E) and Salmon PopCycle (Appendix B). The differences in potential fish populations that could be supported by opening access to new habitat or improving quality of habitat will be gauged using the EDT model (Mobrand Biometrics, Inc. 2003), which connects fish production to habitat. The Salmon PopCycle model (Beamesderfer 2000; Cramer and Beamesderfer 2001) will be fitted to population parameters for the Lewis River, and employed to forecast population response to variable supplementation and life cycle survival rates, including fish collection efficiency, fish passage, adult trapping efficiency, and harvest. These projections of population response will be used in the adaptive management plan to determine when the results of project actions are deviating from expectations. The EDT results are contained in a report by Mobrand Biometrics, Inc. (2003), and the Salmon PopCycle model function, use, and critical assumptions are explained in detail in Appendix A of this document.

An adaptive management framework example displays a 1-5 year study phase, a 6-10 year initial implementation phase, and a 11-40 year long term monitoring and adjustment phase.

DESCRIPTION OF ALTERNATIVES

The Lewis River relicensing negotiation team sub-group discussed alternatives for addressing Lewis River anadromous and resident fish production. As a starting point, the mediation team developed six passage alternatives with the final alternative (F) expected to represent an agreed alternative at the end of the settlement process. For each alternative, they described general strategies, but many of the specific details for their implementation are left to be selected through the adaptive management process described in this report. The draft alternatives are:

A. No action/ status quo
B. Wild fish access to habitat above Swift Dam only
C. Full basin wild fish access with trap and haul
D. Full basin wild fish access with volitional passage
E. Analysis of dam removal
F. Agreed alternative

These alternatives were developed as “strawdogs” to represent a range of actions from the least to most action that could be expected. This wide range of actions was intended to provide the bases for use in a future Environmental Assessment document. The elements of the alternatives were not intended to be aligned exclusively with a particular alternative, and it was expected that discussions concerning a “blend” of elements in a preferred alternative would continue.

This document will compare elements of alternatives B, C, and D and describe the sequence of information gathering and decision making needed to choose specific actions for final implementation. There are eight components shared by all alternatives that relate to reintroduction of migratory trout and salmon. Those shared components are:

- Anadromous fish upstream passage
- Anadromous fish downstream passage
- Resident fish upstream passage
- Resident fish downstream passage
- Hatchery management
- Flow management
- Habitat enhancement
- Water Quality

Although the alternatives do not specify options for harvest management, the outcome of each alternative will be influenced by harvest management. The document will display effects of harvest rates on natural production, and the potential effects of natural production on catch.

We focus our discussion in this report on Alternatives B, C, and D (Table 1). Alternative B provides the passage alternative focused on restoration of anadromous fish to the upper basin above Swift Reservoir, and includes habitat and hatchery actions to mitigate for no reintroduction in the Yale and Merwin reservoirs. Alternative C provides fish passage at each project by the trap and haul method. Alternative D provides volitional passage at all projects with construction of ladders and bypass systems at each dam.

There were three broad basin goals that were derived from a set of fourteen questions asked of the ARG (Appendix A) that would require fish passage facilities to achieve:

1. **Reconnect fish habitat and fish populations in the basin**
2. **Reintroduce anadromous salmon in the upper basin**
3. **Protect and enhance bull trout populations**

Table 1. Summary of Lewis Alternatives B, C, D.

		B	C	D
Passage	**Juvenile**	Collection at Swift only	Collection at all dams	Volitional & collection at all dams
	Adult	Trap and haul, Merwin to Swift	Trap and haul, all dams	Ladders & trap, all dams
Hatchery	**Supp.**	Long term w/Acc.	Initial kick start	10 years
	Modify	Expand production	Reduce over time	Discontinue after construction complete
	Emulation	Natural rearing	NA	NA
Flow	**Swift Reach**	Resident fish access	Anadromous fish access	Aesthetic level
	Below Merwin	Evaluate appropriate flow	Current flow	Current flow
Offsite		Enhancement funds established	Enhance Cedar Cr.	Enhance Cedar Cr., E.F. Lewis
Speelyai		Open lower end for Bull trout	Eliminate upper & lower diversions	Restore diversion to original purpose
Water Quality		Monitor for state standards	Monitor for state standards	Monitor for state standards
Flood Control		Maintain storage-improves notification	Maintain storage-improves notification	Increase storage-improves notification

Alternatives Overview

Adult Passage

ALT B. Trap and haul at Merwin to above Swift only- Adult trap efficiency would need to be optimized at Merwin trap for attraction of returning adults and for handling procedures that minimize stress. Trap efficiency can be optimized by careful design (ONA1995) and controlled flow.

ALT C. Trap and haul at Merwin, Yale, and Swift- Adult trap efficiency must be optimized at three sites. Fish would voluntarily sort in the reservoirs and upper basin fish would have to be inclined to enter multiple traps, with Swift destined fish trapped and trucked three times. Additional handling mortality and delays or reduced effectiveness of trapping may occur in fish expected to be trapped multiple times.

ALT D. Construct ladders at Merwin, Yale, and Swift- This option would provide volitional passage of fish up and down the river and connect the upper and lower basin. Ladder attraction and passage survival would need to be monitored. Free movement of bull trout would need to be monitored as part of this full access scenario.

Passage survival for adults would include a combination of ladder attraction rates, ladder survival, and reservoir survival. NMFS (2000) reports adults passing through Columbia projects at 96-98 percent. The *U.S. v. Oregon* Technical Advisory Committee (TAC) uses 95% as a standard adult ladder passage survival for Columbia River dams (TAC chair, personal communication 2003). Adult dam passage through ladders at the Lewis projects may be less successful than Columbia and Snake dam passage due to the high elevation of the Lewis dams. Ladder rise would approximate 200 ft. at Merwin, 250 ft. at Yale, and 500 ft. at Swift. Some level of straying to lower reservoirs and the lower basin should be expected.

Downstream Passage

ALT B. Construct a collection facility at Swift Dam only- Fish guidance efficiency (FGE) is a key to success. As reintroduced anadromous juveniles present themselves to the head of the dam, guiding them to a collecting mechanism at a high rate is critical. The FGE will need to be studied to determine if additional steps to improve collection and transport are necessary. For example, determine if surface collectors are adequate or if more elaborate screening options need to be considered. A life cycle model (defined later) will interpret the collection efficiency importance to establishing a viable natural population. NWESC (2000b) reports a range of 0.43-0.96 for fish guidance efficiency in Columbia and Snake systems using submersed screens. Fish not guided to a collection system would be subjected to entrainment and passage through the turbines. Eicher Associates (1987) reports wide ranges of survival of juveniles through Francis turbines, with the average approximately 75 percent.

ALT C. Construct a collection facility at Swift, Merwin, and Yale dams- Same considerations and monitoring as Alternative B. Juveniles from the upper two reservoirs which are not collected at the upper dam, and survive the turbines and the next reservoir, would have another opportunity to be collected at the facility at the next downstream dam.

ALT D. Construct full screens and collection capabilities at Merwin, Yale, and Swift- This option would assume to accomplish the highest collection and lowest entrainment rates. Biological response projections will illustrate potential increase in production compared to other collection options. This option may be limited to places where water levels in the reservoir are relatively constant (OTA 1995).

Resident Fish

ALT B. Develop the capability to trap bull trout and resident fish adults below Merwin and Yale dams. Repair Yale spillway to improve downstream passage survival. Reduce potential entrainment of Yale reservoir bull trout.

Hatchery Program

ALT B. Hatchery modernization and expansion- This option calls for substantial investment in the hatchery program to include conversion to long-term supplementation of the upper watershed, natural rearing modifications, and possible consideration of satellite acclimation facilities above Swift. Additionally, the hatchery program aimed at harvest mitigation would be expanded to increase steelhead and spring Chinook harvest by 15 percent and maintain the current coho harvest. This option would require monitoring efforts to assess hatchery rearing and release strategies relative to natural spawning and harvest goals. Criteria would need to be established to prioritize (harvest vs. supplementation) particularly during low ocean survival periods. This option would be detailed in a hatchery review document and the magnitude of change could be assessed relative to mitigation requirements.

ALT C. Gradual reduction in hatchery program- This option would involve monitoring of wild production rebuilding progress with an objective to gradually replace the need for current levels of hatchery production.

Hatchery reductions would fall under two categories: 1) reduction in base program of harvestable fish and 2) reduction in supplementation program. Criteria should be established to trigger specific hatchery production reduction levels. A response to reduce hatchery production would have to be in response to a very successful reintroduction program that has established a trend of significant and stable natural production. This response would be directly connected to the aggregate mitigation responsibility as defined by species-specific population goals. Decision makers should be aware of harvest trade-offs if hatchery release reductions are considered, especially if naturally produced fish are not at harvestable levels to compensate. An egg bank hatchery program to reduce risk during a low ocean survival period or to plan for a catastrophic event may be considered. The management criteria could be further explored in the hatchery review process.

ALT D. Supplement for 10 years until construction complete then cease hatchery production- Expected biological criteria would be for a wild population to be recovered to historic levels before hatchery production would be discontinued. The planning document would model the expectations for natural production and decision makers would take into consideration the complete loss of harvest of Lewis Basin fish unless the natural production became harvestable. This option could also be considered similar to Alternative C with a gradual reduction in the hatchery program, dependent on natural productivity This option is the most extreme hatchery reduction option and is likely not realistic in terms of meeting mitigation levels for salmon populations.

Flows

Flow considerations in the three alternatives are primarily associated with below Merwin and the Swift bypass reach. Alternative C calls for anadromous rearing flows in the Swift bypass reach. Bull trout access to Rain and Ole creeks are also provided in this Alternative. Below Merwin flow levels remain at current license minimum levels under Alternatives C and D (subject to further evaluation) and variable flow levels are evaluated under Alternative B. Potential trade offs in flow operations for enhancement of reintroduced species and the existing wild fall Chinook population below Merwin should be considered. Current flow agreements may be reviewed during this relicensing process. With respect to the Swift bypass reach, consideration for bull trout access is the primary focus under Alternative B as anadromous fish are restricted to the above Swift dam area. The importance of the reach to the Yale bull trout population is the key element of this flow issue.

Offsite Enhancements

We define offsite enhancement as natural production enhancement in areas other than above the Lewis projects where reintroduction may occur. The Alternatives address offsite enhancement potential options for the East Fork Lewis and for Cedar Creek. These options should be evaluated, in particular for chum enhancement. The lower Speelyai Creek water diversion is another area addressed in the alternatives, and becomes an offsite consideration if reintroduction is not implemented in the lower reservoirs. The options identified for Speelyai Creek range from opening the lower end for bull trout to completely eliminating diversions resulting in Speelyai hatchery needing a new water source. Offsite mitigation can be linked to the success expected from upper basin reintroduction of anadromous fish. For example, below Merwin Dam enhancement options could be expanded in area and species in response to poor results in upper basin reintroduction efforts, or in lieu of reintroduction to areas where success is projected to be poor. Offsite enhancement is linked to the Adaptive Management Plan in the Hatchery Review.

Biological Considerations

Choices among alternatives will relate to the managers' concept of how the system is capable of operating to produce fish. A conceptual foundation was developed by Lichatowich et al. (2003) (Appendix G), and recommendations from that foundation are applied to the FPD. We present a synopsis of those recommendations, a list of key considerations in developing a FPD and a brief discussion.

1) Non-fragmented ecosystem perspective:

Key considerations:

- **Native species and natural production is highest priority**
- **Supplementation strategies need to be sensitized to species interactions**
- **Release strategies geared to minimize effect on existing wild production**
- **Bull trout habitat needs to be reconnected**

Discussion: Selection of species, areas, numbers, and life stage for supplementation should take into account interactions with bull trout populations and interaction between salmonid species introduced. Managers should consider variable effects based on different life cycle stages for introduction i.e. adults, smolts, or sub-yearlings. Supplementation and release strategies should be developed with enough understanding to provide reasonable assurance of minimal effect on lower river wild fall Chinook production and bull trout in the upper basin. The inter-specific species interaction issue will be considered in the hatchery review. There should be consideration for passage of bull trout between Yale and Swift reservoirs as part of the ecosystem connectivity objectives.

2) Monitor and research to provide life history-habitat relationships:

Key considerations:

- **Monitor production levels at freshwater life stages to test EDT analysis**
- **Monitor importance of reservoir rearing**
- **Monitor out migrant life stages**
- **Monitor for change in established bull trout or wild fall Chinook populations**

Discussion: Research studies should be focused on understanding life history relationships of adults spawning, progeny rearing in natal streams, smolts passing through the Lewis River migration corridor, and returning adults. Monitoring should include the ability to understand differences in anadromous production from various release strategies, measure changes in established resident fish populations, understand the emigration status of fish collected at the dam, measure effects of various lower river release strategies on lower river natural salmonid populations, and determine homing capabilities of returning adults. Studies should compare survival of salmonids released at the Lewis Basin hatcheries with those reintroduced in the wild to guide adaptive strategy as part of an integrated program. The information gathering process will require a strategic marking program. Results of these studies are intended to address biological uncertainties and provide the basis for adaptive changes to management strategies. The details of these studies should be identified as part of the hatchery review process.

3) Revise management objectives:

Key considerations:

- **Incorporate natural production objectives as high priority**
- **Adjust hatchery objectives to be consistent with natural objectives**
- **Establish periodic review schedule to adapt management to new information**

Discussion: Clear objectives need to be established for management of natural production as well as the Lewis basin hatcheries in order to clearly set the bar for success and understand if actions are contributing towards success. The goals for integration of the hatchery programs with natural production goals need to be clearly established with criteria for actions clearly stated. Production goals for the basin need to be established as a base to set objectives. This consideration will be closely linked to the hatchery review document.

4) Integrate artificial and natural production:

Key Considerations:

- **Monitor abundance of naturally produced fish**
- **Establish criteria to modify hatchery production corresponding to natural production success level**
- **Recognize reduced hatchery program effect on harvest**
- **Establish local broodstock and include wild fish annually**
- **Determine priority scheme for supplementation**

Discussion: Monitoring the level of success of reintroduced natural production will be critical in deciding if modifying hatchery production in the future is sensible. In the absolute sense, the more success measured in the natural production efforts the less need for hatchery produced fish. However, a decision to reduce hatchery production can only be made with information that clearly represents sustained natural production as a viable replacement alternative relative to the aggregate population goals. There are additional factors to consider such as mitigation for harvest. If hatchery production is reduced before natural production is considered harvestable, the result would be reduced harvest opportunity in fisheries that are regulated to retain marked hatchery fish only. There are other hatchery operation modifications to consider besides numbers produced for harvest, including development of local adapted broodstock, natural rearing conditions, altered release strategies, and the need to expand facilities to meet the objectives of a fully integrated system.

These changes to hatchery operations would be aimed at enhancing the natural production effort, reducing risks of predation and competition, assuring the genetic fitness of the naturally produced salmonids, and maintaining harvest opportunity on Lewis fish resources. Future broodstock collection practices could include integration of adults produced naturally with hatchery produced adults. A formula to determine the number of naturally produced adults to include in hatchery broodstock would take into account the annual number of natural spawners returning. Similarly, the annual hatchery supplementation level should be dependent on the expectations for natural returns relative to a natural spawning objective, but should also take into consideration the number of hatchery fish available relative to the hatchery mitigation goal. Criteria should be developed to select hatchery release broodstock vs. supplementation broodstock in years when there may not be enough fish for both programs. There should also be criteria set for mixing naturally produced fish with hatchery broodstock to maintain genetic similarity and fitness between the two in order to establish flexibility in use of the stocks. A hatchery egg bank option may be valid in some circumstances to assure perpetuation of the adapted stock, especially during periods of low ocean survival. Again, decisions that reduce the hatchery level below goal must also recognize there will be a corresponding reduction in future harvest opportunity. These options will be further considered in the hatchery review document.

5) Moving ecosystem attributes closer to historical; consider existing cultural systems:

Key Considerations:

- **Cultural systems will be effected by natural production enhancement**
- **Planning document will assist decision makers by projecting biological benefits.**
- **Resident fish fisheries (i.e. kokanee)**

Discussion: Biological goals need to be realistic in terms of understanding the degree in which actions effect change on existing cultural systems. An objective to restore habitat to pristine condition is not realistic unless major reductions to human benefits associated with the Lewis basin are employed. Use of existing habitat capability above Swift Reservoir with a dedicated effort to move smolts to the ocean and adults back to the spawning grounds still may have significant effect on cultural systems; primarily land use, dam operation, harvest, and hatchery practices, and existing fish population and other recreational uses. Any expansion of production goals beyond this will result in additional effect on cultural systems, including flow enhancement to Swift Reach, flow to Lower Speelyai Creek, and introduction of anadromous fish to Yale and Merwin reservoirs. There will also be biological and cultural trade offs to exercising off site mitigation in lieu of full access to habitat above Merwin Dam, e.g. East Fork Lewis chum restoration. A key concern of fishery managers and some stakeholders is the effect some reintroduction strategies may have on existing fishery opportunities that have been established in response to the impounded condition of the upper basin. In particular there is concern of potential effects to the unique kokanee sport fishery which has been maintained with a sustained naturally produced stock, primarily in Yale Reservoir. There is also concern regarding salmon and steelhead fishing opportunity which has been enhanced by hatchery production for many years and has adjusted to selective regulations to comply with ESA and state conservation policies. The planning document will not judge cultural costs but will attempt to illustrate the biological benefits associated with various restoration alternatives to aid decision makers in weighing biological benefits and cultural costs.

Table 2. The average number of salmon and steelhead harvested in the Lewis River recreation fishery based on punch card returns to WDFW (Lichatowich et al. 2003) (Appendix G).

Species / Stock	Ave. Annual Recreation Harvest	Data Range
Spring Chinook	4300	1980-1998
Fall Chinook	1400	1980-1998
Coho	3500	1980-1998
Winter Steelhead	3400	1980-1998
Summer Steelhead	3600	1980-1998

6) Reintroduce salmonid stocks best suited to attributes of the ecosystem:

Key Considerations:

- **Reintroduction in upper Lewis should focus on current hatchery spring Chinook stock, early stock coho, and winter steelhead (Lichatowich)**
- **Hatchery influence phased out over time if reintroduction is successful**
- **Chum salmon enhancement in lower Lewis, and /or Cedar Creek**
- **Fall Chinook enhancement focused downstream of Merwin Dam**

Discussion: Spring Chinook could become the focal species in which to gauge success in reintroduction efforts. Historically, lower Columbia spring Chinook production areas in Washington were almost entirely limited to the upper Lewis and Cowlitz systems for spring Chinook, while steelhead, cutthroat, fall Chinook, and coho populations were present in many lower Columbia subbasins. NOAA Fisheries concludes the spring Chinook component of the lower Columbia Chinook Evolutionarily Significant Unit (ESU) is currently contained in the hatcheries (NMFS status review, 1998) and identifies reintroduction efforts as an important element of ESA recovery. The vast majority of habitat for spring Chinook in Washington lower Columbia basins is located above the dams in the upper Lewis and the upper Cowlitz basins. This strategy includes initial supplementation with stocks that best fit the attributes of the fish which were historically supported by the ecosystem and should consider availability of suitable hatchery fish. In the upper Lewis, coho stock selection would be explored in the hatchery review process. It is expected that the current Lewis hatchery coho stock would be used, but there are questions with regard to use of early or late stock or both. Spring Chinook supplementation would likely be initiated with the current Lewis Hatchery stock. Hatchery influence would ideally be phased out over time to capture the adaptive traits reinforced through the natural selection processes. Fall Chinook would probably not be considered for reintroduction, as historical habitat for fall Chinook was primarily in the mainstem Lewis half of which is now inundated by reservoirs. Fall Chinook have maintained a healthy population below the dams and the lower river production is currently enhanced through flow mitigation for rearing and for spawning. Lewis River wild winter steelhead would likely be selected for reintroduction as historic production in the upper basin was primarily winter fish. An alternative option for steelhead brood stock could be adults collected from the wild winter steelhead population in the Kalama River. Chum enhancement would be implemented through efforts to restore conditions in East Fork Lewis, lower North Lewis, or Cedar Creek. Cutthroat trout would not likely be a priority for reintroduction but would benefit from enhancement efforts below the dams. Resident cutthroat would benefit from habitat enhancements above and below the dams. These considerations will be developed in the hatchery review document.

7) Monitor upper basin to detect emergence of unique life histories after reintroduction:

Key considerations:

- **Monitor for migration timing to develop juvenile and adult collection strategies**
- **Recognize development of unexpected traits and adjust management strategies to fit**
- **Adapt hatchery strategies to react to changes in wild fish behavior**
- **Monitor habitat conditions to compare life history strategies to habitat conditions**

Discussion: This information will provide the basis for determining if stocks selected are productive, the level of supplementation that should be implemented over time, and adaptive collection and release strategies. As unique traits are developed the hatchery influence can have negative effects on traits critical for success. Also, the hatchery's unique traits, such as time of emergence or migratory behavior, will influence strategies used for passage through the system. For example, monitoring can determine the extent of utilization of the reservoirs for rearing juveniles or changes in migration behavior as a result of the current conditions in the basin. For example, spring Chinook would be expected to migrate in the spring as 1+ year smolts, but there actually could be a significant percentage of the juveniles that begin migration and are collected as younger and smaller fish in the fall. Managers would need to be prepared to consider adjusting operations to collect Chinook in the fall and then determine if they would be released for presumed extended rearing in the lower river. Further details of these kinds of scenarios could be incorporated in the hatchery review.

8) Manage fisheries resources to take into account fluctuations in Ocean productivity:

Key considerations:

Hatcheries- Hatchery program should be periodically evaluated to assess productivity relative to hatchery mitigation goals and integration objectives associated with natural production

Harvest- Recognize that harvest management strategies need to consider differential harvest rates on naturally produced fish during rebuilding years. Explore an abundance based approach similar to harvest approach used for some Pacific Northwest natural salmon stocks, such as Oregon wild coho.

Monitor- Use data from the Pacific States Fishery Management Commission (PSMFC), the Pacific Fishery Management Council (PFMC), the Pacific Salmon Commission (PSC), and the Columbia River Compact to enable evaluation of reintroduction progress with a clear distinction between marine survival fluctuation that provide common effects to Pacific salmonids and success or failure associated with the Lewis basin processes (Figure 1).

Time for recovery measurement- Do not formulate recovery conclusions until several generations of data are established, including years of poor ocean survival. Adaptive management decisions can be made sooner based on Lewis basin studies and a broad interpretation of life cycle production.

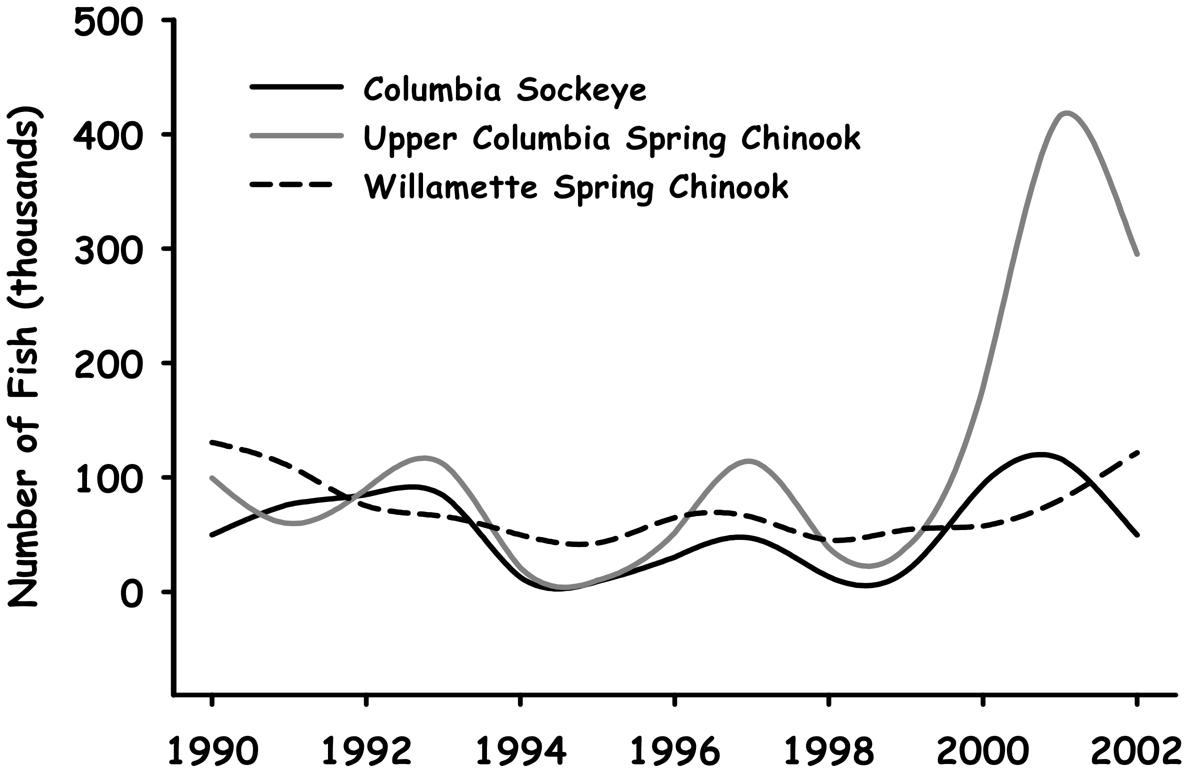

Figure 1. Columbia River anadromous fish runs from 1990 to 2002 (ODFW and WDFW 2003)

METHODS FOR ESTIMATING FISH RESPONSE TO ALTERNATIVES

The interplay of cause-and-effect relationships that will determine how fish populations respond to project actions is complex. To deal with this complexity, we have used two models, EDT and Salmon PopCycle, which together formulate an abstract representation of the real world. These models enable assessment of large amounts of information, and can predict fish population response to changes in habitat carrying capacity and key obstacles to fish survival. The model projections give indication of outcomes prior to implementation and provide opportunity for comparison to future observations to identify the need to adjust management actions.

EDT

The EDT model (Mobrand Biometrics, Inc., 2003) was applied to the upper Lewis River basin to assess habitat potential for anadromous salmonid production in the watersheds entering Swift, Yale, and Merwin reservoirs. This model used specific habitat measurements from stream surveys, and professional judgment of local biologists to estimate the carrying capacity and life-stage survival rates that were used for population analysis. Inherent in the EDT framework is a set of assumptions regarding habitat potential and how salmonid productivity, diversity, and capacity respond to specific environmental conditions. The EDT model can also be used to project habitat productivity under historical conditions. Life-stage survival rates estimated with the EDT model included egg-to-fry, fry-to-smolt, and smolt-to-adult. A first draft of the EDT model was provided to the Lewis River Negotiating Group in February 2003. A second draft of the EDT report was completed in March 2003, following peer review from ARG members. There were changes in habitat capacity and productivity for all species in the second EDT analysis, but changes in outcomes most significantly affected coho production expectations. A final EDT report was completed in January, 2004 and is found in Appendix E of this report. The integration between the EDT habitat information and the Salmon PopCycle to form a model for biologists to gauge expected outcomes of various alternatives is explained in detail in Appendix B. We have conducted a sensitivity analysis (Appendix C) of critical uncertainties including the habitat productivity and capacity estimates of EDT, and passage and harvest mortality variables of the Salmon PopCycle. Different supplementation levels were also assessed to show affect on expected future adult populations.

The Lewis basin study area includes the upper Lewis (upstream of Merwin Dam), the lower Lewis (downstream of Merwin Dam), and the East Fork Lewis (Figure 2). Key habitat reaches are displayed and miles of potential habitat for salmon and steelhead are estimated for the upper Lewis (Figure 3, Table 3), the lower Lewis (Figure 4, Table 4), and the East Fork Lewis (Figure 5, Table 5). The habitat reaches were surveyed for conditions associated with fish capacity and productivity to formulate the base for EDT production estimates for each species in each area. The EDT analysis for the upper Lewis includes estimates which compare historic (template), properly functioning conditions (PFC), with improved estuary conditions (PFC+), and current (patient) conditions. These results reflect habitat potential only and do not include mortality associated with passage through the hydro system or harvest. The additional life cycle mortality will be taken into account later in the report using the Salmon PopCycle Model.

The EDT results (February 2003) were generated using recent period (generally 1976-2000) marine survival for all models, which reflects a low marine survival period. EDT models were updated in March 2003 to reflect updated habitat inputs and results reflect a range of low, average, and high survival estimates. The Marine survival range was developed in March by the ARG and is explained in the Population Goal section of this report.

A comparison of current and historic habitat conditions, using the February 2003 EDT, shows about one third adult production potential for current habitat conditions compared to historic habitat conditions for all species combined (Figure 6). The vast majority of the current adult production potential is upstream of Swift Dam, in particular production potential for spring Chinook and steelhead (Figure 7). The EDT data summarized in February 2003, with lower marine survival assumptions, along with the Salmon PopCycle model, was used to compare expected adult fish abundance between the full reservoir trap and haul, Swift only trap and haul, and full volitional passage systems. The comparison of the three passage systems also includes a viability risk assessment. These results are reported in the Testing Passage Alternatives section of this report.

Updated EDT estimates (March 2003) derived from average marine survival were used, along with historic run reconstruction, to develop the adult fish population goals and to compare expected fish abundance between a full reservoir passage and a Swift Reservoir only trap and haul systems. The average marine survival EDT results reflect spring Chinook historic conditions producing 15,600 adults while current conditions would be expected to produce 2,600, or 16 percent of past conditions. Upper Lewis historic conditions for coho would project 33,900 adults while current conditions are expected to produce 17,600 or 52 percent of past conditions. Historic winter steelhead production is projected at 7,200 adults while current conditions would expect production of 2,900, or 40 percent of past conditions (Figure 8). These estimates reflect adult abundance without passage mortality for juveniles or adults or harvest mortality for adults. Abundance estimates which consider full life cycle mortality are derived from the Salmon PopCycle model and are found in the Testing Passage Alternatives section. These results show adult population estimates significantly less (roughly half) compared to the EDT estimates which do not include passage or harvest mortality (Table 22).

Important information contained in the EDT (March 2003) results includes the current production potential of each species in the three reservoirs and their tributaries (Figure 9). This information will be important to consider as decisions are made regarding where and what species to include in a reintroduction effort. Of the existing productive spring Chinook habitat, 94 percent is located above Swift Dam and 6 percent in Yale Reservoir .There is no spring Chinook habitat currently measured in Merwin Reservoir as the Chinook habitat is inundated by the reservoir. Of the existing coho habitat, 72 percent is above Swift Dam, 20 percent in Yale, and 8 percent in Merwin. Of the existing winter steelhead habitat, 84 percent is above Swift Dam, 8 percent is in Yale, and 8 percent is in Merwin. The habitat in the upper reaches of the Lewis basin (above Swift Dam) has historically produced the majority of spring Chinook, coho, and winter steelhead. When comparing the March 2003 final EDT with the February draft EDT results, the final EDT reflects an even greater proportion of productive anadromous fish habitat located above Swift Dam compared to the habitats above Merwin and Yale dams.

Another important function of the EDT analysis is habitat treatment assessment. The EDT results can diagnose problems such as temperature or silt load to specific reaches within watersheds and can provide the basis for prescriptive actions. The EDT can predict the improvement to fish productivity associated with the action prescribed. This information can be critical to formulating science based decisions concerning habitat improvements.

Fishery managers are also interested in using EDT to determine where to focus supplementation efforts. With respect to the Lewis, we believe the EDT results should be used first to decide if supplementation efforts should be isolated to above Swift Dam where the majority of the habitat remains, or if supplementation should include the lower reservoir areas. Details of a supplementation plan, including most productive habitat reaches, is found in the Hatchery Review Document (Appendix D).

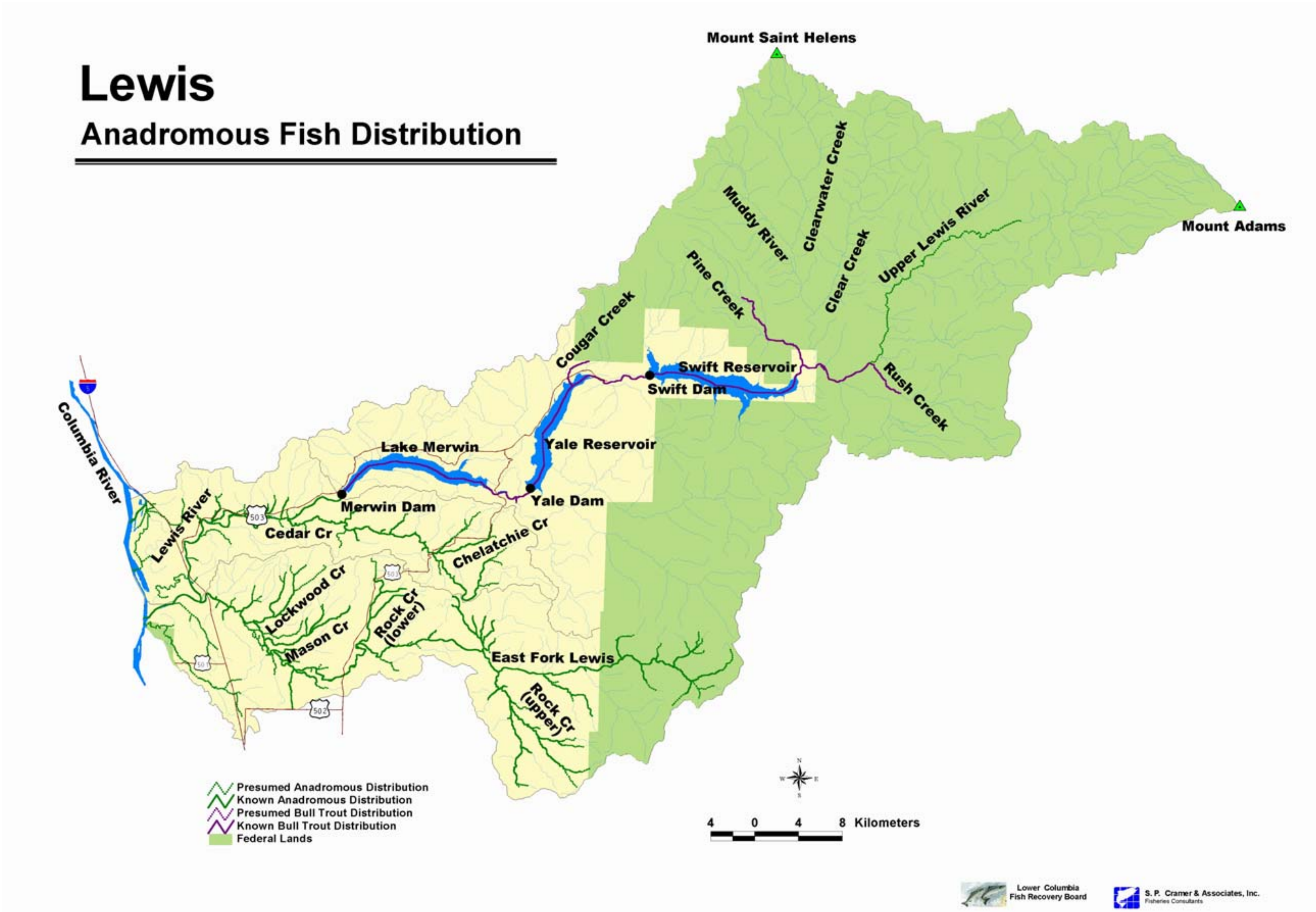

Figure 2. Anadromous fish distribution in the Lewis River basin.

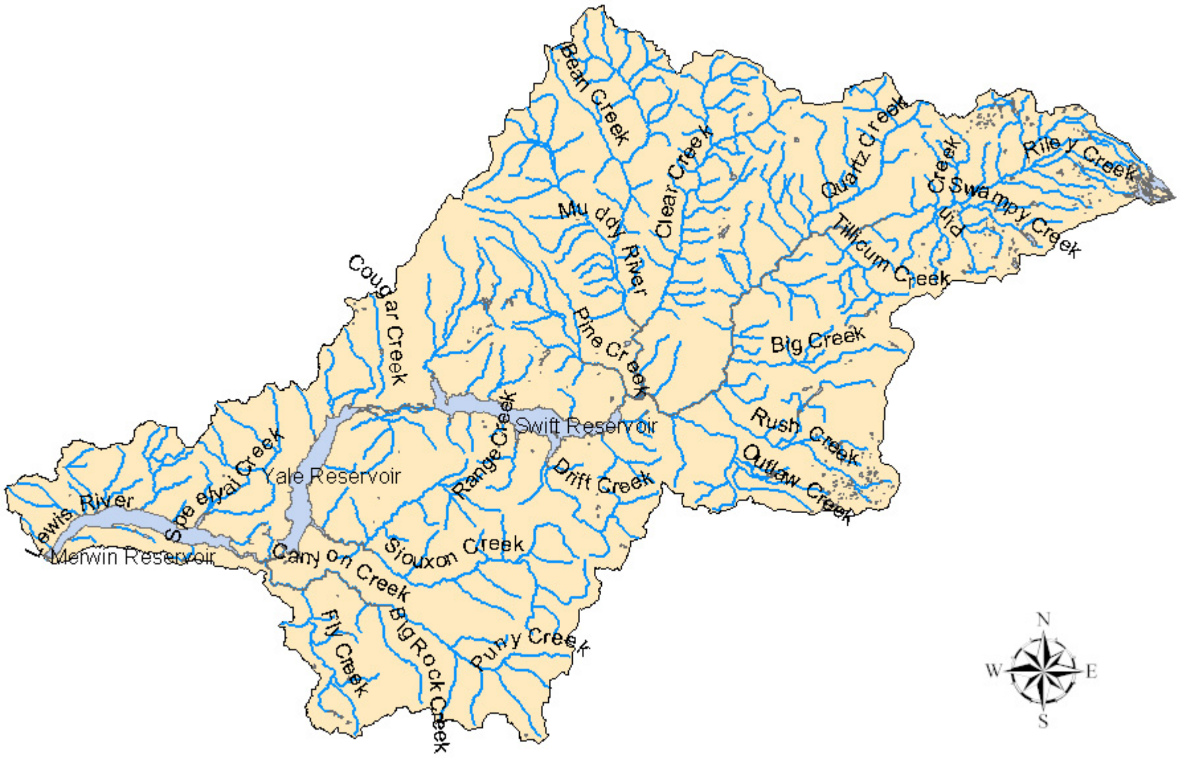

Figure 3. Habitat reaches of the upper North Fork Lewis River basin.

Table 3. Length (miles) of habitat in upper North Fork Lewis basin

Species	Area	Habitat	Miles (reservoir inundated)
Winter Steelhead	Merwin	28.9	17.8
	Yale	29.5	16.3
	Swift	107.9	7.3
Coho	Merwin	29.4	17.6
	Yale	27.3	9.9
	Swift	117.1	17.9
Spring Chinook	Merwin	14.7	14.5
	Yale	17.3	11.7
	Swift	93.7	14.9
Fall Chinook	Merwin	14.5	14.5
	Yale	13.0	10.3
	Swift	37.3	10.7

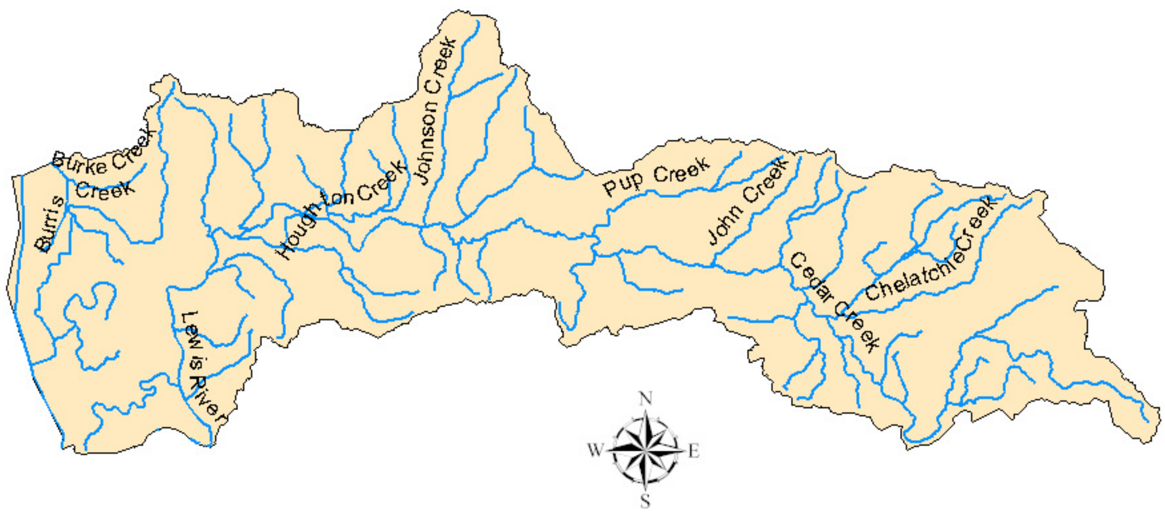

Figure 4. Habitat reaches of the lower North Fork Lewis River basin.

Table 4. Miles of accessible habitat in the lower North Fork Lewis.

Species	**Miles of accessible habitat**
Fall Chinook	44
Spring Chinook	45.7
Chum	27.2
Winter Steelhead	84.2
Summer Steelhead	28
Coho	79.5

Note: Miles of stream habitat estimates based on data from Salmon and Steelhead Habitat Assessment Project (SSHIAP)

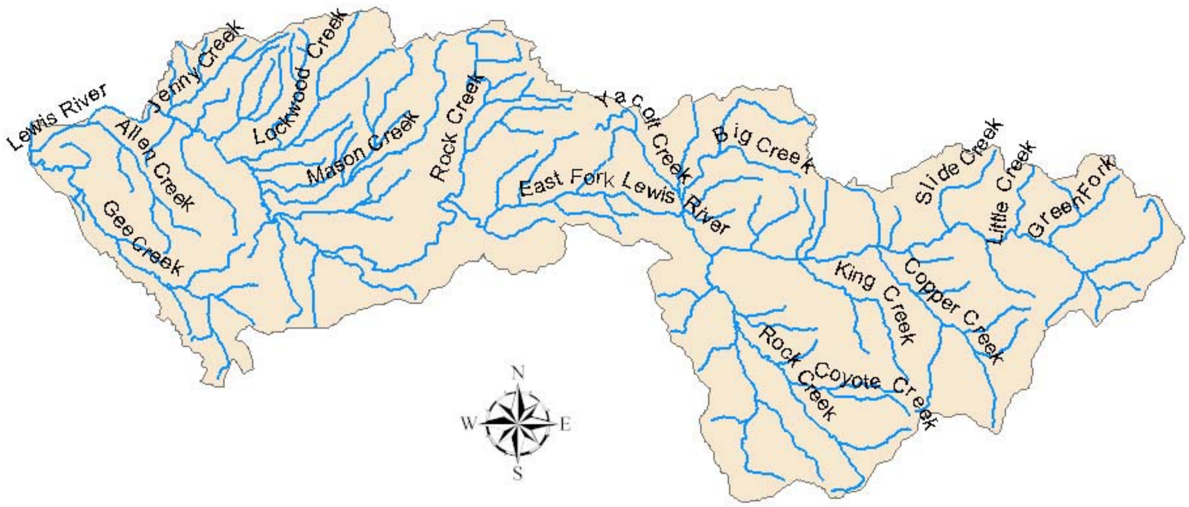

Figure 5. Habitat reaches of the East Fork Lewis River basin.

Table 5. Miles of accessible habitat in the East Fork Lewis.

Species	Miles of accessible habitat
Fall Chinook	22.3
Spring Chinook	21.8
Chum	40.3
Winter Steelhead	140
Summer Steelhead	130
Coho	69

Note: Miles of stream habitat estimates based on data from Salmon and Steelhead Habitat Assessment Project (SSHIAP)

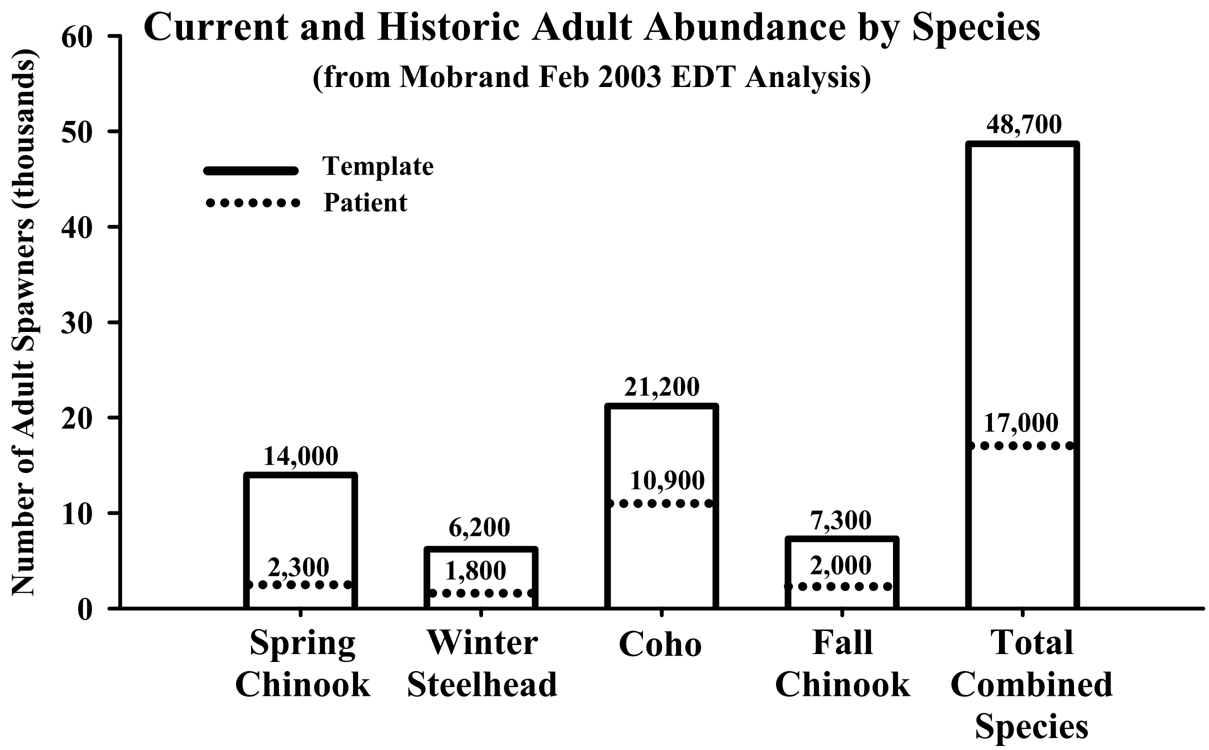

Figure 6. Current and historic adult abundance potential in the upper Lewis reservoirs.

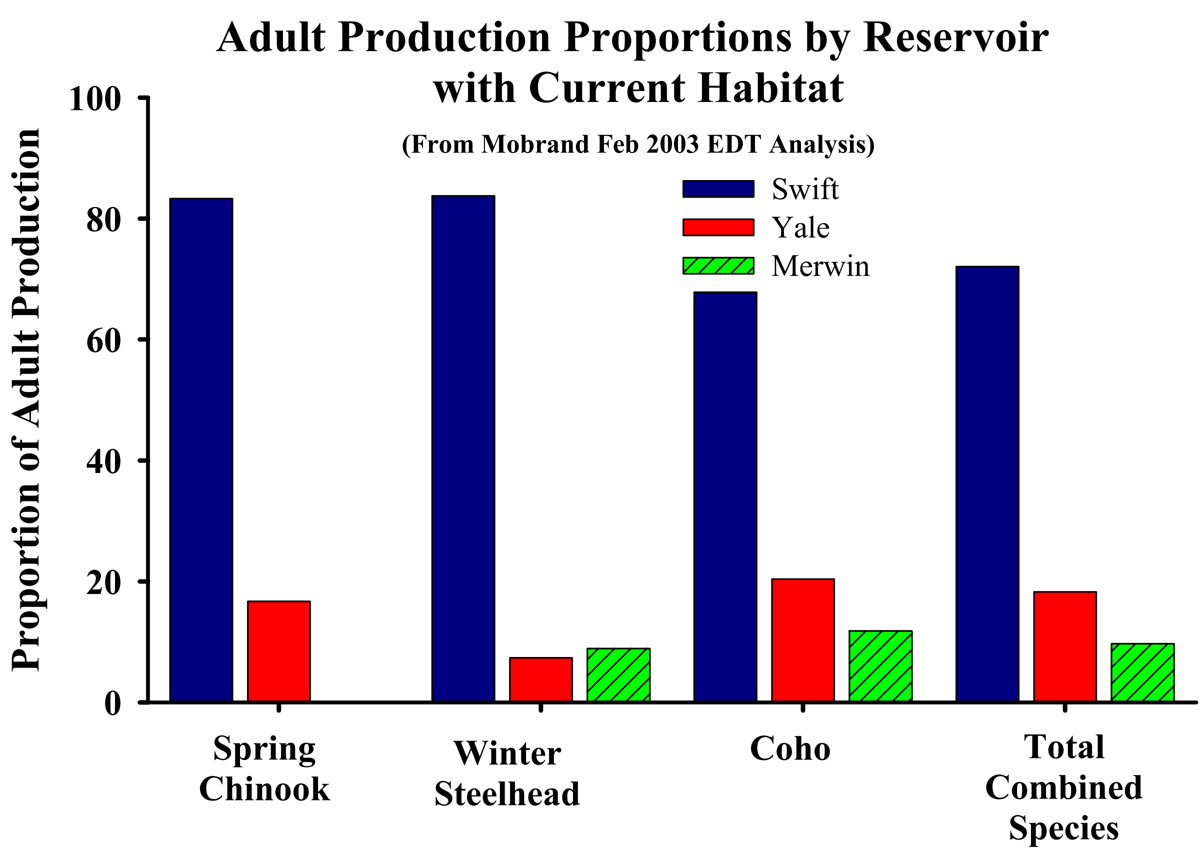

Figure 7. Current adult production proportions by reservoir.

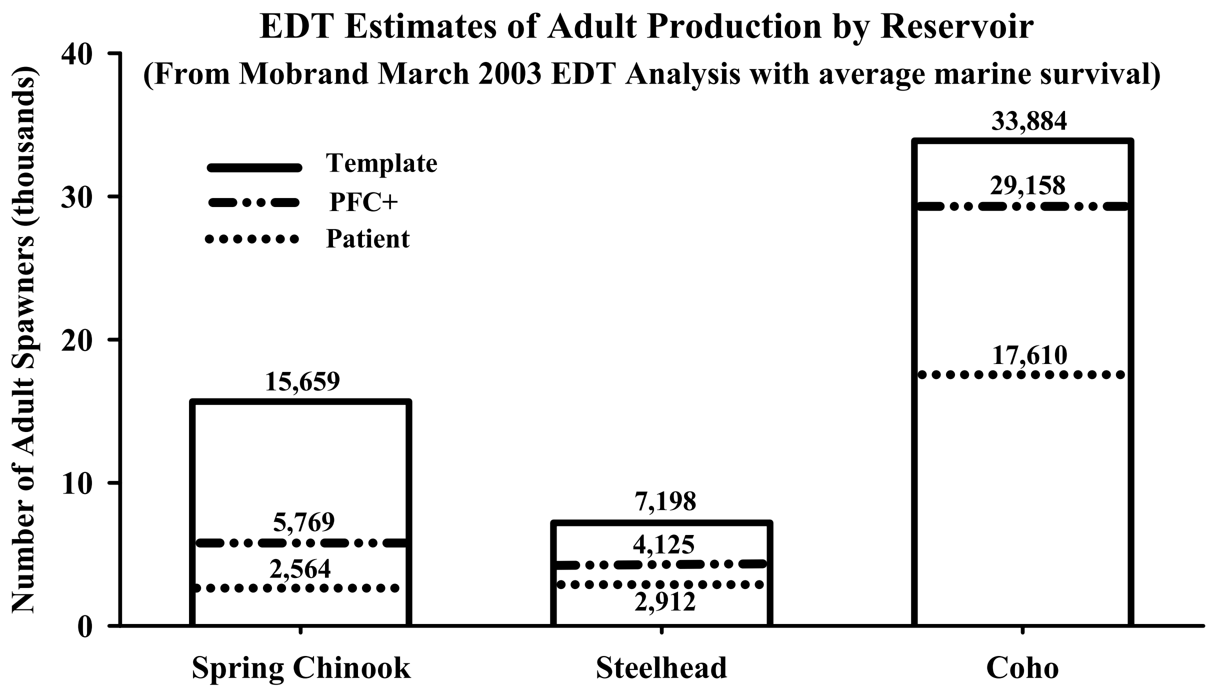

Figure 8. Upper NF Lewis EDT results by reservoir (average marine survival).

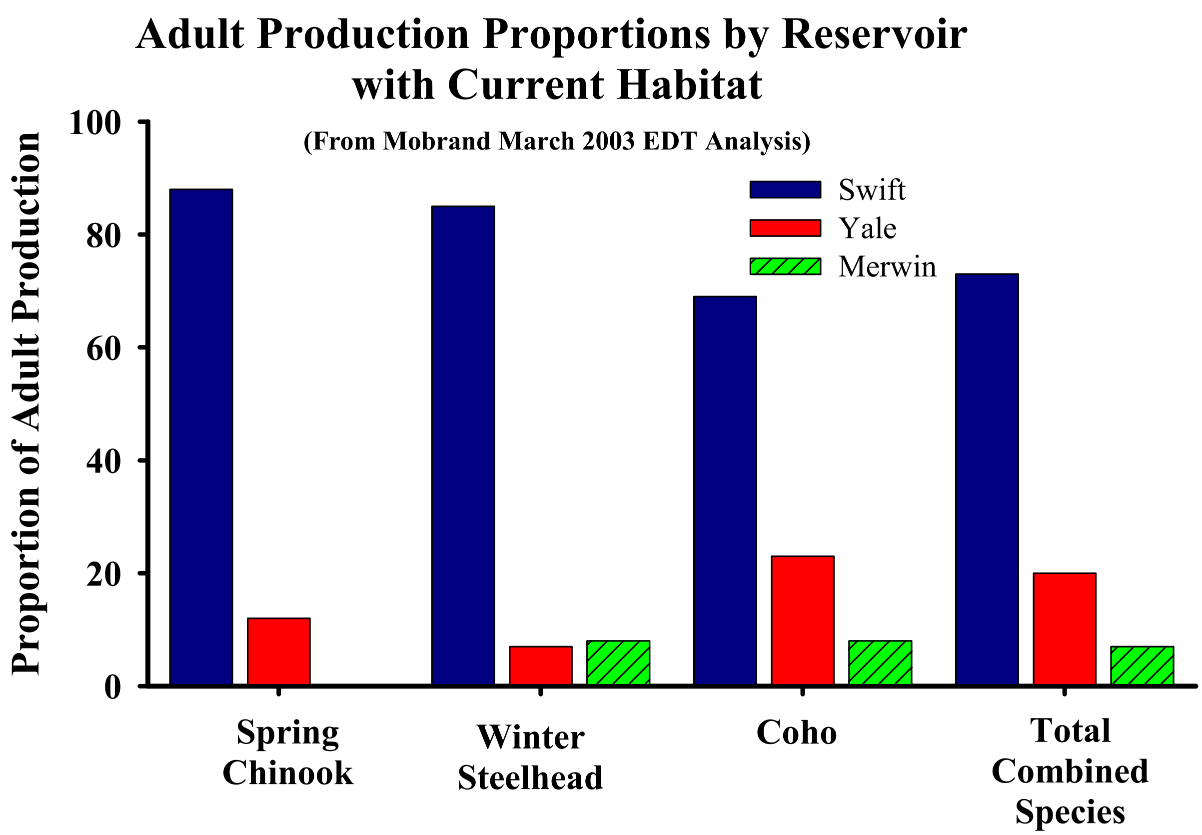

Figure 9. Patient adult production proportions by reservoir.

Salmon PopCycle Model

The Salmon PopCycle was used to propagate effects of project actions into the future and forecast the stable population size likely to be achieved. Salmon PopCycle was developed to predict the effects of harvest on population viability of spring Chinook in the Willamette Basin (Beamesderfer 2001) and to predict effectiveness of alternatives for reintroducing steelhead above dams in the Deschutes Basin (Cramer and Beamesderfer 2002). Estimates of carrying capacity and life-stage survival rates for the Lewis River from EDT were directly input to PopCycle, where additional parameters regarding collection efficiencies, passage survival, supplementation rates, and harvest rates were added (Figure 10). Salmon PopCycle was used to simulate the population 50 years into the future for each alternative. Simulated population levels stabilized well before 50 years, so we used the abundance of spawners in 50 years as the performance measure for comparing alternatives.

The Salmon PopCycle model is a series of mathematical equations which calculate future salmon or steelhead numbers based on numbers of eggs, juveniles, or adults outplanted or passed above Merwin, Yale, or Swift dams, survival rates, and reproduction rates. The model breaks the salmon life cycle into different stages so that the effects of specific activities and limiting factors can be evaluated. For example, smolt passage mortality in the Lewis is an input which can be varied to examine its effects on future salmon numbers. Similarly, ocean survival rate is an input which can be used to examine how salmon numbers would be affected by changes in ocean rearing conditions which have contributed to poor returns of many salmon stocks in recent years. The model also can simulate a hypothetical resident trout population and it's interaction with steelhead.

The Salmon PopCycle model is described in detail in Appendix B, including instructions for use. The PopCycle model is user friendly and can be utilized by ARG members or others to model alternatives and test variable assumptions.

Salmon PopCycle model: migration corridor based and considers:

Habitat capacity

Habitat productivity

Juvenile reservoir survival

Juvenile collection efficiency

Juvenile passage survival

Juvenile handling/trucking mortality

Smolt Columbia River survival

Marking mortality

Estuary/Ocean survival to adult

Ocean harvest

Columbia River harvest

Adult dam passage rate

Adult trucking mortality

Adult sorting mortality

Adult conversion to spawning area

Hatchery supplementation strategy

- adults
- smolts
- number of years

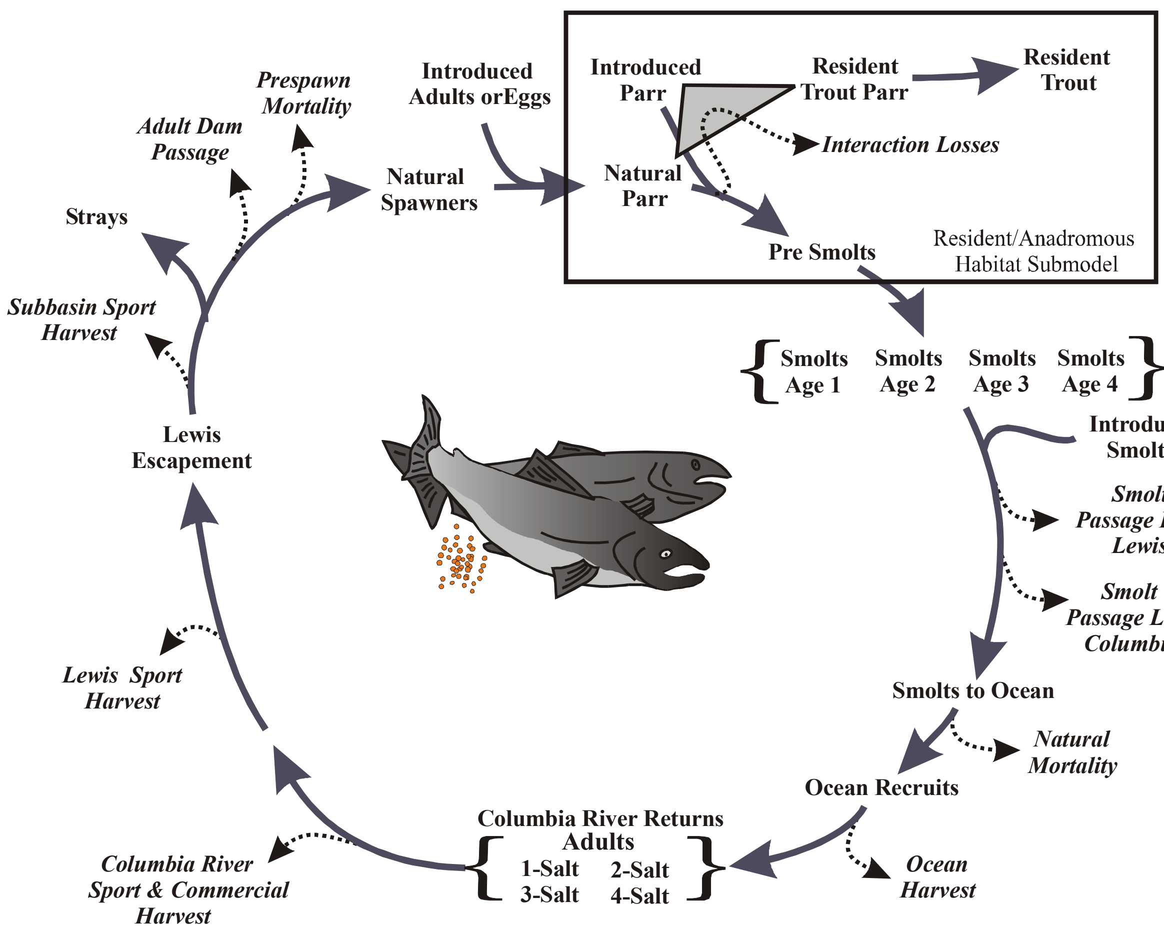

Figure 10. Lifecycle stages included in PopCycle. Values for parr capacity and egg-to-smolt survival were input from EDT results.

Testing Passage Alternatives

There are several factors to consider when testing fish passage alternatives. Some of those include:

1. The amount of habitat above each of the dams
2. Juvenile and adult survival rates through the system
3. Potential for reestablishing stable populations
4. Fishery management goals for the basin
5. Cost of facility construction and operation

We focus the test of passage alternatives on providing comparisons of potential for establishing viable salmon and steelhead populations. We analyze Swift, Yale, and Merwin populations of coho, spring Chinook, and steelhead as separate populations. The three reintroduction passage systems include:

> System 1: Volitional- This system relies on volitional juvenile and adult passage with construction of juvenile bypass systems and fish ladders. This system is designed to meet the connectivity, reintroduction, and bull trout enhancement goals
>
> System 2: Trap and Haul- (or lift tram system for adults)This system would be designed to meet the same objectives as System 1 but with trap and haul or lift facilities for adults and trap and haul system for juveniles instead of volitional passage
>
> System 3: Upper Basin Trap and Haul. This option restricts the anadromous reintroduction goal to areas above Swift Dam where most of the habitat is located
>
> Other systems which are considered to protect and enhance bull trout include a system to connect the Yale and Swift bull trout population and another that keeps them isolated but reduces entrainment mortality. These options can be considered with or without anadromous reintroduction and are important to consider independent of the test for anadromous fish reintroduction success. The tests conducted in this analysis are for testing anadromous reintroduction options to evaluate chance of success under the three passage systems.

The life cycle model evaluates survival assumptions for the three passage systems by projecting future fish populations. The obstacles in which the fish encounter as juveniles and as adults are different for each of the three passage systems. The differences can be associated with similar configuration, but multiple encounters in some systems or can be associated with different facilities. Other mortalities associated with Columbia River emigration, smolt to adult ocean survival, and harvest is in addition to passage mortality and are included in the PopCycle model (detailed in appendix B).

The System 1 passage configuration includes volitional passage for adults and juveniles (Figure 11). This system will include a fish guidance system intended to divert fish to a bypass facility at each dam to pass juveniles through the projects. Adults would return to spawning areas by fish ladders constructed at each dam. It is assumed that the juvenile collection system for Swift would be located at Swift 1 and a ladder for adults would be constructed at Swift 2 powerhouse. This system reflects a complete volitional system for juveniles and adults. It is not intended to reflect a consensus alternative.

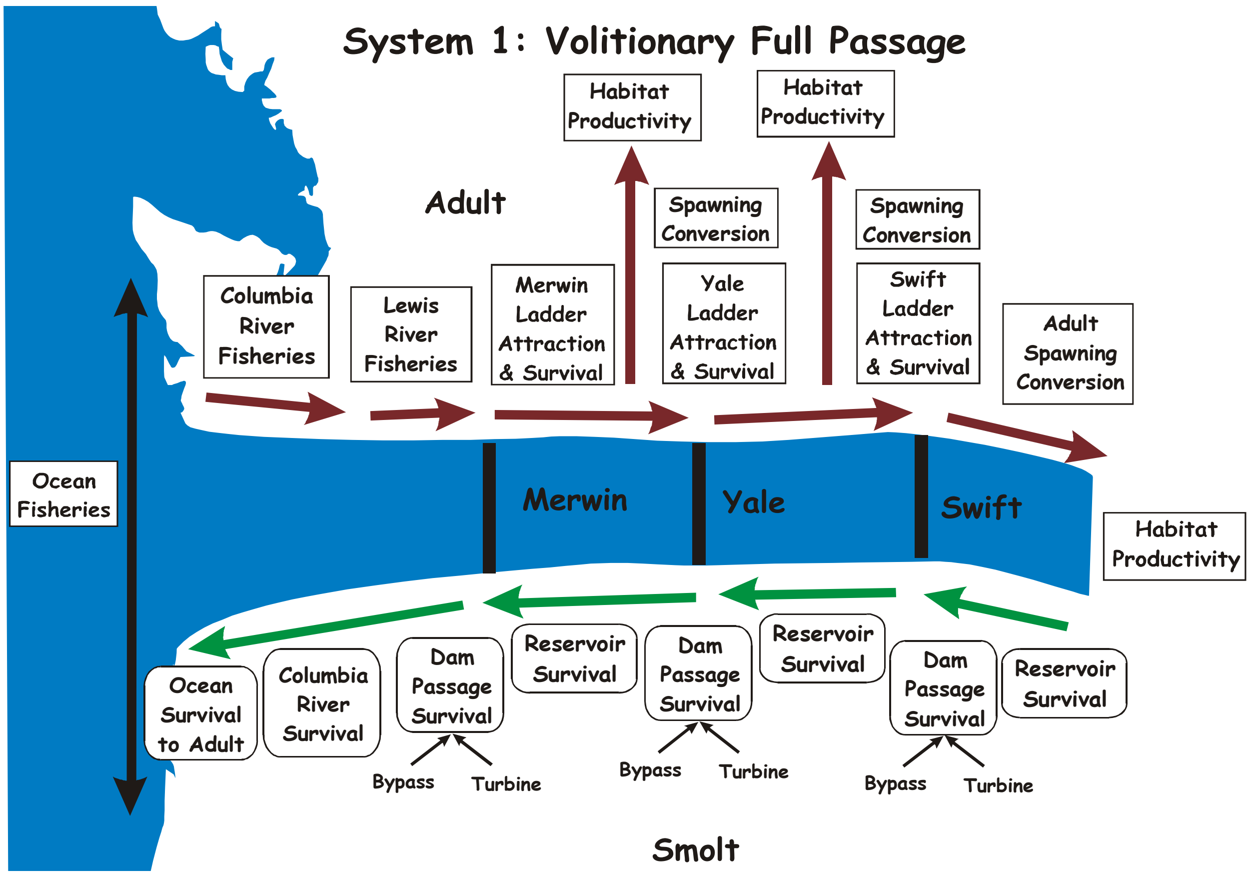

Figure 11. Salmon PopCycle model inputs for juvenile to spawning adult survival of salmonids introduced to Merwin, Yale, and Swift reservoirs with full volitional passage past dams.

The System 2 passage configuration relies on trap and haul (or tramway lift system for adults) facilities to move juveniles and adults past all project structures (Figure 12). Juveniles are collected at each of the three dams and transported to below Merwin Dam. Those fish not collected would be expected to pass through the turbines with fish having opportunity for collection at the next dam downstream. Adult migrants are collected at Merwin, Yale, and Swift No. 2 powerhouse and transported into the next upstream reservoir, or lifted with a tramway system to the next reservoir. Adult fish destined for above Swift Dam would be trapped and handled three times.

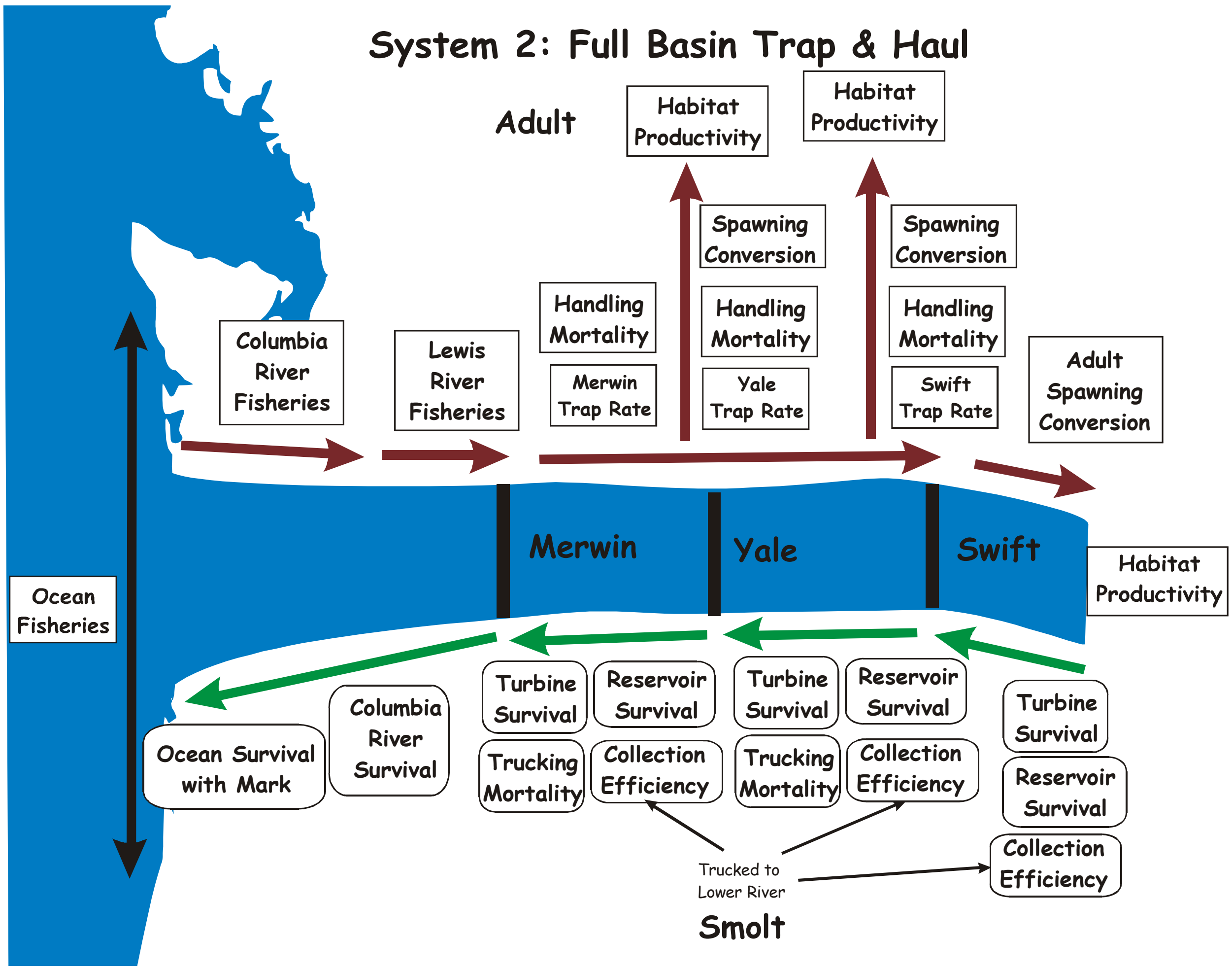

Figure 12. Salmon PopCycle model inputs for juvenile to spawning adult survival of salmonids introduced to Merwin, Yale, and Swift reservoirs with trap and haul / tramway passage.

The System 3 passage configuration (Figure 13) would include a juvenile collection facility at Swift 1, and a trap and haul facility at Merwin Dam. This system is focused on re-introducing anadromous fish above Swift and presents Swift fish with the fewest passage obstacles.

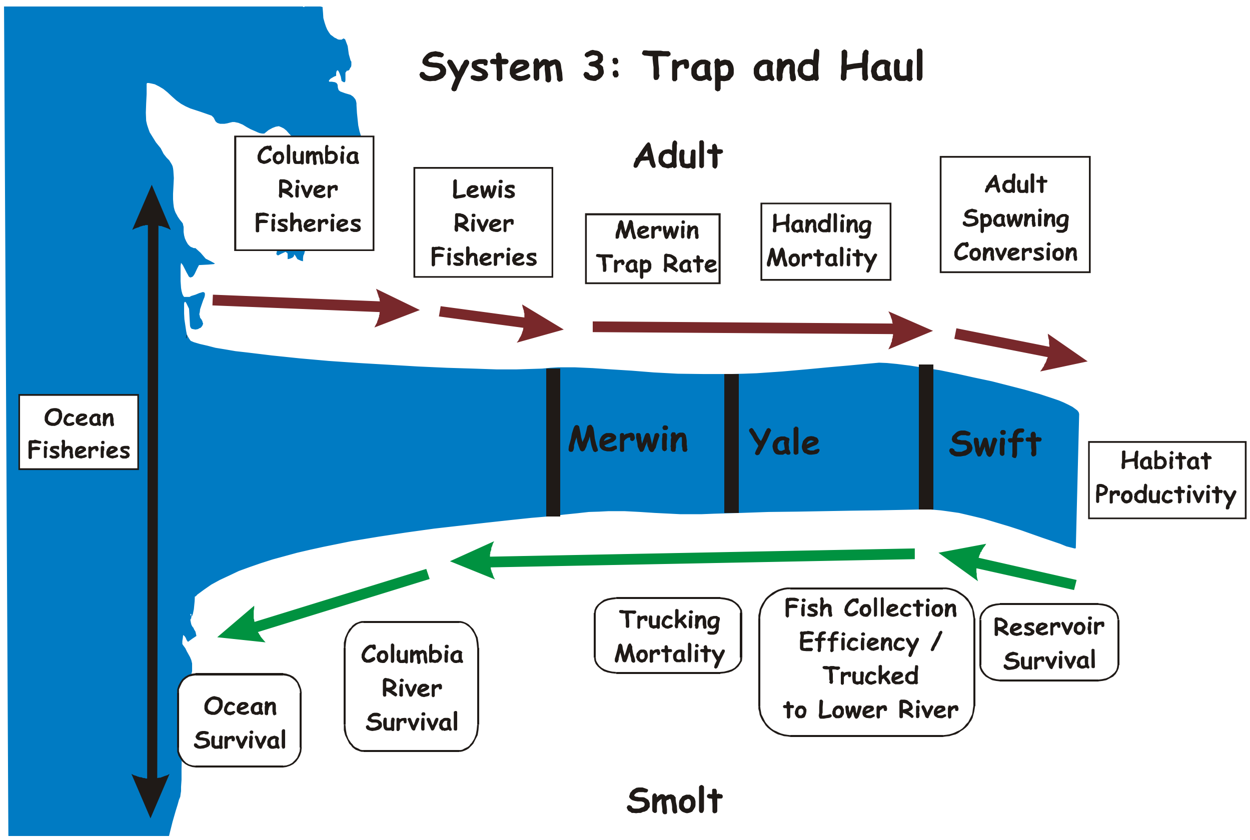

Figure 13. Salmon PopCycle model inputs for juvenile to spawning adult survival of salmonids introduced above Swift Reservoir.

Project Passage Survival

To evaluate relative difference between alternatives we assumed passage rates comparable to those that have been discussed by the ARG in development of the Lewis River Fish Passage Analysis Model (LRFPAM). These passage assumptions were also similar to the assumptions reported in a Comparative Risk Assessment of Lewis passage co-authored by the 10,000 Years Institute and Stewart and Associates on behalf of the Cowlitz Indian Tribe. The passage assumptions are not absolutes and certainly not expected to be final assumptions. However they can be useful to compare differences in expected populations between systems. We chose passage survival assumptions similar to those previously discussed to avoid debate over specifics regarding passage survival and to hopefully move the discussions towards relative differences in outcomes which are highly influenced by differences in available habitat. The risk assessment should ultimately be transformed into a collective decision on which option for passage has the best chance for success in establishing anadromous populations. This choice could be made in full knowledge of the uncertainty in passage assumptions but decision makers could move forward with an understanding of relative odds of success between the systems.

The effect of a range of passage assumptions on population forecasts is explored in detail through sensitivity analysis (Appendix C). The sensitivity analysis assists decision makers in assessing the risks in establishing a population given a range of uncertainty in passage assumptions. The outcomes displayed in the analysis with fixed passage assumptions combined with sensitivity analysis should provide the essential information needed to answer the two critical passage questions:

1. **Reintroduction focus above Swift Dam or the full basin?**
2. **Volitional or trap and haul passage?**

Passage assumptions fixed for the analysis were:

Passage		
Smolt Reservoir Survival		92%
Fish Guidance Efficiency		70%
Turbine Survival		70%
Bypass Survival		98%
Juvenile Transport Survival		98%
Adult Trap Attraction		95%
Adult Trap Survival		99%
Adult Trucking Survival		99%
Adult Ladder Attraction		95%
Adult Ladder / Reservoir Survival		
	Merwin	98%
	Yale	98%
	Swift	95%

Differences in passage assumptions compared to the LRFPA Model include:

We assumed that fish trapped and hauled multiple times would be subjected to additional handling mortality. We used an additional 1% mortality for each time adult fish were handled. This results in a cumulative handling survival of 98% for Merwin fish, 95% for Yale fish, and 91% for Swift fish in the System 2 trap and haul (or tramway) configuration.

We did not add spawning adults to the lower reservoir populations to account for the assumed 5% loss of adults per trap. Even if some of the non-trapped fish successfully spawned in another reservoir we don't believe it would appreciably change the outcome for those reservoirs.

We did not apply any additional mortality for differential (D-value) survival for fish transported nor for a bypass delayed mortality for fish subjected to 1 or more bypass systems. Potential for reduced survival associated with the D-value is addressed in the sensitivity analysis Appendix C).

Following are cumulative passage survival assumptions for fish populations from the three reservoirs. Other passage assumptions can be assessed in the sensitivity analysis: These are the inputs for the Salmon PopCycle Model with the above passage assumptions:

Table 6. Cumulative passage survival assumptions for fish populations of the three reservoirs.

		Swift	Yale	Merwin
System 1	Juveniles	56	68	82
(Volitional)	Adults	78	87	93
System 2	Juveniles	78	79	82
(Trap & Haul/Lift all Dams)	Adults	78	86	93
System 3	Juveniles	71	na	na
(Trap & Haul to Swift)	Adults	94	na	na

Projected Biological Response to System Alternatives

We used the PopCycle Model, with inputs on carrying capacity and rearing survival from the EDT model, to predict the average run size of spring Chinook, coho and winter steelhead that might be achieved from natural production under the three passage systems. In this analysis, we used the marine survival from the recent year low survival period as used by Mobrand Biometrics, Inc. in the draft EDT results available in February 2003. Each alternative was carried forward 50 years, by which time natural populations were fully established, and both catch and spawner escapement had stabilized. We refer to these stable numbers as the “equilibrium” values, given the set of survival and mortality factors we assigned in the model. We used these equilibrium values for naturally produced fish to compare outcomes of the alternatives. We also assess the relative risk of the population to not persist based on the number of years the population is expected to fall below a low run risk level. We use 300 fish as the low run risk level consistent with the risk level adopted into the Oregon Native Fish Conservation Policy. The supplementation level and duration was fixed (Swift example Table 7) for 5 years and the harvest rate was fixed at 20 percent for spring Chinook, 15 percent for coho, and, 3 percent for steelhead. Details concerning harvest assumptions can be found in Appendix A and variable harvest and supplementation levels are tested in the sensitivity analysis.

Table 7. Supplementation rates assumed for Swift Reservoir reintroduction.

	Supplementation Input to Model			
Species	**Hatchery Adults**	**Years Introduced**	**Hatchery Smolts**	**Years Introduced**
Spring Chinook	500	2	100,000	5
Coho	500	2	100,000	5
Winter Steelhead	200	2	20,000	5

Spring Chinook (Figure 14)

System 1- The Swift population reaches equilibrium at 175 fish and has a significant low run risk 76 percent of the years (Table 8). The Yale population reaches equilibrium at 105 fish with a low run risk 92 percent of the years. There is no spring Chinook production modeled in Merwin Reservoir. These values would cast serious doubt in establishing a spring Chinook population in the upper basin.

System 2- The Swift population reaches equilibrium at 416 fish with a low run risk 11 percent of the years. The Yale population reaches equilibrium at 155 fish with a low run risk 91 percent of the years (Table 8). These results display an opportunity for a low stabilized return above Swift with moderate low run risk and small population in Yale with a high level of risk to low production levels.

System 3- The Swift Population increases to 503 fish with a 6 percent low run risk (Table 8). This system increases the odds of success in establishing a Swift population while foregoing a Yale program with heavy odds against success.

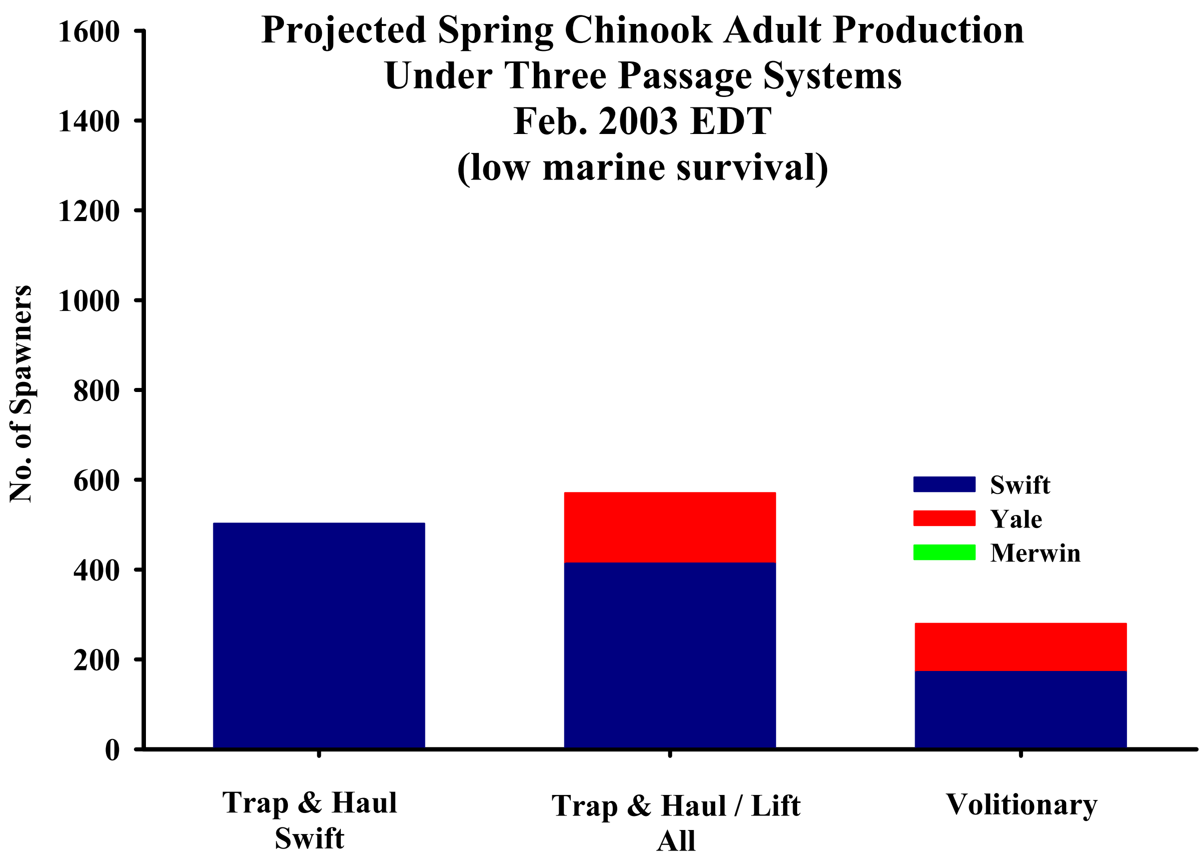

Figure 14. Comparison of potential spring Chinook spawner production sustained long term with three passage systems.

Coho (Figure 15)

System 1- The Swift population reaches equilibrium at 933 fish with a low run risk of 4 percent (Table 8). The Yale population reaches equilibrium at 452 fish with a low run risk of 18 percent. The Merwin population reaches equilibrium at 466 fish with a 15 percent low run risk. This system provides a moderate level coho population above Swift with small risks and lower level runs in Yale and Merwin with moderate risks of populations low enough to risk continued productivity.

System 2- The Swift population reaches equilibrium at 2,181 fish with a 2.5 percent low run risk (Table 8). The Yale population reaches equilibrium at 675 fish with a 2.5 percent low run risk. The Merwin population reaches equilibrium at 466 fish with a 15 percent low run risk. This system projects a stable coho run in Swift reservoir with small risk, a moderate but stable coho run in Yale with small risk and a lower level population in Merwin with moderate risk.

System 3- The Swift population reaches equilibrium at 2,612 fish with a 2.5 percent low run risk (Table 8). This system projects a stable population for Swift Reservoir while foregoing low to moderate but stable populations in Merwin and Yale.

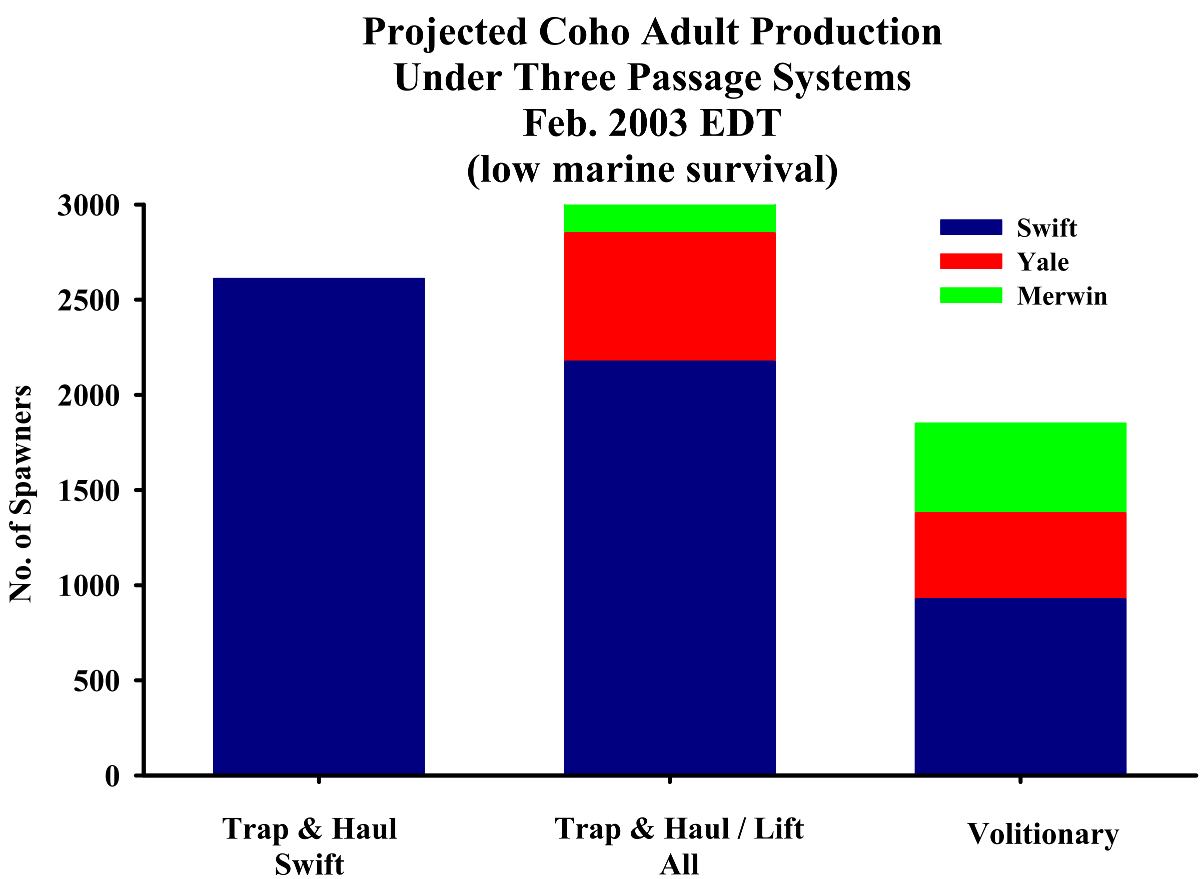

Figure 15. Comparison of potential coho spawner production sustained long term with three passage system.

Steelhead (Figure 16)

System 1- The Swift population reaches equilibrium at 635 fish with a low run risk or 2.5 percent (Table 8). The Yale population reaches equilibrium at 89 fish with a low run risk of 92 percent. The Merwin population reaches equilibrium at 141 fish with a low run risk of 91 percent. This system projects a low but stable steelhead population in Swift but low odds for sustaining production in the lower reservoirs.

System 2- The Swift population reaches equilibrium at 1,010 fish with a low run risk of 1.8 percent (Table 8). The Yale population reaches equilibrium at 106 fish with a low run risk of 92 percent. The Merwin population reaches equilibrium at 141 fish with a 91 percent low run risk. This system projects a moderate and stable population in Swift with populations slightly increased in the lower reservoirs but remain at levels that would likely not sustain productivity.

System 3- The Swift population increases to an equilibrium of 1,140 fish with a low run risk of 1.5 percent (Table 8). This system provides a moderate and stable population above Swift while foregoing attempts at establishing populations in lower reservoirs, which are projected to be long shots for success.

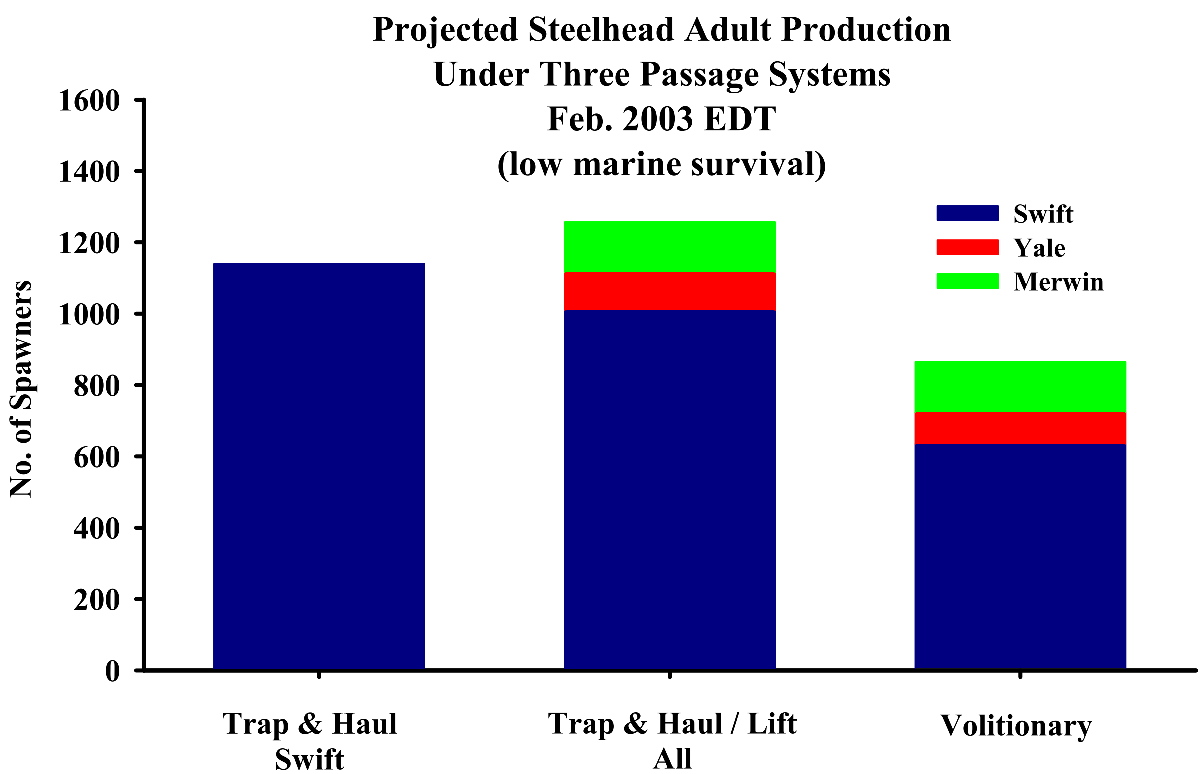

Figure 16. Comparison of potential steelhead spawner production sustained long term with three passage systems.

Biological Response Summary

These results derived from the integrated EDT and Salmon PopCycle analysis should be interpreted as indicators of potential for success of establishing populations in the upper basins. This type of information is valuable to weigh comparative risks to success before making significant change to fishery management and existing attributes of the system and incurring significant costs.

We believe this data, along with the sensitivity analysis leads to a conclusion that the highest odds of success are linked to an anadromous reintroduction effort prioritized to above Swift Dam where the majority of habitat is available for all fish.

The results of the models show that there is a cost to the odds of success to reintroducing salmon and steelhead above Swift Reservoir if the passage system is structured to also connect anadromous fish in Yale and Merwin reservoirs (Figure 17).

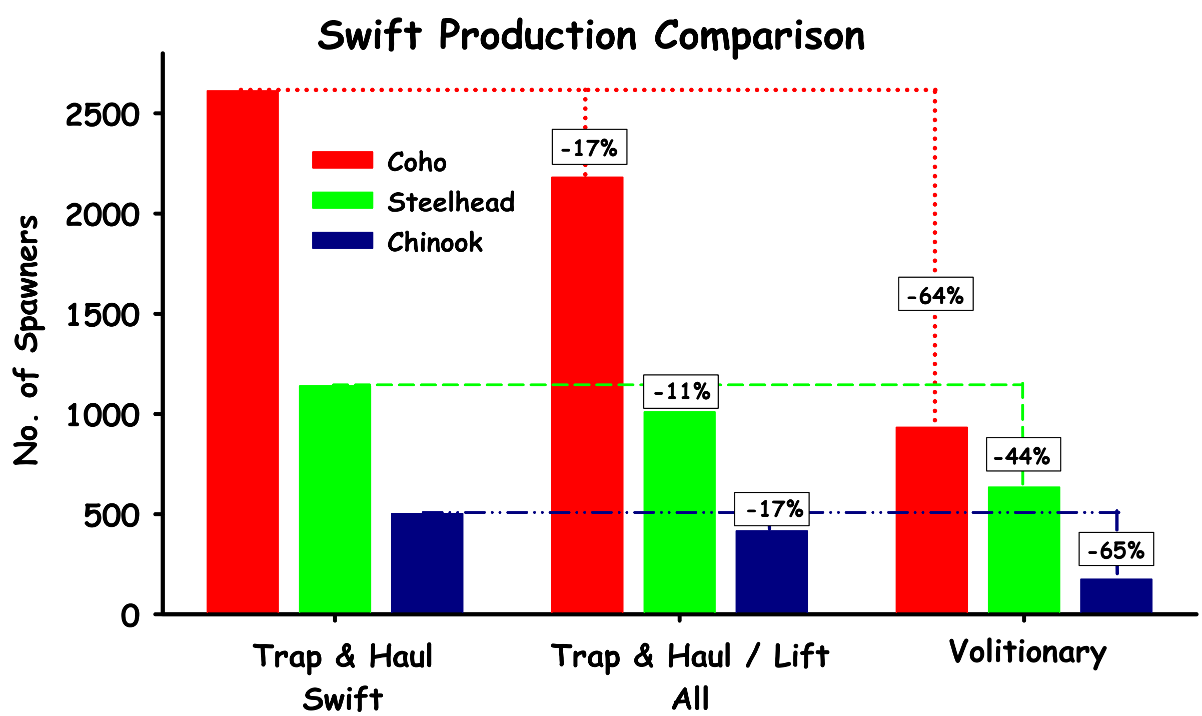

Figure 17. Reduction in Swift Reservoir production under the three passage systems.

Swift fish are taxed with additional obstacles and uncertainty when subjected to full passage systems. This result will hold true even when passage assumptions are changed because the relative difference between the systems will remain. There appears to be a fair chance of establishing sustainable coho populations in the lower reservoirs, especially with the updated EDT results showing increased coho habitat. However, there appears to be little chance of sustaining stable steelhead or spring Chinook populations below Yale (current EDT analysis indicates there is simply not enough usable habitat available for these species in the lower reservoirs)), and the cost to Swift populations, in particular spring Chinook is high. The spring Chinook population may be the most difficult to achieve stability, and we believe in the face of uncertainty, the data suggest the odds should be stacked towards the highest chance of success for this population.

The low level projected populations with high risks are subjected to expanded risk associated with fluctuations in ocean conditions, freshwater conditions, and variations in passage survival. Many of the annual natural survival variations cannot be controlled, which reinforces the importance in providing the highest opportunity for establishing populations which can withstand these natural events.

Viable Populations and Risk

Population viability goals must consider goals related to Endangered Species Act requirements and “broad sense” goals related to a desire to support opportunities for other fish uses such as harvest. Population viability goals generally represent minimum standards for fish restoration to a level where unique groups of populations are no longer threatened with declines where they are at risk of extinction. Broad sense goals generally correspond to higher levels of fish restoration that maintain population viability while also providing additional fish for other uses. We can include a measurement of depensation in our model to represent the risk of low spawner escapement. Depensation is the reduced production or survival which may occur at low spawner numbers. We have used a threshold of 300 spawners consistent with the Oregon Department of Fish and Wildlife, native fish policy. Table 5 displays risk comparisons of the three passage system in percentage of years the Salmon PopCycle model projects abundances below 300 spawners for Swift Reservoir populations.

We chose to illustrate risks to the Swift population only to demonstrate differences in risk associated with passage systems designed for a Swift reservoir only effort compared to a system designed to achieve full connectivity. This assessment could also be considered in terms of risk to the entire population combined for all reservoirs for each species in a full connected system. We believe the main consideration (in a connected population assessment) would still be the risk to the fish produced in Swift reservoir for spring chinook and steelhead because the projected number of equilibrium spawners produced in the lower reservoirs is so low, it does not compensate for the risk focused on the Swift population. We believe the increased risk to the Swift populations represents increased risk to the ability to establish natural populations anywhere in the upper Lewis for spring chinook and steelhead. However, the risk to coho is not substantially changed with a full connected system and there are more adults potentially gained with coho in the lower reservoir habitats. More detail on low run risks can be found in Appendix C.

Table 8. Maximum, 50 year, and low run risk for Swift Reservoir population under three passage systems.

	Swift Spring Chinook			Swift Coho			Swift Steelhead		
	Max	50 Years	Low Risk	Max	50 Years	Low Risk	Max	50 Years	Low Risk
Volitional	863	175	76.5%	1868	933	3.7%	845	635	2.5%
Trap & Haul/Lift	1203	416	11.0%	2934	2181	2.5%	1225	1010	1.8%
Trap & Haul Swift	1319	503	6.2%	3326	2612	2.5%	1359	1140	1.5%

COMPARISON OF SYSTEMS 1 and 2 WITH "AVERAGE" MARINE SURVIVAL

The EDT estimates were updated in March 2003 and modeled to reflect average marine survival for wild fish as agreed to by the AQU 18 work group. The updated EDT data was incorporated into the Salmon PopCycle to produce a comparison of projected adult abundance between a full reservoir trap and haul system (System 2) and a Swift only trap and haul system (System 3). The results were also compared under current (patient) conditions (Table 9, Figure 18) and under PFC+ conditions (Table 9, Figure 19). The results show larger abundance than the results derived with lower marine survival (Figures 14-17), but the relative difference in the systems are similar. The system difference remains the most apparent for spring Chinook and steelhead where few fish, if any, are gained by a full reservoir effort while Swift numbers are reduced and risks are increased. However, there is more potential gained for coho with a full reservoir effort, reflecting that the habitat potential remaining in the lower reservoirs is predominately suited for coho. The PFC+ estimates are useful to compare the potential for improvement in abundance if the habitat is improved to reach future potential. The PFC+ estimates assume the reservoirs remain as is and that estuary conditions improve. It should be noted that the marine survival used in this analysis assumes an improvement from the recent "low period" survival and assumes the reintroduced populations will survive similar to wild fish. The wild fish survival attributes may not be realistic during the initial years when the production is initiated with hatchery supplementation.

Table 9. Salmon PopCycle model estimates of adult equilibrium populations under patient and PFC+ habitat conditions and average marine survival for wild fish (March 2003).

	Patient		PFC+	
Population	Swift Only	Full Trap and Haul	Swift Only	Full Trap and Haul
Spring Chinook[1]				
Swift	1,175	1,014	2,266	2,029
Yale	-	92	-	268
Merwin	-	-	-	-
Total	1,175	1,106	2,266	2,297
Steelhead[2]				
Swift	1,440	1,289	1,800	1,628
Yale	-	127	-	222
Merwin	-	173	-	275
Total	1,440	1,589	1,800	2,125
Coho[3]				
Swift	6,190	5,382	10,398	9,303
Yale	-	1,791	-	2,389
Merwin	-	742	-	1,049
Total	6,190	7,915	10,398	12,741

[1] Average assumed smolt-to-adult survival for spring Chinook was 4.5%.
[2] Average assumed smolt-to-adult survival for steelhead was 9%.
[3] Average assumed smolt-to-adult survival for coho was 7.5%. NOTE: Assumes improved marine survival as compared to recent period (1977-2000)

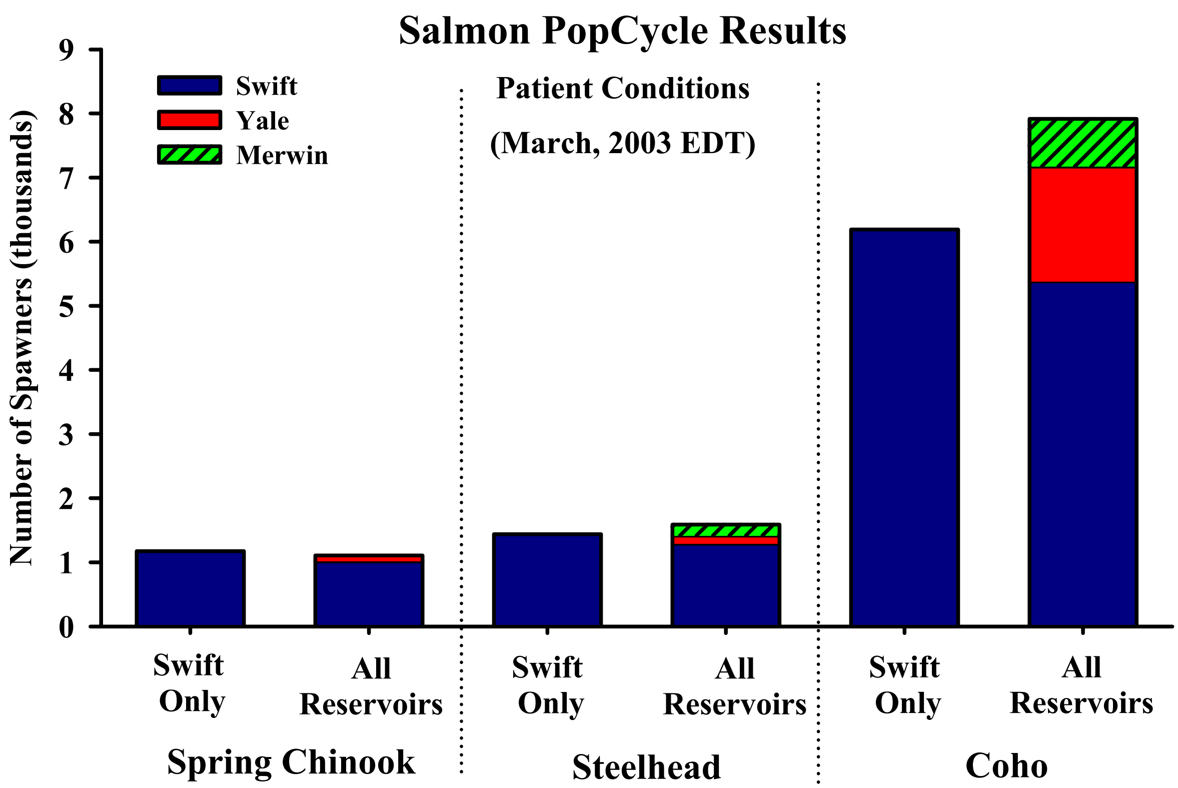

Figure 18. PopCycle projected adult equilibrium spawners at patient habitat conditions by reservoir (March 2003 EDT).

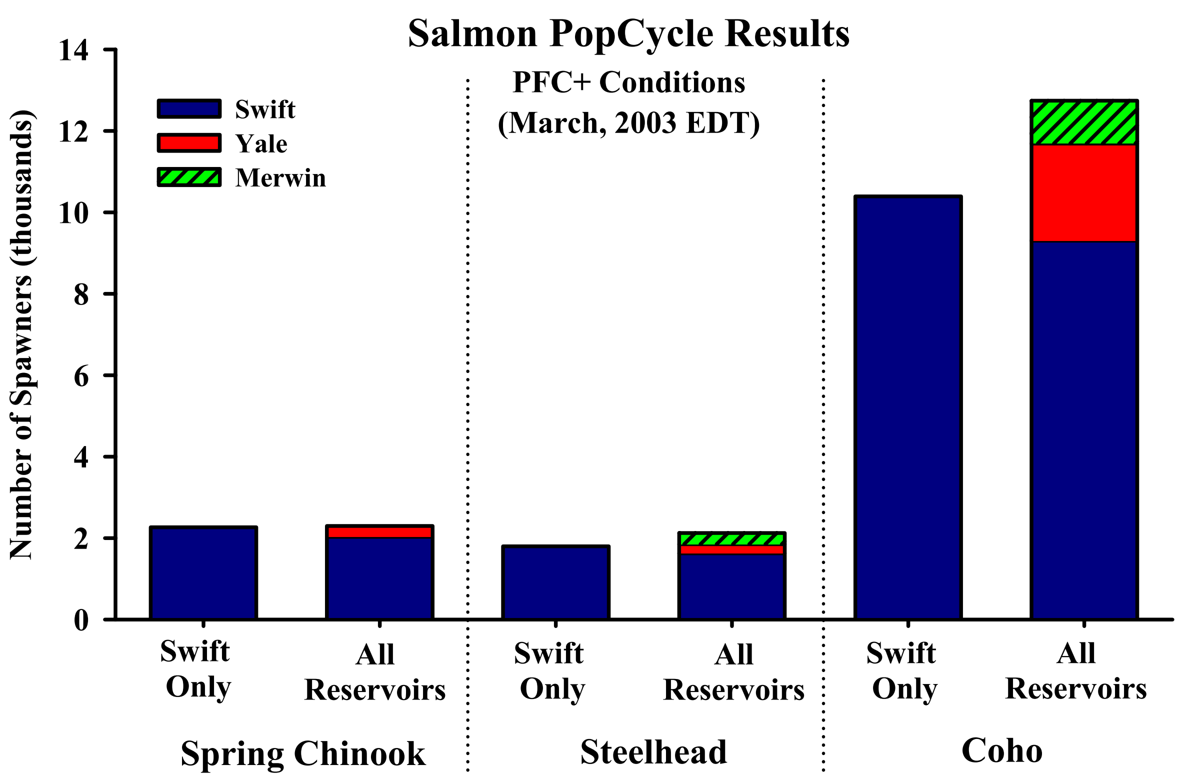

Figure 19. PopCycle projected adult equilibrium spawners at PFC+ habitat conditions by reservoir (March 2003 EDT).

COMPARISON OF MBI & SPCA POPULATION MODEL RESULTS FOR THE UPPER LEWIS RIVER

The ARG requested a comparative analysis between the Salmon PopCycle Model used to generate the projected adult equilibrium spawning and estimates with the Lewis Fish Passage Assessment Model developed by the ARG for coho. Following is a report comparing results of the two models for coho using the same life cycle mortality assumptions.

Summary

1. This analysis compared simulation results from two life cycle models (LFPAM and Salmon PopCycle) recently employed to weigh the effects of different passage and transportation scenarios at Merwin, Yale, and Swift dams.
2. The same model input parameters were used in each model so that potential differences in formulation could be identified by differences in results.
3. Despite slightly different formulations of some life stages and functional relationships, LFPAM and Salmon PopCycle produced essentially the same results when parameterized with equivalent input values.
4. In the final analysis, application of these two different modeling packages is analogous to the difference between using different spreadsheet programs (e.g. Excel vs. Quattro).

Introduction

Evaluations of fish reintroduction alternatives in the upper Lewis River basin have employed a fish life cycle modeling approach to weigh the effects of different passage and transportation scenarios at Merwin, Yale, and Swift dams. Two different modeling programs have been applied to this problem over the course of this modeling effort. Programs were formulations of the same basic set of fish life history processes but varied slightly in their configuration and capability. This side-by-side comparison of the two modeling programs was undertaken to verify that the conclusions of either model are not an artifact of peculiarities of specific formulations of either method.

Methods

This analysis compared simulation results for the Lewis River Fish Passage Analysis Model (LFPAM) developed by Mobrand Biometrics, Inc. (Mobrand Biometrics, Inc. 2002) and the Salmon PopCycle model adapted by S.P. Cramer and Associates, Inc. (Norman and Cramer 2003). The same model input parameters were used in each model so that potential differences in formulation could be identified by differences in results. The test hypothesis was that results would be substantively the same because both models are based on a series of stage-specific survival rate calculations. Slight differences in numerical outputs were expected because of small differences in mathematical calculations and rounding. However, both models were expected to lead to the same basic conclusions, especially with respect to the relative ranking of the effects of different passage scenarios.

The LFPAM is a stage-specific mortality rate population model constructed in Microsoft Excel with modeling routines written in Visual Basic computer programming language. LFPAM was developed specifically to evaluate coho reintroduction scenarios in the upper Lewis Basin. This modeling software includes a series of advanced features to automate comparison of scenarios and analysis of model sensitivity to inputs.

The Salmon PopCycle model is also a stage-specific mortality rate population model constructed as a stand-alone executable program written in Visual Basic computer programming language. The Salmon PopCycle model was originally developed at the Oregon Department of Fish and Wildlife to conduct population viability analysis of spring Chinook under various fishing strategies (Beamesderfer 2000). The model was subsequently adapted at S.P. Cramer and Associates, Inc., to evaluate steelhead reintroduction scenarios in the upper Deschutes River basin as part of Pelton/Round Butte Relicensing considerations (Cramer and Beamesderfer 2002). Where LFPAM is specific to coho, the Salmon PopCycle model provides the flexibility to model coho as well as spring Chinook and steelhead that are distinguished by different juvenile and adult age schedules. For instance, virtually all coho migrate as age 1+ smolts and return as adults at age 3. Spring Chinook also typically migrate as age 1+ smolts but age of return varies from 3 to 6. Steelhead juveniles can migrate at ages 1 through 4 and return after 1 to 3 years in the ocean. Salmon PopCycle is a generic population model that lacks the advanced features of LFPAM to automate evaluations of Lewis River scenarios but provides the flexibility to test the same scenarios with a series of individual model runs. Salmon PopCycle also provides the capability of conducting stochastic simulations to estimate probabilities of various outcomes given input uncertainty or variability.

Results from each model were compared for three reintroduction scenarios as described in Norman and Cramer (2003). System 1 involved volitional passage of adults and juveniles at Merwin, Yale, and Swift dams. System 2 relied on full basin trap and haul facilities to move juveniles and adults past all project structures. System 3 included a juvenile collection facility at Swift 1 and a trap and haul facility at Merwin Dam. All comparisons were based on coho salmon because the LFPAM was configured for this species. Analyses were performed for the coho population upstream of Swift Dam. Results were expressed as equilibrium numbers of spawners after sufficient time to allow reintroduced populations to become established. A baseline simulation was also evaluated. This baseline included only stock-recruitment and smolt-to-adult survival inputs while assuming 100% passage survival and 0% fishing mortality.

Inputs were based on values identified in Norman and Cramer (2003). Equivalent input values were derived to accommodate differences in functional forms of the two models (Table 10). For instance, LFPAM defined the Beverton-Holt spawner to smolt recruitment function with parameters based on smolts per female at low density and smolt carrying capacity per meter. Salmon PopCycle defined the Beverton-Holt spawner to smolt recruit function with parameters based on egg-smolt survival at low density and total number of smolts at capacity. These alternatives are just different formulations of the same equation; hence, use of equivalent values produced the same numbers of smolts at any given spawning escapement. Similarly, LFPAM provided for specific inputs for different components of passage while Salmon PopCycle only provided inputs for net passage rates.

Table 10. Parameter inputs for side-by-side comparison of Lewis River Fish Passage Analysis Model (LFPAM) and Salmon PopCycle Model results for coho upstream from Swift Dam under three passage scenarios. Numbers not in parentheses or brackets are direct model inputs. Numbers in parentheses are component rates used to derive direct model input values. Numbers in brackets are equivalent values corresponding to inputs in the other model.

	1. Volitional		2. Full Trap & Haul		3. Swift Trap & Haul	
	LFPAM	PopCycle	LFPAM	PopCycle	LFPAM	PopCycle
Juvenile Passage						
Reservoir survival [1]	0.92	(0.92)	0.92	(0.92)	0.92	(0.92)
Fish Guidance Efficiency [1]	0.70	(0.70)	0.70	(0.70)	0.70	(0.70)
Turbine Survival [1]	0.70	(0.70)	0.70	(0.70)	0.70	(0.70)
Bypass Survival [1]	0.98	(0.98)	0.98	(0.98)	0.98	(0.98)
Juvenile Transport Survival [1]	0.98	(0.98)	0.98	(0.98)	0.98	(0.98)
Tagging Survival	1.00	(1.00)	1.00	(1.00)	1.00	(1.00)
Bypass Outfall Survival	1.00	(1.00)	1.00	(1.00)	1.00	(1.00)
Transport Sorting Survival	1.00	(1.00)	1.00	(1.00)	1.00	(1.00)
Bypass Effect (SAR Multiplier)	1.00	(1.00)	1.00	(1.00)	1.00	(1.00)
Transport D-value	1.00	(1.00)	1.00	(1.00)	1.00	(1.00)
Net Juvenile Passage Survival	[0.563]	0.563	[0.784]	0.784	[0.712]	0.712
Adult Passage						
Ladder or Trap Attraction [1]	(0.95)	(0.95)	(0.95)	(0.95)	(0.95)	(0.95)
Ladder / Reservoir Survival [1]						
Merwin	(0.95)	(0.98)	--	--	--	--
Yale	(0.98)	(0.98)	--	--	--	--
Swift	(0.98)	(0.95)	--	--	--	--
Trap & Truck Survival [1]	--	--	(0.98)	(0.98)	(0.98)	(0.98)
Trap/Truck Multiple Handling [1]			(0.99)	(0.99)	--	--
Volitional Passage Efficiency						
Merwin Attraction, Ladder & Res.	0.931	[0.931]	--	--	--	--
Yale Attraction, Ladder & Res.	0.931	[0.931]	--	--	--	--
Swift Attraction, Ladder & Res.	0.903	[0.903]	--	--	--	--
Trap and Haul Survival						
Merwin collection	--	--	0.931	[0.931]	0.931	[0.931]
Yale collection	--	--	0.922	[0.922]	--	--
Swift collection	--	--	0.913	[0.913]	--	--
Net Passage Through Swift	[0.783]	0.783	[0.784]	0.784	[0.931]	0.931

	1. Volitional		2. Full Trap & Haul		3. Swift Trap & Haul	
	LFPAM	PopCycle	LFPAM	PopCycle	LFPAM	PopCycle
Other Parameters						
Smolt Carrying Capacity						
Number per Meter	1.259					
Total (asymptote)	[226,000]	226,000	[226,000]	226,000	[226,000]	226,000
Productivity						
Smolts per Female (low density)	196	[196]	196	[196]	196	[196]
Percent Female	(50)	50	(50)	50	(50)	50
Eggs per Female		2600		2600		2600
Egg-smolt Survival (low density)		0.0754		0.0754		0.0754
Smolt to Adult Survival	0.05	0.05	0.05	0.05	0.05	0.05
Harvest Rate (all fisheries)	0.15	0.15	0.15	0.15	0.15	0.15

[1] *Per dam and/or reservoir*

Results

Despite slightly different formulations of some life stages and functional relationships, LFPAM and Salmon PopCycle produced essentially the same results when parameterized with equivalent input values (Figure 20). PopCycle numbers were 1-6% more optimistic than LFPAM results. Differences of this small magnitude could merely be a result of differences in rounding.

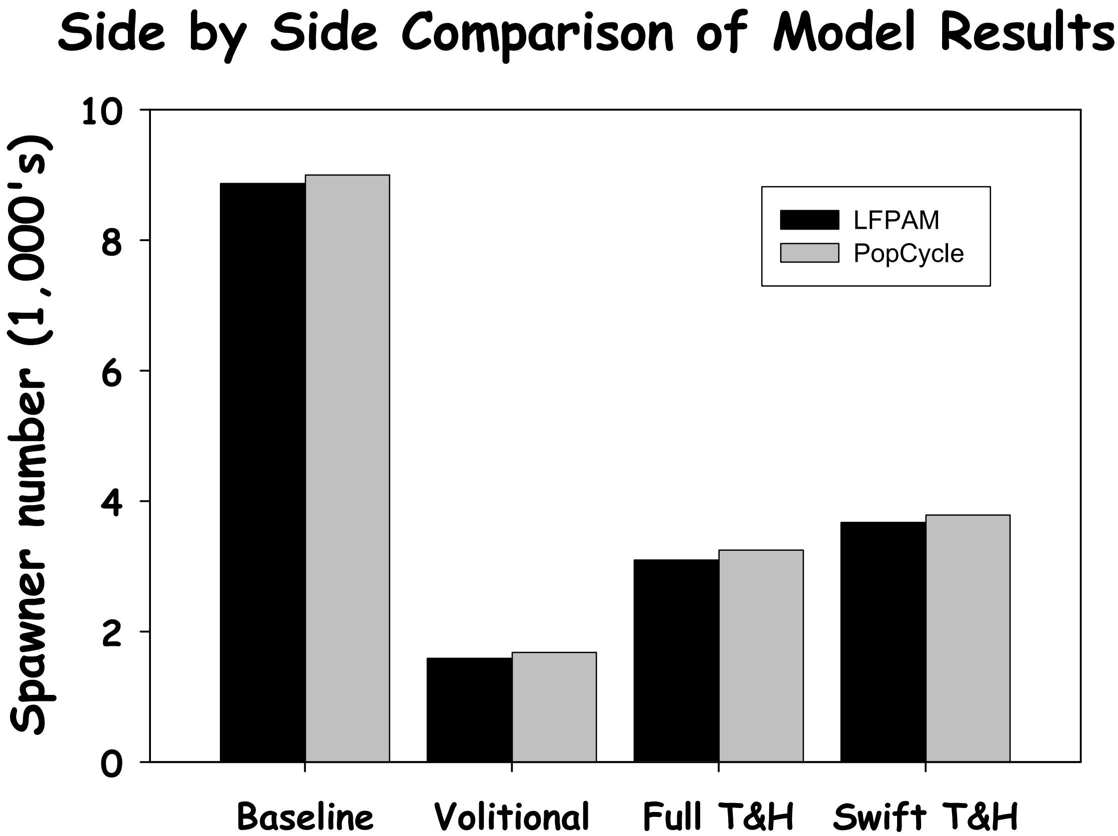

Figure 20. Comparison of LFPAM and Salmon PopCycle results for coho salmon above Swift Dam under three passage scenarios.

Discussion

In the final analysis, application of these two different modeling packages is analogous to the difference between using different spreadsheet programs (e.g. Excel vs. Quattro). Although each modeling package includes a different mix of features and is configured slightly different, both alternatives apply the same basic functions and formulas. Both are life cycle based approaches that partition productivity throughout the life cycle into stage-specific rates that can be varied by the user to explore sensitivity of the outcome to inputs consistent with different passage scenarios. When similar inputs are used, both modeling packages provide the same result.

ADAPTIVE MANAGEMENT PLAN FRAMEWORK

The actions to protect and enhance Lewis River fisheries resources would be implemented through the use of adaptive management. The Adaptive Management Plan (AMP) is designed to provide a logical performance-based method for addressing project-related fish passage, riverine habitat, and hatchery issues. The AMP would:

- Reduce risk by applying well designed experiments to test the critical uncertainties (assumptions) that determine whether program goals can be achieved;
- Use pre-set performance criteria for evaluating facilities and for decision making; and
- Use what are essentially public resources in a logical cost-effective manner.

Adaptive Management Defined

Adaptive management is defined as an "adaptive policy that is designed from the outset to test clearly formulated hypotheses about the behavior of the ecosystem being changed by human use" (Lee 1993). Generally, these hypotheses are predictions about how one or more species would respond to management actions.

Adaptive management is a process that is based on *learning by doing*. This can imply that resource managers need to take action in the face of scientific uncertainty. However, the actions taken through adaptive management are not selected at random. Rather, action is prescribed through the thoughtful and disciplined application of the scientific method. The scientific method can be broken down into 5 steps:

Step I -Observation. The process begins with the scientist making observations and collecting data on the natural phenomena, population, or species of interest.

Step 2 -Theory. From these observations, the scientist forms a theory about how the species functions within the ecosystem. This is achieved by organizing and analyzing data in a manner that allows the scientist to uncover relationships between the species and its environment and interactions with other species.

Step 3 -Hypothesis. The scientist next makes a prediction (hypothesis) about how the species would respond to different actions which is then tested through experimentation.

Step 4 -Experimentation. Well designed experiments are developed and used by the scientist to test the validity of the hypotheses put forth. Ideally, only a single variable is altered so that a cause and effect relationship can be established.

Step 5 - Acceptance or Rejection of the hypothesis. Based on the results of the experiment, the hypothesis is either accepted or rejected. If the hypothesis is proven to be wrong, an alternative hypothesis is developed and the process repeated.

Role of EDT and Salmon PopCycle Modeling in Adaptive Management

The EDT methodology was developed by scientists to be used within the context of adaptive management. EDT is designed to both mimic the scientific method and provide a logical framework for developing and evaluating hypotheses about treatment effectiveness and impacts on fisheries resources. EDT and Salmon PopCycle models will be used in the Lewis Basin to:

- Diagnose habitat problems in the basin,
- Formulate the treatments (actions) that could be used to cure these problems,
- Formulate hypotheses regarding how fisheries resources would respond to proposed treatments,
- Model fisheries resource performance after implementation of the treatment, and
- Identify key uncertainties regarding treatment effectiveness.

The AMP, EDT, and Salmon PopCycle Model would provide the conceptual framework under which actions would be selected and evaluated.

Lewis River Adaptive Management Program

This program was developed based on the authors' current knowledge of the relicensing processes to date. Changes can be expected based on information the authors were unaware of while developing the draft Adaptive Management Program (AMP), updated information, or as part of settlement discussions.

A proposed AMP is described in detail under the following headings:

- Goals
- AMS Management Structure
- Critical Uncertainties
- Performance Criteria
- Risks
- Strategy Identification
- Phase 1 – License years 1-4
- Phase 2 – License years 5-10
- Phase 3 – License years 11-40

Goals

The overall objective of the AMP is to change project facilities and operations over time to achieve the following basin goals:

- Restore self-sustaining and harvestable runs of native anadromous fish populations into the upper North Fork of the Lewis River;

- Increase the productivity, diversity of life history patterns, and habitat capacity for anadromous and resident fish populations in the upper and lower basin. This would be accomplished through the use of innovative hatchery practices; development of fish passage facilities, and by providing appropriate flows for fish population enhancement;
- Integrate the hatchery and natural production fish management practices. This would be accomplished by broodstock selection, rearing strategy, release strategy, and disease control;
- Improve hatchery operations to decrease impacts on naturally produced fish;
- Integrate natural production in the upper Lewis, lower Lewis and East Fork Lewis by linking off-site mitigation to the Lewis AMP.

Critical Uncertainties

The EDT and Salmon PopCycle analysis for the Lewis River Basin was developed as part of the relicensing process and described in Mobrand Biometrics, Inc. (2003). The results of the EDT analysis indicate that basin fisheries goals may be achieved with the construction of highly effective fish passage facilities situated at key locations, improvements in hatchery fish fitness, and disease control. However, for basin fisheries goals to be realized, multiple assumptions used in the EDT and Salmon PopCycle analysis must be accurate. Because there is a large amount of uncertainty associated with each assumption, the accuracy of each is important for determining whether proposed treatments would provide desired results and achieve identified fisheries goals.

The critical uncertainties (assumptions) are listed below. These would be addressed (tested) through research and long-term monitoring:

- Fish passage effectiveness for both juveniles and adults at each of the dams and reservoirs;
- Post-release survival of hatchery fish, as well as the scope of these releases (size of release, release location, release timing);
- Effect of reintroduced salmonids on existing natural populations;
- Ocean and lower Columbia River harvest levels;
- Conversion rates of returning adults to Merwin trap or ladder;
- Survival rate of adult salmonids collected and transported by truck to the upper Lewis River Basin; and
- Additional marking and sorting mortality associated with reservoir manual sorting.

Another uncertainty is the EDT and Salmon PopCycle model results. In the AMP, the EDT, and Salmon PopCycle models would be used as the conceptual framework under which actions are selected and implemented. Because proposed actions were partially based on model results, it is important that the assumptions in the framework are constantly reviewed for scientific validity. Thus, throughout the term of the new license, the EDT and Salmon PopCycle models and framework would be revised to account for new knowledge regarding salmon performance, their response to environmental changes, and actions. Or, new models or methods may be considered to replace existing tools if superior methods are discovered in the future.

Performance Criteria

The EDT and Salmon PopCycle models were used to establish performance needed to select AMP actions, strategies, and pathways. The performance criteria selected are dependent on objectives for sustained natural population levels and affect on other important attributes of fish management. One factor to consider is fish passage rates which result in sustaining populations at a low risk of extinction. For example, models suggest that cumulative passage of 70 percent of the juveniles and 80 percent of adults maintains Spring Chinook populations in Swift reservoir above risk levels (300 fish) 79 percent of the years using low marine survival. These criteria are based on low marine survival expectations and current EDT habitat conditions. The actual fish performance will better inform biologists of what these criteria need to be. Examples of Lewis basin management performance criteria are as follows (intended for illustration):

- Smolt reservoir survival/conversion $ 90%
- Juvenile guidance/collection efficiency at dams $ 80%
- Merwin adult trap efficiency $ 90%
- Adult truck transport survival $ 95%
- Percent increase in hatchery fitness TBD
- Reduction in bull trout or fall Chinook populations 0%
- Maintain lower river and reservoir fishing opportunity

Smolt Reservoir Conversion to Dam

Juvenile migration through reservoirs and to collectors or passage facilities is a key component in success of a reintroduction effort. It is expected that some portion of juvenile fish will be lost to predation or residualism. As part of a series of relicensing studies, PacifiCorp and Cowlitz PUD estimated conversion of coho smolts through Swift reservoirs via radio-tagged hatchery smolts released at the head of the reservoir. Results estimated a median travel time of 3.6 days and a conversion rate from the head of Swift Reservoir to the dam of 90 percent. For comparison, NMFS has measured reservoir survival through the lower Snake reservoirs at 89 percent and Northwest Fish Science Center (NWFSC) has measured Columbia reservoir survival ranging from 86-94 percent.

Juvenile Guidance/ Collection Efficiency at Dams

The radio-telemetry and hydroacoustic studies of hatchery released coho at the head of Swift Reservoir concluded that 85% of the fish arriving at the dam would be susceptible to collection with a surface collector based on depth and distribution of the fish. NWFSC has measured collection efficiency with submersible screen guidance ranging from 43 to 96 percent for yearling Chinook in the Columbia basin.

Adult Upstream Conversion to Merwin Dam

This is an unknown factor to be considered when estimating performance of reintroduction strategies. There is little information on the appropriate rate to assume, but conversion could be maximized with effective trap design, appropriate attraction flows, and responsible handling procedures. Success of adult fish passage and a resulting high conversion factor depends on:

- Homing of adults originating from the upper basin to Merwin Dam
- The effectiveness of a Merwin Trap to attract fish to enter
- Trapping handling mortality
- Delayed passage

Adult Truck Transport Survival

Survival data collected on adult steelhead and coho trucked and released above Cowlitz Falls Dam estimates survival at close to 100 percent (Harza 1999a and Harza 1999). It is expected that trucking survival in the Lewis Basin will be correlated with the quality of sorting facilities and handling methods. The LFPA model uses 99 percent trucking survival. Alternative C would have an expanded trucking mortality for Yale and Swift fish due to multiple transports.

Increase Hatchery Fish Fitness (Survival)

It is assumed that completing innovative hatchery practices aimed at integrating the natural production and hatchery programs would result in an increase in smolt to adult survival of hatchery fish and development of stocks suitable for supplementation options. The percent increase in fitness is not quantified, but Deschutes River experiments of spring Chinook suggest potential for significant increase.

Reduction in bull trout and fall Chinook populations

Monitoring for indicators of potential impacts to bull trout populations above Yale and Swift Reservoirs and to wild fall Chinook populations below Merwin Dam should be a consistent part of the post licensing studies. Potential for impacts are associated with spawning and rearing competition, release strategies, predation, and flow regimes.

Maintaining current fishery Opportunity in the Lewis basin

Important fisheries occur in the lower Lewis for hatchery spring Chinook, hatchery coho, and hatchery steelhead. A significant Kokanee fishery occurs in Yale and Merwin reservoirs. Reintroduction options could be evaluated partially on how they affect these important fishery opportunities which attract significant interest.

Phase 1:

Objectives of this initial phase would be:

1. Improve hatchery fish performance
2. Protect and improve habitat
3. Implement studies to clarify fish passage configuration
4. Test habitat potential in specific areas
5. Monitor existing natural populations
6. Monitor harvest

Table 11. Example of implementation phases 1-3 (intended for illustration purposes).

Phase 1: Years 1-5	Phase 2: Years 6-10	Phase 3: Years 11+
Hatchery Actions: • Mark all hatchery fish with adipose clip • Develop feasibility and design for rearing or acclimation facility • Develop feasibility and design for lower river stress relief ponds • Implement innovative rearing practices • Implement supplementation experiments • Develop broodstock for supplementation **Habitat Protection:** • Forest and Fish Plan • Provide large woody debris supply • Continue lower river instream flow regime • Bull trout spawning area enhancement	**Fish Passage Implementation:** **ALT B** Merwin Dam trap and haul Swift smolt collection Potential offsite mitigation **Potential Facilities:** • Adult holding/ sorting facilities • Merwin trap upgrade • Enhanced holding pond for back up • Surface collector or non-criteria/criteria screens • Yale trap for resident fish • Ladder to sorting/loading facilities • Fish truck loading facility • Stress relief ponds **ALT C** Merwin, Yale, Swift trap and haul Merwin, Yale, Swift smolt collection **Potential Facilities:** • Merwin, Yale, and Swift adult holding/sorting • Surface collector or non-criteria/criteria screens • Ladders to sorting facilities • Fish truck loading facilities • Seasonal/modular smolt collector upper Swift • Stress relief ponds • Speelyai Hatchery alternative water supply	**Actions:** • Dependent on Phase 1 and 2 results Actions Could Include: • Changes in hatchery production • Elimination of supplementation program and facilities • Facility operation and maintenance • Implementation of long-term monitoring program • Increased offsite mitigation • Upgrade in facilities • Expanded reintroduction program

Phase 1: Years 1-5	Phase 2: Years 6-10	Phase 3: Years 11+
Initial Studies: • Swift species interactions • Hatchery management plan • Swift fish guidance efficiency • Harvest monitoring • Bull trout passage Swift/Yale • Bull trout spawning enhancements • Yale/Merwin productivity potential • Wild fall Chinook population monitoring • Bull trout population monitoring • Water quality monitoring • Resident trout studies	**ALT D** Volitional adult passage ladders Full criteria screens for juvenile passage **Potential Facilities** • Fish ladder/ exit structures Merwin, Yale, Swift #1, Swift #2 • Fishway entrance • Fish truck loading facilities • Adult holding ponds • Criteria screens Merwin, Yale, Swift #1 • Bypass facility Merwin, Yale, Swift #1 • Subsampling facility Merwin, Yale, Swift #1 • Stress relief ponds	

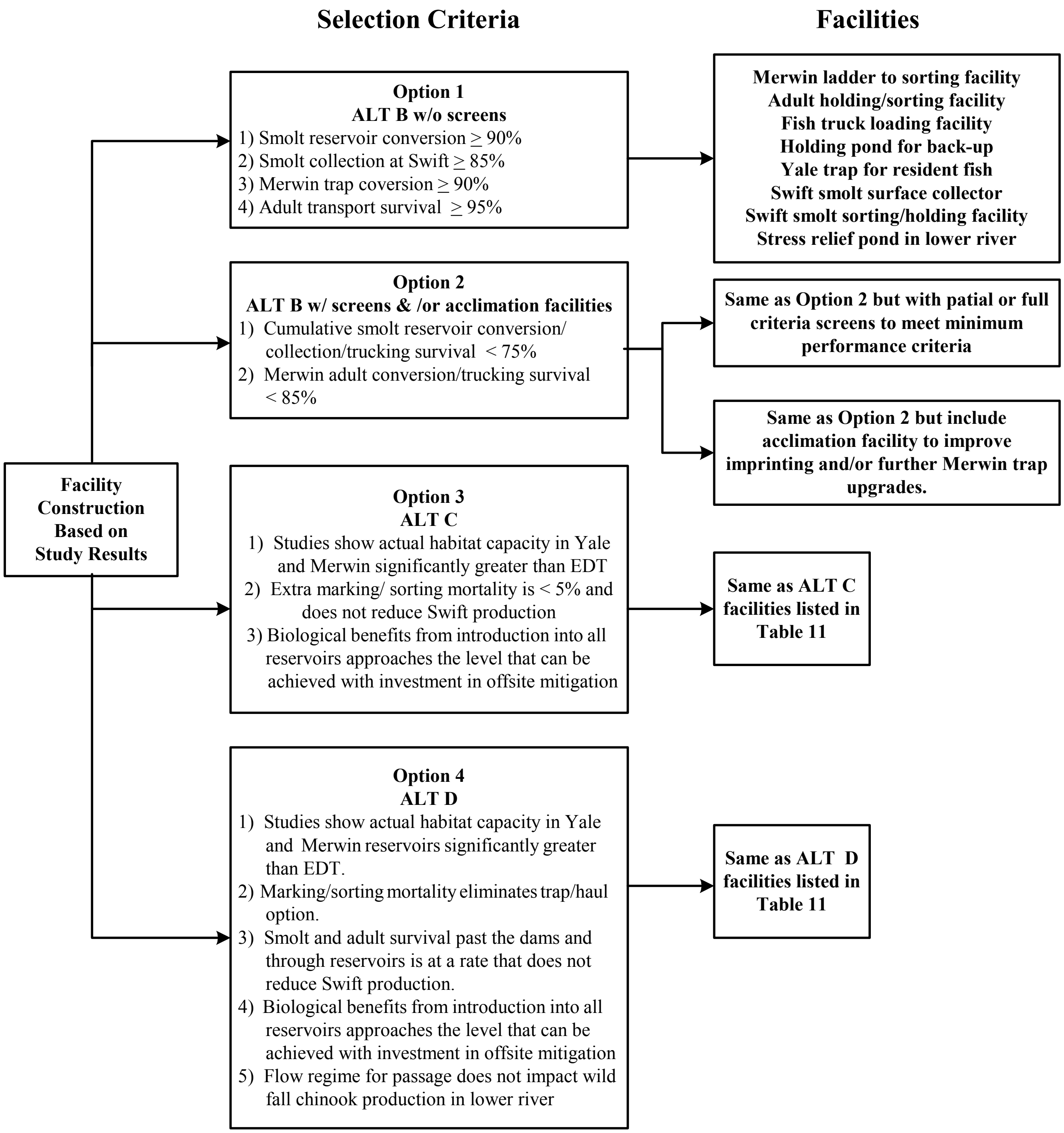

Figure 21. Phase 2 implementation/construction decision.

Phase 1 Studies Summary

Species Interactions

Develop studies to assess introduced salmonid interactions with resident fish upstream of Swift Dam. Use this information to aid in selecting release sites and numbers of fish introduced by tributary. This may include snorkel surveys to assess displacement of bull trout adult or juveniles, predation in the reservoirs, and interaction between resident rainbow, cutthroat, or steelhead. Note, no kokanee above Swift .

Hatchery Management Plan

Develop a plan that integrates natural production management with hatchery management. Include rearing strategies, broodstock development, release strategies, disease control and additional facility designs. This plan can be developed with information from the Hatchery Review.

Bull Trout Entrainment and Trap Studies

Study methods to reconnect bull trout population in Yale and Swift reservoirs.

Per Pratt's study this does not have high potential Yale Productivity Potential.

Research egg to fry and fry to smolt productivity potential in Yale Reservoir tributaries, i.e. Siouxon Creek. This information could support or challenge EDT data which indicates extreme habitat limitations for reintroduction in lower reservoirs.

Wild Fall Chinook Production Monitoring

Continue to tag representative group of wild fall Chinook on an annual basis to maintain abundance data base. This information will be important to use as a base in which to measure any changes in productivity following the reintroduction efforts.

Bull Trout Monitoring

Monitor bull trout abundance to establish and maintain a database to measure any changes in productivity following the reintroduction effort.

Water Quality Monitoring

Monitor total dissolved gas (TDG) below Swift and Yale dams and tailrace temperatures. Use data to introduce potential remedies to meet state water quality standards.

Lamprey Population Assessment

Design a study to assess the current status of lamprey in the basin. Information will be used to incorporate Lamprey into a longer term management plan.

Offsite Mitigation Feasibility

Investigate potential habitat enhancement areas in tributaries, the mainstem North Lewis below Merwin Dam, and in the East Fork Lewis. Focus efforts initially on potential chum enhancement.

Harvest Monitoring

This study would include ocean, mainstem Columbia, and Lewis basin commercial and recreational harvest of anadromous and resident fish species. The task would assess harvest of hatchery production and expectations for harvest of reintroduced natural production. This research will be important to advance understanding of the relationship between harvest objectives, hatchery mitigation objectives, and natural production objectives.

Phase 2:

Phase 2 Implementation

Smolt reservoir conversion: ≥ 90%

Preliminary study by PacifiCorp and Cowlitz PUD indicates this level may be possible. If predation or residualism is higher and conversion through the reservoir is reduced, then compensation would need to be made through a higher collection efficiency standard at Swift Dam or an alternative collection site at the head of the reservoir.

Smolt collection: ≥ 85%

Adult production reduces significantly at lower smolt collection levels, most significantly with spring Chinook. When combined with reservoir conversion and trucking mortality the total smolt conversion from tributaries to release would be 75%. Upgrades to collection facilities (screens) would need to be considered if collection efficiency were not adequate.

Merwin trap conversion: ≥ 90%

Homing and attraction rates to Merwin Trap are critical for converting the surviving adult fish to the spawning grounds. It is reasonable to assume that less than 100 percent of adults that escape the lower Columbia will convert to Merwin Trap. If 90 percent convert, then 81 percent are projected to spawn in the upper basin (after trucking mortality and reservoir passage). If conversion is less, then efforts would need to be made to improve homing or trap efficiency, or compensatory adjustments would need to be made in juvenile passage or harvest reductions (if possible).

Adult transport survival: ≥ 95%

Trucking transport survival should be maintained at 95% or greater. If a higher mortality is experienced then it is likely associated with poor facility structure for sorting and loading causing a higher level of handling stress on the fish. Adjustments would need to be made if adult mortality is not minimized.

Adult habitat potential in Yale is greater than EDT results

Current models indicate very little to gain in terms of production in lower reservoirs with options that provide anadromous fish access below Swift. Conversely, these options add more obstacles for Swift fish and actually result in reduced production in Swift. However, if life history productivity studies in lower reservoir tributaries change this picture, then options to reintroduce below Swift Dam could be considered. Studies should focus on coho and steelhead habitat in Yale.

Extra marking / sorting mortality: < 5%

A major uncertainty in the Alternative C option is the additional mortality associated with I.D. Marking and adult sorting to assure fish produced from a particular reservoir are returned to spawn there. If this additional mortality is significant then it reduces production in lower reservoirs and in Swift.

Smolt and adult volitional reservoir and dam passage survival rate:

At 90 percent reservoir and 95 percent dam passage survivals, the total conversion to the lower river for Swift smolts is 63%. Adult passage at 95% per dam ladder results is 73% survival to the spawning areas above Swift. Ladder distance to meet gradient requirements would be substantial in length. Flow manipulations needed for ladder entry and exit needs are not guarantees. For this option to be implemented there would need to be assurance that passage survival would be substantially increased from the above assumptions and at a level that does not reduce production potential above Swift Dam.

Flow required for passage does not impact wild fall Chinook production

Flows for optimizing juvenile and adult volitional passage through the Lewis hydro system will likely change operation procedures significantly. These new flow patterns may result in reduced rearing habitat for Chinook downstream of Merwin or less than optimal spawning flows.

Offsite mitigation trade-off

Any reintroduction options to Yale or Merwin should be considered in the context of biological gains in these habitats vs. potential benefits in enhancement investments to areas below the dams.

Phase 3:

Phase 3 Implementation

Would involve continued adaptive management in the form of actions or modifications associated with study results, new studies initiated, and reactions to other fishery resource management changes within the Columbia Basin. This phase is represented in more detail in the Hatchery Review Appendix. Some potential response could include:

Changes of hatchery production level

High success level of the reintroduction effort could reduce the need for as many mitigation hatchery fish, dependent on consistency with aggregate hatchery and wild mitigation levels. Changes made must consider affect on harvest.

Elimination of supplementation program and facilities

This could be a result of self-sustaining natural populations in the upper basin or corresponding to a complete failure in the reintroduction effort. In a sustained population scenario the hatchery supplementation now would ideally be reduced to an egg bank program with appropriate broodstock.

Facility operation and maintenance

Maintenance of facilities and operations would continue consistent with the program objectives.

Long term monitoring

This program would be developed in Phase 2 and updated throughout the term of the license as studies were completed, technology advancements, or new fisheries issues identified. Monitoring of life history response in specific tributaries where fish are reintroduced should be included.

Increased offsite mitigation

This would be investigated in Phase 1 and implemented in Phase 2. Phase 3 would involve monitoring of enhancement efforts and expansion of enhancements in lower Lewis Basin sites if upper basin reintroduction results are unsuccessful or in lieu of attempts in some upper basin areas. East Fork Lewis enhancement could be considered in this phase.

Expand reintroduction program

Phase 3 consideration:

- Studies indicate more significant production potential in lower reservoirs than is currently understood.
- Studies conclude that passage, marking, and sorting mortality are not significant enough to preclude an expanded reintroduction effort.
- Expected impacts to other natural stocks (including introduced Swift production) are negligible.
- Cost/benefit comparison supports lower reservoir introduction over offsite mitigation options below Merwin Dam.

LEWIS RIVER FISH POPULATION GOALS

Overview

A sub-technical work group was appointed by the Negotiating Group in February, 2003 to establish methods and provide estimates of pre-dam construction adult, anadromous fish populations in the Lewis Basin.

The purpose of this work is to develop the technical basis for estimating pre-project fish production potential, as a benchmark, and to display the results in a form which would facilitate the Negotiating Group in making decisions concerning population goals for the new license period. The results are expressed in total adults produced.

Work by the sub-group was developed in a collaborative process with a transparent display of methods.

The sub-group was asked to report results after all alternative methods were completed.

Approach

- Use EDT analysis to measure habitat productivity under properly functioning conditions (PFC) and historic conditions
- Evaluate marine survival expectations for next 40-50 years.
- Document current mitigation goals and investigate past methods for establishing goals
- Develop other methods to help corroborate results
- Project population potential downstream of Merwin and on the East Fork Lewis

Considerations for Negotiating Group

- Population estimates above Merwin Dam are directly linked to mitigation goals
- Population estimates below Merwin Dam are not as clearly linked to mitigation goals
- Expectations for the natural production portion of goals to be developed
- Hatchery production level to be developed
- Consideration for habitat enhancements (i.e. Article 49)
- Ocean survival equivalent method can be developed to assess performance
- Adaptive management based on monitoring results

Lewis River Production Goal Development (Upstream of Merwin Dam)

Results

The following tables compare Lewis basin (above Merwin Dam) adult population production estimates using historical (pristine) EDT habitat productivity (Table 12), "good" habitat potential EDT productivity values (Table 13), current mitigation production (Table 14), and Lewis River run construction (Table 15). These methods are presented as a range of population goal summaries in Table 16.

Marine Survival The EDT production estimates are displayed under a range of high and low marine survival assumptions (Rawding and Norman analysis).

EDT Historical assumes pristine (pre-European settler conditions) for tributaries, upper mainstem Lewis, lower Lewis, and Columbia estuary (model by K. Malone).

EDT Good Habitat Potential assumes properly functioning conditions (NMFS model) in upper basin tributaries, historic condition in reservoir (upper mainstem), and current (patient) conditions in lower Lewis and Columbia estuary (model by K. Malone).

Previous Current Mitigation Adult goals for spring Chinook and coho based on WDFW/PacifiCorp 1982.

Run Reconstruction based on terminal escapement and harvest estimates pre-project (Norman analysis).

Additional assumptions:

1. Lewis wild fall Chinook survival of 0.9% was measured from pre-smolt to adult. We expanded by 25% to reflect a smolt to adult survival rate.
2. We adjusted for a repeat spawner rate of 8% for steelhead.
3. Summer steelhead EDT analysis was not completed- assumed value focused on Canyon Creek and Siouxon Creek production potential.
4. Estimated sea-run cutthroat production at 10% of coho based on Cedar Creek trap ratios.
5. Low marine survival based on recent year conditions (late 1970's to late 1990's), high survival 200% of low (based on mid 1940's to mid 1970's). Average survival is midpoint of high and low.

Table 12. Historical EDT production estimates above Merwin Dam

Species	Avg. Ocean	High Ocean[1/]	Low Ocean[1/]	Range of Ocean Survival[2/]
Chum	12,105	18,230	5,979	0.12%-0.22%
Fall Chinook	8,298	11,064	5,532	1.2%-2.4%
Spring Chinook	15,659	20,757	10,560	3%-6%
Coho	33,886	44,439	23,332	5%-10%
Winter Steelhead	7,778	10,205	5,350	6%-12%
Summer Steelhead	~500	656	344	--
Sea-Run Cutthroat	3,389	4,444	2,333	--
Total	**81,615**	**109,795**	**53,430**	

[1] High and low marine survival represents averages for a time period (typically 20-40 years). The survival actually varies significantly within a period. For example:

a. Coho low marine survival averages 5%, however some years survival may be less than 1 percent and some years it may exceed 10 percent.

b. Coho high marine survival averages10 percent, however, in some years survival may be as high as 20 percent and some years it may be less than 5 percent.

[2] Historic (pre-European settlement) survival may be higher than displayed under high marine survival – due to higher fitness level associated with fish not affected by harvest or habitat degradation beginning in the late 19th century.

Table 13. EDT potential habitat. Estimates assume current habitat below project, historical habitat under reservoirs, and PFC habitat in tributaries for area above Merwin Dam.

Species	Avg. Ocean	High Ocean[1]	Low Ocean[1]	Range of Ocean Survival[2]
Chum	2,775	4,469	1,082	0.12%-0.22%
Fall Chinook	5,287	7,049	3,525	1.2%-2.4%
Spring Chinook	9,855	14,151	5,559	3%-6%
Coho	21,753	28,747	14,579	5%-10%
Winter Steelhead	7,018	9,232	4,804	6%-12%
Summer Steelhead	~500	656	344	
Sea-Run Cutthroat	3,101	3,933	2,269	
Total	**50,289**	**68,237**	**41,900**	

[1] High and low marine survival represents averages for a time period (typically 20-40 years). The survival actually varies significantly within a period. For example:

a. Coho low marine survival averages 5%, however some years survival may be less than 1 percent and some years it may exceed 10 percent.

b. Coho high marine survival averages10 percent, however, in some years survival may be as high as 20 percent and some years it may be less than 5 percent.

[2] Historic (pre-European settlement) survival may be higher than displayed under high marine survival – due to higher fitness level associated with fish not affected by harvest or habitat degradation beginning in the late 19th century.

Table 14. Current hatchery production goals.

Species	Hatchery Smolts	Expected Adults	Expected Marine Survival
Chum	0		
Fall Chinook[1]	0		
Spring Chinook	1,050,000	12,800[2]	1.2%
Coho	1,800,000	71,000[3]	3.94%
Winter Steelhead	125,000	1,250	1%
Summer Steelhead	125,000	5,000	4%
Sea-Run Cutthroat	25,000	750	3%
Total		**90,800**	

[1]Article 49 flow agreement

[2]Assumed 4,000 escapement at 2.2:1 harvest to escapement ratio

[3]Mid-point of Lewis estimates (60,000) and Cowlitz estimate (82,000) – Lewis estimate assumed 30,000 escapement and 50 percent harvest rate

Table 15. Lewis salmon and steelhead run reconstruction for above Merwin production

Species	Terminal Run	Harvest Rate	Total Production
Chum	3,000	53%	6,400[1]
Fall Chinook	1,300	81%	6,800
Spring Chinook	3,500	50%	7,000
Coho	29,264	63%	78,600
Winter Steelhead	5,250	34%	8,000

[1]Include entire Lewis basin (above Merwin production estimated at ~ 10% of total)

Table 16. Above Merwin population goal range (Based on comparison of four work group methods).

Species	Current Hatchery Production	EDT Potential[1]	EDT Historical[1]	Run Reconstruction
Chum	0	2,800	12,100	6,400[2]
Fall Chinook	Article 50	5,300	8,300	6,800
Spring Chinook	12,800	9,900	15,700	7,000
Coho	71,000	21,800	33,900	78,600
Winter Steelhead	1,250	7,000	7,800	8,000
Summer Steelhead	5,000	500	550	NA
Sea Run Cutthroat	750	3,100	3,400	NA
Totals	90,800	50,400	81,700	106,800

[1]Average marine survival rates used

[2]Estimate for entire Lewis Basin (approx. 10% above Merwin)

Below Merwin Population Goals

The following tables display a preliminary representation of below Merwin Dam population potential. These projections are based on May 2002 EDT analysis and do not include recent updates. The 2002 estimates do not include coho.

Table 17. Preliminary Lewis Basin population projections (Downstream of Merwin Dam)

North Fork Lewis River

	Habitat Condition[1]			
Species	**Current**	**PFC**	**PFC+**	**Historic**
Fall Chinook	13,200	20,800	34,200	43,200
Spring Chinook	400	1,100	1,200	1,700
Chum	2,200	12,700	31,200	53,300
Winter Steelhead	300	500	600	700

East Fork Lewis River

	Habitat Condition[1]			
Species	**Current**	**PFC**	**PFC+**	**Historic**
Fall Chinook	1,400	2,400	3,600	4,200
Chum	0	13,700	24,300	36,400
Winter Steelhead	1,100	2,200	2,500	3,100
Summer Steelhead	100	300	300	400

[1]Projections made in May 2002, not updated to new EDT inputs

Low and High Marine Survival Estimates

A range for smolt to adult marine survival rate was used for inputs to EDT to project a range of Lewis River adult salmon and steelhead historic abundance. This analysis does not consider the pre-European settlement time period for high survival estimates. The marine survival range was estimated based on the following basic assumptions:

1. Survival rates during late 1970s to late 1990s represent a relatively low period of marine survival
2. Survival rates during the mid 1940s to 1976 represent a relatively high period of survival
3. Wild fish survival rates are greater than hatchery fish survival rates
4. These estimates are long-term survival averages within a time period. There is expected significant survival variation between years

Results

The following table represents a range of marine average survival rates projected for Lewis River salmon and steelhead:

	Range of marine survival rates for wild fish	
Species	**Low %**	**High %**
Spring Chinook	3	6
Fall Chinook	1.2	2.4
Coho	5	10
Winter Steelhead	6	12
Summer Steelhead	6	12
Chum		

Methods

The following table represents the data used to project the relationship between average marine survival during the recent year low survival period and the previous higher survival period. The average is 1.96 and was rounded to 2.0: SAS means smolt-to-adult survival rate.

Low to High Period Survival Expansion (2.0)

Indicator Stock	Early Period		Late Period		Early/Late Ratio
	Years	**SAS**	**Years**	**SAS**	
OPI Coho	1960-77	6.1%	1978-95	2.7%	2.26
Willamette Spring Chinook	1969-76	1.8%	1977-96	1.4%	1.29
Cowlitz Spring Chinook	1971-76	4.4%	1977-95	1.9%	2.32
				mean	1.96

Hatchery to Wild Survival Expansion (1.75)

The following table represents the data used to predict the relative marine survival of wild fish compared to hatchery fish. The average is 1.77 and was rounded to 1.75:

Wild Stock	SAS	Hatchery Stock	SAS	Wild SAS/ Hatch SAS
Lewis Fall Chin (78-79 BY)	0.77	Lower Columbia Fall Chin (78-79 BY)	0.50	1.54
Lewis Fall Chin (78-79 BY)	0.77	Lewis Fall Chin (78-79 BY)	0.45	1.71
Hanford Fall Chin (86-87 BY)	0.30	Priest Rapids Fall Chin (78-79 BY)	0.15	2
Bingham Cr. Coho (80-96 BY)	4.22	Bingham Cr. Coho (80-96 BY)	2.29	1.84
		mean		1.77

Marine Survival Estimates by Species (calculations)

Spring Chinook 3% - 6%

Low 1977-95	Will. & Cowlitz Hatchery SAS	= 1.7%
Wild Expansion	(1.7%)*(1.75)	= 2.98% rounded to 3%
High	(3%)*(2)	= 6%

Fall Chinook 0.8% - 1.6%

Low 1977-present	Lewis River wild survival(.09/.75)	= 1.2%
High	(1.2%)*(2)	= 2.4%

Coho 5% - 10%

Low 1977-95	OPI	= 2.7%
Wild Expansion	(2.7%)*(1.75)	= 4.73% rounded to 5%
High	(5%)*(2)	= 10%

Winter / Summer Steelhead 6% - 12%

Low 1976-96	Deschutes Summer, Eagle Creek Winter, Kalama Winter, Kalama Summer	= 3.7%
Wild Expansion	(3.7%)*(1.75)	= 6.47% rounded to 6%
High	(6%)*(2)	= 12%

Lewis River Salmon and Steelhead Run Reconstruction Methods Summary

Scope:

Develop as another method to consider for corroborating habitat productivity based results (reality check)

Approach:

Reconstruct salmon and steelhead production from above Merwin based on available terminal escapement data and estimates of ocean and Columbia basin harvest.
Focus on late 1920s and early 1930s population estimates.

	Harvest Rates by Fishing Area			
Species	**Lewis River**	**Columbia River**	**Ocean**	**Total Exploitation**
Chum	5%	51%	0	53%
Fall Chinook	5%	75%	20%	81%
Spring Chinook	5%	34%	20%	50%
Coho	5%	51%	20%	63%
Winter Steelhead	5%	31%	0	34%

Species	Terminal Run	Harvest Rate	Total Production
Chum	3,000*	53%	6,400*
Fall Chinook	1,300	81%	6,800
Spring Chinook	3,500	50%	7,000
Coho	29,264	63%	78,600
Winter Steelhead	5,250	34%	8,000

* Includes Lewis production above and below Merwin Dam site

Terminal Escapement Estimates

Chum: Smoker et al. (1951) included entire Lewis Basin

Fall Chinook: Lichatowich et al. (2003)

Spring Chinook: Smoker et al. (1951) – "at least 3,000"

Current mitigation calculated from 4,000 terminal run

Coho: Merwin return reported in 1933

Winter Steelhead: Mid-point of Smoker et al. (1951) – "at least 1,000"

Lavoy (1983 WDG) estimate 8,000-11,000

Harvest Rate Estimates

(Preliminary Summary-Details by species will be documented in the future)

Lewis: Assumed 5 percent removal for all species

Columbia River: Important Assumptions:

1. 1938-1942 salmonid harvest rates used as base.
2. 1960s comparison of lower river specific harvest rates (1950s for steelhead) to total harvest rates.
3. Total salmonid poundage expansion for Chinook (1938-1942) vs. pre 1933.
4. Seasonal adjustments:
    a. Winter steelhead- commercial season open November, February in 1954-1958, open November through February 1938-1942
    b. Spring Chinook- commercial season historically closed early March through late April. Lower river spring Chinook timed earlier then upriver spring Chinook

Ocean: Based on 25 percent estimate in 1950 for Chinook (Cramer 1996), reduced to 20 percent for 1920s – 1930s

RECOMMENDED POPULATION GOALS

The Negotiating Group met and addressed recommendations from the sub-group in May and discussed these as possible population goals as a baseline for developing fish production goals for the upper and lower Lewis basin in an integrated natural and hatchery salmonid program.

Table 18. Recommended Lewis River population goals above Merwin; low, high, and midpoint range of population goals (based on 3 methodologies).

Species	Low (Source)	High (Source)	Mid-Point
Chum	640 (RR[1])	12,100 (EH[2])	6,370
Fall Chinook	5,300 (EP[3])	8,300 (EH)	6,800
Spring Chinook	7,000 (RR)	15,700 (EH)	11,350
Coho	21,800 (EP)	78,600 (RR)	50,200
Winter Steelhead	7,000 (EP)	8,000 (RR)	7,500
Summer Steelhead	500 (EP)	550 (EH)	525
Sea Run Cutthroat	3,100 (EP)	3,400 (EH)	3,250
Totals	45,340	126,650	**85,995**

1RR = Run Reconstruction Method 2EH = EDT Historical Method 3EP = EDT Potential Method

The above table utilizes the range of potential population estimates to develop a midpoint estimate for all species. The range displayed in the table aggregates the three scientific methodologies as a means to buffer the uncertainty contained within each method. Because of the difficulty in projecting marine survival, low and high survival estimates were established based on the past 60 year's experience. An average marine survival was used to capture the range of potential marine survival levels that may be experienced (on average) during the next 50 years.

A run reconstruction method, utilizing available historic Lewis River escapement information and estimating the proportion of the fish harvested before they returned to the Lewis River, was used as an alternative method to compare with EDT results. The run reconstruction method provides an alternative scientific approach to estimating population levels, which enables a comparative analysis between the results of a habitat measuring method and a retrospective fish accounting method.

Comparing the individual species results shows that the EDT methods and run reconstruction method provide both highest and lowest estimates depending on the species. The fact that one method is not consistently high or low compared to the other supports the notion that these methods may, as an aggregate, reflect the range of potential production estimates.

The coho results show the largest difference between the methods, with the run reconstruction method estimate significantly higher then the EDT estimate. The run reconstruction method is based on a count of 29,264 coho at Merwin Dam in 1933, which were progeny of adults not affected by dam construction. An estimated 63 percent of the 1933 run were harvested before entering the Lewis River resulting in an estimated total coho production of 78,600. The 1933 coho return does not appear to be a result of an exceptional marine survival year based on Columbia River commercial landings data. The total salmon and steelhead pounds landed in Columbia River commercial fisheries was about 28 million in 1933, compared to a range of 22-48 million pounds landed during the years 1890-1940.

The spring Chinook results show the lowest estimate of 7,000 from the run reconstruction method and the highest estimate of 15,700 from the EDT historical results.

Based on the results of the subgroups' methods for estimating population goals, and recognition that uncertainty in results may be balanced by utilizing all methods, a mid-point of 85,995 is recommended as a reasonable estimate for a total adult anadromous fish production goal for the Lewis River upstream of Merwin Dam.

In view of the recommendations above, and in view of the stated interests of parties to enhance and recover wild populations while maintaining cultural and recreational fishing opportunities, the federal and state resource agencies, and the Utilities propose the following:

(1) The Utilities' mitigation obligation for the new license will be to ensure production of 86,000 adult salmonids through a combination of hatchery production and natural production, with an emphasis on enhancing and restoring listed and wild salmonid stocks. Production will be the estimated number of smolts needed to produce a total of 86,000 adult ocean abundance.

(2) As natural production levels increase over time, hatchery production will correspondingly decrease. <u>However, the Utilities will continue to produce a minimum of 18,000 hatchery-raised salmonids ("the hatchery floor") during the term of the new license to compensate for inundated habitats below Merwin, Yale, and Swift reservoirs</u>. This means that if natural production reaches 86,000 adults, then total production would be 86,000 total adults plus 18,000 hatchery fish, for a total of 104,000 adults. Hatchery production shall not conflict with survival or recovery of listed species, and the hatchery program shall be subject to ongoing review by NMFS and USFWS to ensure such a conflict does not arise.

The Agencies and Utilities arrived at "the hatchery floor" by averaging the high and low production estimates by reservoir and by species using EDT, then summing across species to arrive at a total mitigation value. The Agencies and Utilities believe that this is a conservative estimate of inundated habitat potential production potential, and is a reasonable basis for establishing the Utilities' mitigation obligation.

The mitigation obligations described above will be subject to the following requirements:

(3) The Utilities, in consultation with NMFS, WDFW, USFWS, and the Tribes, will develop a plan to determine the appropriate allocation of production by species. Total production for each of the first 5 years of the new license will consist of a

combination of natural fall Chinook, hatchery spring Chinook, coho, and winter and summer steelhead.

(4) The Utilities, in consultation with NMFS, WDFW, USFWS, and the Tribes, will collect and sort all returning adult salmonids collected at the Merwin trap, and will transport naturally spawned adult salmonids above Swift, or to other areas as may be required by the settlement agreement.

LEWIS RIVER SALMON AND STEELHEAD RUN RECONSTRUCTION

(*Pre Merwin Dam Construction)*

The population goal/recommendations were derived by using both EDT and Run Reconstruction methods for estimating historic fish abundance in the basin. The run reconstruction method is reported in more detail as follows:

Introduction

The purpose of this analysis is to provide an alternative method (other than habitat assessment) to aid in corroborating results of methods for estimating salmon and steelhead adult production potential in the upper Lewis River prior to the 1932 construction of Merwin Dam. The run reconstruction method utilizes available historic data to provide a reasonable account of total adult fish production in a given year or period, including fish harvested and fish returning to their natal streams to spawn. The final account of run size is measured in total mature adult fish produced from parents that spawned in the Lewis River in areas upstream of the Merwin Dam site. The mature adult currency is measured as fish in the ocean prior to harvest interception. These estimates should be regarded as a general ("ball park") assessment of adult production in the 1920s and early 1930s return years. The basic formula for determining salmon and steelhead production is:

Total adults=escapement + harvest

Estimates of historic escapement were taken from available references, primarily from WDG and WDF (Smoker, et al. 1951) report. Information was also used from LaVoy (1983) and Lichatowich et al. (2003).

In the 1920s and early 1930s, the period immediately prior to the 1932 construction of Merwin Dam, most harvest was associated with Columbia River commercial fisheries which were open 270 days per year. There were commercial fishing closures each year from early March through late April, and August 25 through September 10 and one day per week (Saturday night to Sunday night) was closed during May 1-August 25. Salmon and steelhead landings exceeded 40 million pounds annually several times between 1883 and 1925 (Figure 22). The Columbia River commercial seasons remained consistent in structure until season reductions began in 1943. This analysis uses data compiled in the Columbia River Fish Runs and Fisheries 1938-1999 Report (WDFW and ODFW annual report, 2000) for historic catch and escapement information. The 1938-42 period is used as a baseline to estimate pre-Merwin harvest rates in the Columbia River. The Columbia River fisheries and escapement data is applied independently for each species as the type of historic (harvest and escapement) information available varies between species and races.

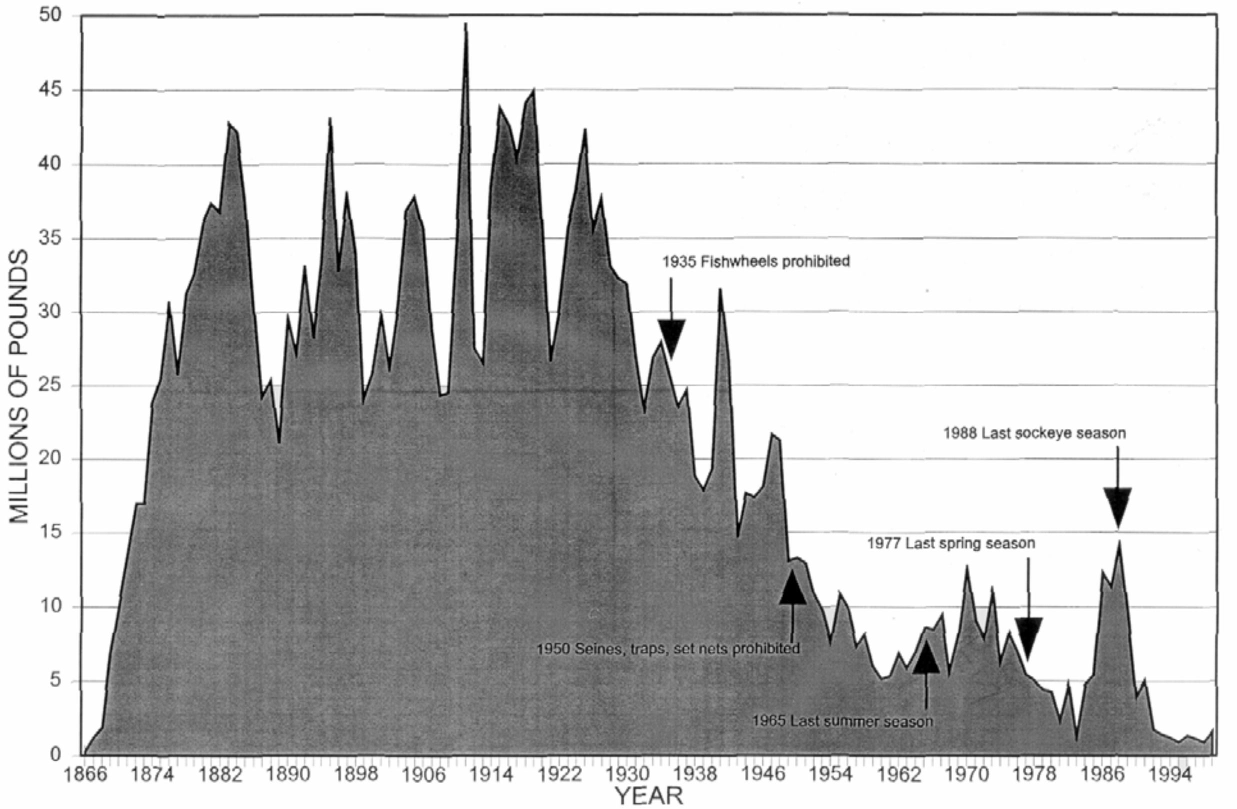

Figure 22. Commercial landings of salmon and steelhead from the Columbia River in pounds, 1866–1999 (ODFW and WDFW 2000)

Ocean commercial salmon fishing effort was low during the big Columbia River harvest years in the late 1800s and early-mid 1900s. Ocean fisheries became more important in the 1950s as Columbia River and coastal estuary fisheries continued to be reduced and sea-worthy craft were improved. This analysis uses information from Cramer (2000) concerning historic ocean fishery harvest rates on Cowlitz Chinook to project pre-Merwin ocean harvest of Lewis fish.

Tributary harvest was relatively low until the 1960s when recreational effort in the tributaries increased as mainstem Columbia seasons were reduced. This analysis assumes a modest sport harvest for all species returning to the Lewis River.

Coho Methods and Results

Escapement: Terminal escapement to Merwin Dam trap in 1933 was 29,264 adult coho, which were fish produced from parents (presumably in habitat above Merwin Dam) in 1930 prior to construction of Merwin Dam. The coho trap number was assumed to be representative of the total return to spawn in the upper Lewis River after a portion of the population was removed in fisheries in the ocean, Columbia River, and Lewis River. The 1933 escapement account was assumed to represent an average production year prior to Merwin Dam construction.

Ocean harvest: Cramer and Vigg (1999) reported a lower Columbia Chinook ocean harvest rate of 25% in 1950. Cramer (1996) reported a 59% average ocean harvest rate of Cowlitz spring Chinook during 1975-79, based on coded wire tag recoveries. The increase in Chinook harvest rates between 1950 and 1975 reflects the ocean fishing effort increase beginning in the late 1950s. This analysis assumes a similar harvest increase pattern for coho and a modest increase in ocean effort between 1930 and 1950. The lower Columbia River coho ocean harvest rate for 1933 was estimated at 20 percent.

Columbia River harvest: Minimum accounting of coho returns to the Columbia were recorded beginning in 1938 based on Bonneville Dam counts plus commercial harvest in the lower river below Bonneville Dam. Minimum coho accounting was expanded to include Willamette Falls, North Fork Dam, and Marmot Dam counts, and Lower Columbia sport fishery catch in 1964. Below Bonneville Dam hatchery return data was available beginning in 1960.

Steps to estimate the Columbia River coho harvest rate are as follows (data in Table 19):

1) Estimate harvest rates on minimum coho run size during 1938-42 (artificially high because escapement to lower Columbia River below Bonneville Dam was not included)
   1938-42 avg. =90%
2) Estimate coho harvest rates during 1964-69 using the same minimum run size accounting as 1938-1942
   1964-69 avg. =77%
3) Estimate coho harvest rates during 1964-69 using more complete run size accounting which includes lower Columbia River escapement.
   1964-69 avg. =44%
4) Compare harvest rates in two methods used for 1964-69 and determine ratio
   44/77=0.57
5) Adjust 1938-42 by difference in rates calculated for two methods for 1964-69
   90% x 0.57 =51%

Tributary harvest: Data was not found concerning Lewis River harvest in the 1930s, but commercial fisheries were mainstem only and sport fishing effort was low compared to recent years-assume 5% harvest rate within the Lewis River.

Table 19. Coho harvest work table (number in 1,000s of fish).

Year	Lower Columbia Commercial Catch	Bonneville Dam Count	Min Run Size[1/]	Max Harvest Rate
1938	256.7	15.2	271.9	94.4%
1939	169.8	14.4	184.2	92.2%
1940	152.8	11.9	164.4	92.8%
1941	113.6	17.9	131.5	86.4%
1942	71.4	12.4	83.8	85.2%
			1938-42 Average	**90.2%**

Year	Lower Columbia Commercial Catch	Bonneville Dam Count	Min Run Size [1/]	Max Harvest Rate	Min Run Size (including lower river esc and sport catch)[2/]	Harvest Rate	Harvest Rate[3/] Ratio
1964	203.4	53.6	257.3	79.2%	453.9	44.9%	0.567
1965	231.5	76.0	307.5	75.3%	519.0	44.6%	0.592
1966	415.5	71.9	487.4	85.3%	785.9	52.9%	0.620
1967	368.8	96.5	465.3	79.3%	694.2	53.1%	0.670
1968	125.1	63.5	188.6	66.3%	423.9	29.5%	0.445
1969	190.1	49.4	239.5	79.4%	463.4	41.0%	0.516
						1964-69 Average	**0.568**

[1/] *Includes lower Columbia commercial catch and Bonneville Dam count*
[2/] *Includes lower Columbia commercial catch, lower Columbia sport catch, lower Columbia hatchery escapement and dam counts at Willamette Falls, North Fork Dam and Marmot Dam.*
[3/] *Relationship between harvest rate with expanded escapement accountability and harvest rate with only Bonneville Dam escapement accountability (similar to 1938-1942)*

Exploitation rate= total harvest rate of ocean population:

1- (1-.20Ocean)(1-.51Columbia)(1-.05Lewis) =62.76 percent harvested

1933 escapement proportion = 1-62.76 = 37.24% escaped fisheries

ESTIMATE OF LEWIS RIVER COHO PRODUCTION

29,264/0.3724 esc. prop. = 78,582 total production

Note: This method treats the terminal escapement measured at Merwin Dam as representative of all fish that escaped past fisheries. This analysis does not adjust for fish that escaped fisheries but did not enter the Merwin Trap.

Because ocean survival is variable between brood years, independent of the freshwater habitat productivity, the 1933 return year was compared with other years based on Columbia River commercial salmon landings. The annual commercial landings were assumed to be a fair indicator of overall salmon survival because the vast majority of salmon produced in the Columbia River were harvested in Columbia River commercial fisheries during the early 1900s. During the period 1890-1940 the salmon and steelhead landings ranged from about 22 to 48 million pounds annually. The 1933 landings were about 28 million pounds, which is about average for the period. The 1934 and 1935 landings totaled about 24 million, or slightly below average, which would include 1930 brood Coho, the same brood year corresponding to the 1933 coho adult return. The comparison of 1933-35 Columbia River commercial landings to the average landings during the period suggest that the 1933 return of coho to the Lewis River were not subjected to exceptional marine survival conditions compared to other pre-dam years, and the 1930 brood (1933 adult return) year likely provides a fair representation of coho production above Merwin in a typical year prior to dam construction

Spring Chinook Methods and Results

Escapement: The Lewis River spring Chinook terminal escapement to the Lewis River above the Merwin Dam site was estimated to be "at least 3,000 fish" based on WDG and WDF reports (Smoker, et al. 1951). A Lewis escapement estimate of 4,000 was used by WDF and PacifiCorp along with a 2.2:1 harvest to escapement ratio to develop an adult spring Chinook production goal in 1982. This analysis used a mid point of the two escapement estimates (3,500) for the escapement component.

Harvest: An important consideration in estimating historic harvest of Lewis River spring Chinook in Columbia River commercial fisheries is that the fishery was closed from March to late April during the period 1909-1942. This closure is an important factor when measuring harvest specific to Lewis River fish, because lower Columbia spring Chinook stock migration through the mainstem Columbia is earlier than upper Columbia and Snake River stocks.

Harvest in the 1938-42 period can be measured similar to coho, which includes total spring Chinook harvest in the lower Columbia and minimum escapement measured by Bonneville Dam counts. Lower Columbia escapement was measured beginning in 1946 with Willamette Falls counts and, beginning in 1962 Cowlitz River escapement was measured. The majority of harvest, until spring seasons were closed after 1977, occurred during the late April-May period, with the earlier winter season averaging less then 10 percent of the total spring Chinook annual harvest. The vast majority of the early winter catch was comprised of lower river stocks, while the vast majority of the spring season catch was comprised of later timed upriver stocks, with the peak abundance of lower river runs moving into the tributaries by late April. The migration timing was understood by fishery managers historically and catch accounting between 1938-1980 recorded winter season landings as lower river stock and spring season landings as upriver stock. Beginning in 1981, stock composition of catch was derived from coded-wire tag recoveries and genetic stock identification. These recent year results confirm the differential run timing between the upper and lower river stocks, but also show overlap in the timing of the runs. Harvest of a particular stock is affected by both fishery timing and relative size of the runs in a given year.

Another consideration for Chinook fisheries is the relative harvest rates in 1938-42 compared to the years before Merwin Dam construction. The seasons in 1938-42 were identical to 1909-1937, however fish wheels (and traps, seines, and set-nets in Washington) were prohibited in 1935 and total commercial landings of salmon and steelhead decreased in the years following. Landings during 1936-42 ranged from 15 million to 32 million pounds. To account for the difference in harvest pressure, the

1938-42 spring Chinook harvest rates were expanded by 20 percent to make them more comparable to the pre-project period when fish wheels were used as well as nets and traps. This adjustment was not made for coho because the coho analysis was specific to 1933, when fish wheels were used, and the coho maximum harvest rate during 1938-42 was already estimated to be 90 percent.

Ocean harvest- Cramer estimated 1975-79 Cowlitz spring Chinook harvest at 59 percent and Cowlitz spring Chinook harvest in 1950 at 25 percent. In this analysis, we assumed a gradual increase in ocean harvest from the 1920s to 1950 and estimated a 20 percent ocean harvest rate for the pre-project period.

Columbia River harvest- We used a method similar to the coho method, but with additional adjustments for the fish wheel prohibition and run timing differences between upriver and lower river spring Chinook stocks. The bulk of the spring Chinook harvest occurred during the latter part of the run (late April to May), which resulted in a higher harvest rate of upriver stock compared to lower river stock. Steps to estimate the Columbia River harvest rate are as follows (data in Table 20):

1) Estimate lower Columbia commercial harvest rates based on minimum Columbia River spring Chinook run during 1938-42 (artificially high because escapement to lower Columbia tributaries is not included)
   1938-42 avg. =55%

2) Expand 1938-42 harvest rates to account for 1935 commercial gear prohibitions.
   55%/0.80 =69%

3) Estimate 1962-66 total spring Chinook harvest rates using the same minimum run size accounting as 1938-42

4) Estimate lower river stock specific commercial harvest rate during 1962-66
   *Assume 100 percent of winter landings are lower river stock
   *Assume 10 percent of spring landings are lower river stock to account for progressive reductions in lower river proportions in fishery. As follows:
      -lower river stock=30 percent of total run (1962-66 avg.)
      -assume 15 percent of first 50 percent of catch is lower river stock (historic county catch records indicate 50 percent of catch occurred in first two weeks of the fishery)
      -assume 5 percent of second 50 percent of catch is lower river stock

5) Determine ratio between lower river specific harvest estimate (step 4) and total harvest estimate (step 3)
   1962-66 avg. lower river/total =.49
6) Apply 1962-66 lower river to total harvest rate ratio for to 1938-42 harvest estimate (after 20 percent expansion)
   (69%)0.49=34% estimated Lewis River spring Chinook harvest rate

Tributary harvest: No commercial fishing and sport harvest considered low in 1920s and 1930s. Assume 5 percent tributary harvest rate.

Table 20. Spring Chinook harvest work table (numbers in 1,000s of fish)

Year	Commercial Harvest			Bonneville Dam Count	Minimum Run	Maximum Harvest Rate
	Feb - Mar	Apr - May	Total			
1938	1.3	94.7	96.0	22.4	118.4	81.0%
1939	3.6	75.2	78.8	76.7	155.5	50.7%
1940	7.6	23.6	31.2	66.4	97.6	32.0%
1941	21.4	35.3	56.7	72.3	129.0	44.1%
1942	10.7	36.7	57.4	40.5	87.9	65.3%
					1938-42 Average	**54.6%**

Year	Commercial Harvest			Total Min Run Size	Total Harvest Rate	Lower River			Lower River to Total Harvest Ratio[4/]
	Feb - Mar[1/]	Apr - May	Total			Harvest[2/]	Min Run[3/]	Harvest Rate	
1962	2.8	119.6	122.4	255.4	47.9%	14.8	56.7	26.1%	0.545
1963	5.4	85.2	90.6	219.6	41.3%	13.9	66.8	20.8%	0.504
1964	5.6	77.1	82.7	247.2	33.5%	13.3	86.4	15.3%	0.457
1965	3.2	91.2	94.6	241.9	39.1%	12.3	75.5	16.3%	0.417
1966	4.1	62.5	71.6	236.1	30.3%	10.4	67.2	15.5%	0.512
								1962-66 Average	**0.490**

[1/] *Includes commercial and sport catch*
[2/] *Includes 100% Feb-Mar harvest and 10% April-May harvest*
[3/] *Includes escapement to Willamette Falls and Cowlitz*
[4/] *Relationship of lower river specific to total spring Chinook harvest rate*

Exploitation rate= total harvest rate of ocean population

1- (1-0.20 Ocean)(1-0.34 Columbia)(1-.05 Lewis) =50 percent harvested

Escapement proportion= 1-0.50= 50 percent escapement past fisheries

ESTIMATE OF LEWIS RIVER SPRING CHINOOK PRODUCTION

3,500 esc./0.50 esc prop. =7,000 total production

Fall Chinook Methods and Results

Escapement: WDF and WDG (Smoker, et al. 1951) reported that the "original pre-project fall Chinook run past the dam site was believed to be at least 1300 fall Chinook". This analysis used 1,300 as a terminal Lewis River adult fall Chinook escapement number.

Ocean harvest: Cramer (1996) concluded that ocean harvest rates on spring and fall Chinook from the Cowlitz River could be used as surrogates for one another, "because the distribution of harvests in the ocean was similar and harvest rates were correlated in years when cohort analysis were available from both races. We used a 20 percent estimate of ocean harvest for fall Chinook during the pre-project period.

Columbia River harvest: The method used to estimate historic harvest of Lewis River fall Chinook also utilized 1938-42 harvest and Bonneville Dam count information in conjunction with later years (1961-65) information when lower river escapement data were available. The fall Chinook estimates were derived by comparing the relationship of lower Columbia and upper Columbia fall Chinook harvest rates during 1961-65 to the estimate of upper Columbia stock harvest during 1938-42. The upper Columbia fall Chinook harvest rates for 1938-42 were also expanded by 20 percent to adjust for the reduced effort associated with the gear prohibitions in 1935.

The Columbia River fall Chinook harvest was divided into upriver and lower river components based on time of catch from 1938-79 and with coded wire tag analysis beginning in 1980. Prior to 1980 the August harvest was recorded as upriver stock catch and the September-December harvest as lower river stock catch. Recent year coded-wire-tag stock composition displays overlap in harvest of the stocks between the early fall and late fall periods, however the season separation method is justified as a general stock separation method, considering that upriver fish were and still are predominately earlier arriving Upriver Bright Stock. The Upriver Bright fall Chinook run timing is also broader then lower river Tules and upriver fish move rapidly through the lower Columbia, without large portions of the run concentrated like lower river fish. The run timing characteristic differences result in higher historic commercial harvest of lower river stock fall Chinook than upriver stock. However, Lewis River fall Chinook run timing is different than lower river Tule fall Chinook and is actually more similar to upriver bright stock run timing. An adjustment was made to account for the unique Lewis River fall Chinook run timing

Fall Chinook Columbia River harvest estimate steps (data in table 3):

1) Estimate the 1938-42 upriver stock fall Chinook average harvest rates based on August commercial catch and Bonneville Dam counts
   1938-42 avg. = 50.6%
2) Expand the 1938-42 upriver fall Chinook harvest rate by 20 percent to adjust for 1935 gear prohibitions
   50.6/0.80=63.3% upriver stock harvest rate

3) Estimate the 1961-65 upriver stock fall Chinook harvest rate based on August commercial catch and Bonneville Dam counts
4) Estimate the 1961-65 lower River stock harvest rate based on September-December commercial catch and lower river escapement data
5) Compare upriver and lower river fall Chinook harvest rates during 1961-65.
   1961-65 avg. lower/upper=0.733
6) Expand upriver stock 1938-42 harvest rate(after 20 percent expansion for fish wheel prohibition) by lower to upper river harvest ratio from 1961-65
   63.3/0.733=86.4% lower stock harvest rate
7) Mid point of upriver and lower river harvest estimates to adjust for Lewis stock run timing
   86.4 + 63.3=149.7/2= 75% Lewis River stock harvest rate

Note: The Lewis River fish run timing is different then most other lower Columbia River Tule type stocks and is similar to the broader run timing of Upriver Bright stock. The Lewis River fall Chinook harvest rate is presumed to be lower than Tule stocks because of run timing, but higher than upriver stocks because of extended availability in lower River commercial fishing areas downstream of the Lewis River.

Tributary harvest: Considered to be low during 1920s and 1930s. Assumed 5 percent.

Table 21. Fall Chinook harvest work table (number in 1,000s of fish)

Year	Lower Columbia Harvest (Aug)	Bonneville Dam Count	Upriver Fall Run	Upriver Fall Harvest Rate
1938	281.5	234.7	516.2	54.8%
1938	293.8	186.1	479.9	61.2%
1970	254.6	303.2	557.8	45.6%
1941	305.2	372.7	677.9	45.0%
1942	290.6	336.8	627.4	46.3%
			1938-42 Average	**50.6%**

Year	Lower Columbia Upriver Stock Catch[1/]	Lower Columbia Lower River Stock Catch[2/]	Upriver Stock Run[3/]	Lower River Stock Run[4/]	Upriver Stock Harvest Rate	Lower River Stock Harvest Rate	Relationship Upper to Lower Harvest Rate[5/]
1961	89.6	26.1	206.4	45.9	43.4%	56.9%	0.762
1962	127.2	31.7	245.2	45.4	51.8%	69.8%	0.742
1963	67.6	31.4	206.7	58.4	32.7%	53.8%	0.608
1964	107.3	47.2	279.8	92.4	38.4%	51.1%	0.752
1965	146.2	57.1	303.9	95.3	48.1%	59.9%	0.803
					1961-1965 Average		**0.733**

[1/] *August commercial catch*
[2/] *Sept-Dec commercial catch*
[3/] *August catch plus Bonneville Dam count*
[4/] *Sept-Dec catch plus hatchery and natural spawner returns*
[5/] *Relationship of upriver harvest rate to lower river harvest rate*

Fall Chinook exploitation rate=total harvest rate of ocean population

1- (1-0.20 Ocean)(1-0.75 Columbia)(1-0.05 Lewis) = 81 percent harvested

escapement proportion=1-0.81 =19 percent escaped past fisheries

ESTIMATE OF LEWIS RIVER FALL CHINOOK PRODUCTION

1300 esc./0.19 esc prop =6842 total production

Chum Methods and Results

Escapement: WDF and WDG (Smoker, et al. 1951) estimated a total Lewis basin chum escapement of 3,000 adults. An estimated 10 percent were fish originating upstream of Merwin Dam. In this analysis we use the 3,000 estimate and then adjust for the proportion originating upstream of Merwin Dam.

Ocean fisheries: It is believed that Columbia River chum salmon act similar to Puget Sound chum and migrate to the high seas and, when mature, move directly back to the Columbia River. This migration pattern results in a negligible harvest in coastal fisheries. In this analysis we assume historic ocean harvest of Columbia River chum to be zero.

Columbia River fisheries: Chum salmon were historically harvested in large numbers in the Columbia River commercial fisheries with landings ranging from 1 to 8 million pounds (50,000 to 650,000 fish) in most years prior to the early 1940s (Figure 19). The commercial season was open daily from September 10 through February until 1943, making the October to December chum migration period wide open for harvest.

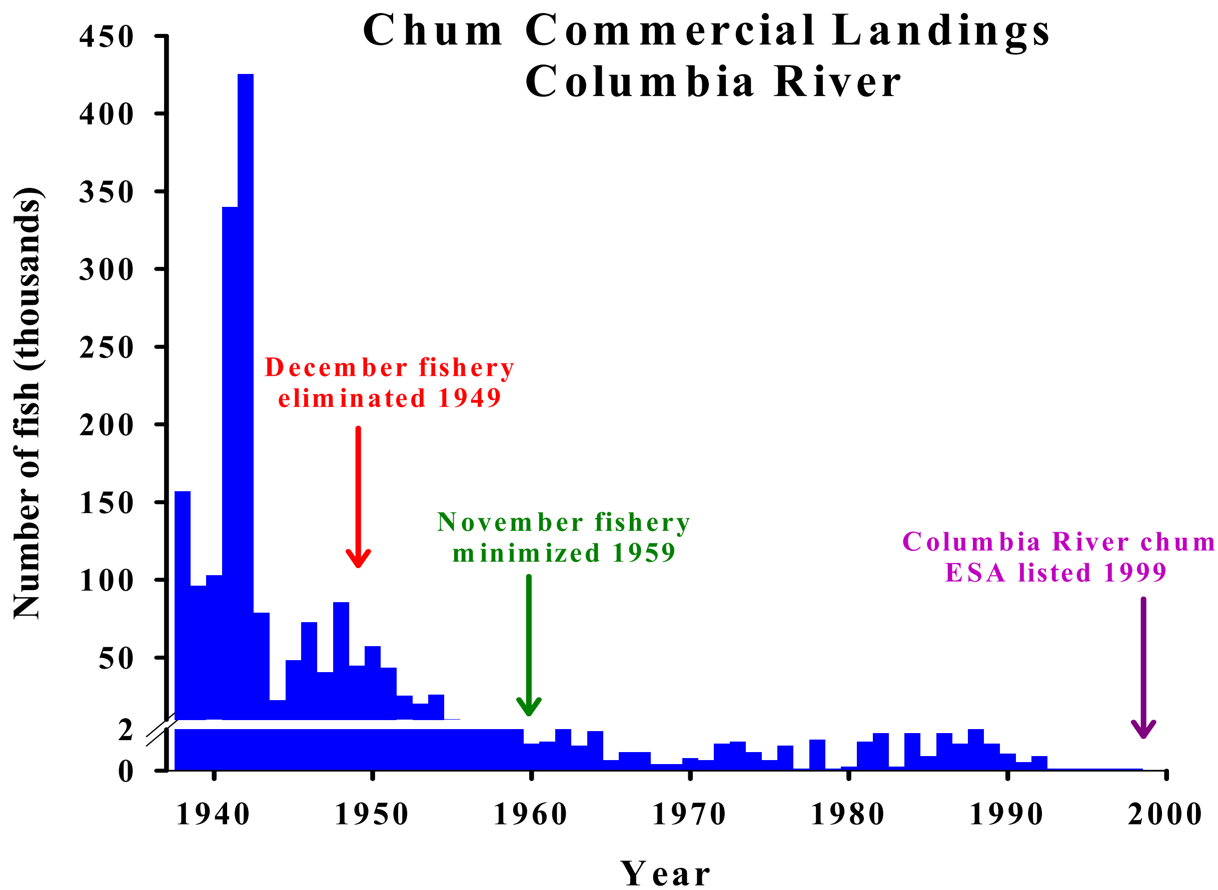

Figure 23. Commercial landings of chum salmon in the Columbia River from 1938-1999.

Historic escapement index counts for chum were not used for harvest rate calculations, as the majority of chum returned to areas in the lower Columbia without passing fixed counting stations, like Bonneville Dam or Willamette Falls. As an alternative method we assumed that the Columbia River chum rate of harvest was similar to the lower Columbia coho harvest rate of 51 percent. We used the coho estimate because:

1) Coho and chum were both exposed to daily commercial fishing in the fall and early winter
2) Late coho and chum run timing is similar
3) Similarity in physical size between chum and coho results in similarities in gear capture effectiveness

Tributary harvest: Assumed a 5 percent harvest rate

Table 22. Chum harvest work table (number in 1,000s of fish)

Year	Lower Columbia Harvest	
1938	156.5	Match coho harvest rate in Columbia fishery open (Oct – Feb)
1939	94.6	
1940	102.7	
1941	340.1	
1942	425.1	

Exploitation rate= total harvest rate of ocean population
1- (1-0 Ocean)(1-0.51 Columbia)(1-.05Lewis)= 53 percent harvested

Escapement proportion= 1-0.53 =47 percent

ESTIMATE OF LEWIS RIVER CHUM PRODUCTION

3,000 esc./0.47 esc. Prop. = 6,383 (0.10 above Merwin) =638 total production

Winter Steelhead Methods and Results

Escapement: WDF and WDG (Smoker, et al. 1951) estimated that the total steelhead spawning abundance above the Merwin Dam site exceeded 1,000 fish. Lavoy (1983) estimated that the total steelhead spawning escapement ranged from 8,000 to 11,000 fish. For this analysis we used the average of the midpoint of Lavoy's estimate (9,500) and the Smoker, et al. (1951) estimate for an escapement estimate of 5,250 winter steelhead.

Ocean harvest: Steelhead migrate to the high seas and harvest in ocean coastal fisheries is negligible and assumed to be zero in this analysis.

Columbia River harvest: The Columbia River winter steelhead harvest and index escapement counts were available beginning in 1953-54. In this analysis we used the lower Columbia commercial harvest rate average for 1953-1959 as an index. The average harvest rate for this period was 23.5 percent. There was a difference in season structure between the 1950s and pre-1943 that had to be accounted for in the analysis.

We assumed the winter steelhead migration period in the lower Columbia included November into April. Pre-1943, the season was open daily from September 10 through February. In the 1950s there were weekly fishing periods (with some days closed) from September 10 through November, and December and January were completely closed. A 25 percent increase in harvest rate was applied to the 1950s harvest to account for the season differences. (23.5%/0.75= 31%)

Tributary harvest: Assumed a 5 percent sport harvest in the Lewis.

Table 23. Winter Steelhead harvest work table (number in 1,000a of fish)

Year	Lower Columbia Commercial Catch	Lower Columbia Run Index	Commercial Harvest Rate
1953-1954	23.4	76.8	30.4%
1954-1955	16.4	49.8	32.9%
1955-1956	11.6	56.0	20.7%
1956-1957	10.7	51.2	20.9%
1958-1959	6.8	54.8	12.4%
		1953-1959 Average	**23.5%**

Exploitation rate= total harvest of adult population

1- (1-0 Ocean)(1-0.31 Columbia)(1-0.05 Lewis)= 34 percent harvested

Escapement proportion= 1-0.34= 66 percent escapement

ESTIMATED LEWIS RIVER WINTER STEELHEAD PRODUCTION

5,250 esc./0.66 esc. Prop. = 7,954

Summary

The following table provides estimates of total adult production from salmon and steelhead originating upstream of the Merwin Dam site prior to construction of Merwin Dam. These results do not include estimates for summer steelhead or sea run cutthroat.

Table 24. Estimate of historic harvest, escapement, and total production of Lewis River salmon and steelhead originating upstream of the Merwin Dam site.

Species	Harvest	Terminal Escapement	Total Production
Coho	49,318	29,264	78,582
Spring Chinook	3,500	3,500	7,000
Fall Chinook	5,542	1,300	6,842
Chum	338	300	638
Winter Steelhead	2,704	5,250	7,954
Total	**61,402**	**39,614**	**101,016**

MANAGEMENT OF LEWIS RIVER BULL TROUT POPULATIONS

Background

The USFWS listed the Columbia River and Klamath Basin Distinct Population Segments (DPSs) of bull trout as threatened on June 10, 1998 (USDI 1998a; 63 FR 31647). This rule combined all DPSs of bull trout in the coterminous United States, and declared them all as threatened.

Bull trout distribution has been reduced by an estimated 40 to 60 percent since pre-settlement times, due primarily to local extirpations, habitat degradation, and isolating factors. The remaining distribution is highly fragmented. Many populations and life history forms have been extirpated entirely. Highly migratory, fluvial populations have been eliminated from the largest, most productive river systems across their range.

Bull trout sub-population persistence requires more than maintaining fish in individual streams, it requires the ability to migrate (Rieman and McIntyre 1993; Gilpin 1997; Rieman, et al. 1997). Migratory bull trout ensure interchange of genetic material between populations, thereby ensuring genetic variability. Migratory corridors tie seasonal habitat together for anadromous, adfluvial, and fluvial forms, and allow for dispersal of resident forms for recolonization of recovering habitats (Rieman and McIntyre 1993).

FWS concludes that each bull trout sub-population is an important phenotypic, genetic, and distributional component of its respective DPS. Therefore, adverse effects that compromise the functional integrity of a bull trout sub-population will be considered an appreciable reduction in the likelihood of survival and recovery of the DPS by reducing its distribution and potential ecological and genetic diversity.

Lewis River Bull Trout

The Columbia River basin supports a total of 141 subpopulations of bull trout with 20 located in the Columbia River DPS. Of these 20 subpopulations, two are located in the Lewis River (Federal Register, Vol. 63, No. 111, June 10, 1998). The Lewis bull trout population is classified as depressed due to chronically low numbers (WDFW 1998). Adfluvial populations exist in Merwin, Yale, and Swift reservoirs.

It is not known how the present hydroelectric reservoirs have affected the North Fork Lewis River bull trout population because of the uncertainty as to what bull trout life histories existed before construction of the hydro projects. Two theories are possible: 1) that the population of bull trout in the North Fork Lewis River was fluvial, with adults residing in the Columbia River and migrating into the North Fork Lewis River to spawn; and, 2) the population was fluvial and completed its life cycle entirely in the North Fork Lewis River and its tributaries. There is some archeological evidence indicating the possible existence of anadromous bull trout in the lower Columbia River and some of its tributaries. The WDG (1973) and WDFW (1998) believe that anadromous and fluvial bull trout/Dolly Varden utilized the Lewis River downstream of Merwin Dam before the dams were constructed.

The two sub-populations of bull trout in the Lewis River are both within the North Fork, with one sub-population in Yale Lake and one in Swift Reservoir (USDI 1998a). As of 1997, only migratory (adfluvial) bull trout had been identified in these reservoirs (WDFW 1998). No known spawning sites are accessible to bull trout in tributaries to Merwin Reservoir or the lower North Fork Lewis River. Therefore, bull trout found in Lake Merwin are probably there due to spill over Yale Dam and are considered part of the Yale sub-population.

Two Lewis River sub-populations were verified by recent genetic analysis (Spruell, et al. 1998). This analysis indicated that North Fork Lewis River bull trout are similar to the Columbia DPS, but that Yale and Swift Reservoir bull trout sub-populations differ significantly. They suggest that some genetic separation could have occurred between the two groups before construction of the dams and that it is unlikely that the 35 years of separation created by the dams could have resulted in genetic drift to this extent. They also suggest that if population sizes are approaching extinction, transfer of individuals between reservoirs may be appropriate. The USFWS does not believe that the two Lewis sub-populations are at risk of extinction in the near-term. But if conditions change or trends indicate a declining population, then this will need to be re-evaluated.

Merwin, Yale, and Swift dams segment the North Fork Lewis River and do not allow upstream passage. The occurrence of limited downstream passage by bull trout over these dams or through the turbines is assumed based on observed adult bull trout in Merwin Reservoir and subadults in the Swift No. 2 power canal. Bull trout currently occupy 22.1 km (11.9 mi) of the mainstem North Fork Lewis River including identified spawning tributaries in Pine, Rush and Cougar creeks (USFW 1995). Although Platts et al. (1995) concluded that insufficient information existed to determine the status and trends of bull trout in Swift and Yale reservoirs, WDFW (1998) considers the sub-populations to be depressed due to "chronically low abundance." The status summary for the Klamath and Columbia DPS lists both the Swift and Yale sub-populations as depressed (USFWS 1998).

Abundance Trends

Bull trout spawning abundance surveys have been conducted in Cougar Creek (Yale population) since 1979, and in Rush and Pine creeks areas since 1994. Annual peak counts are displayed for Cougar Creek for the years 1979-2003 (Figure 24) (WDFW 2003) and spawning population estimates have been small for Swift Reservoir tributaries from 1994-2000 (Figure 28)(WDFW). Current spawning estimates indicate an improving trend for Swift bull trout since then.

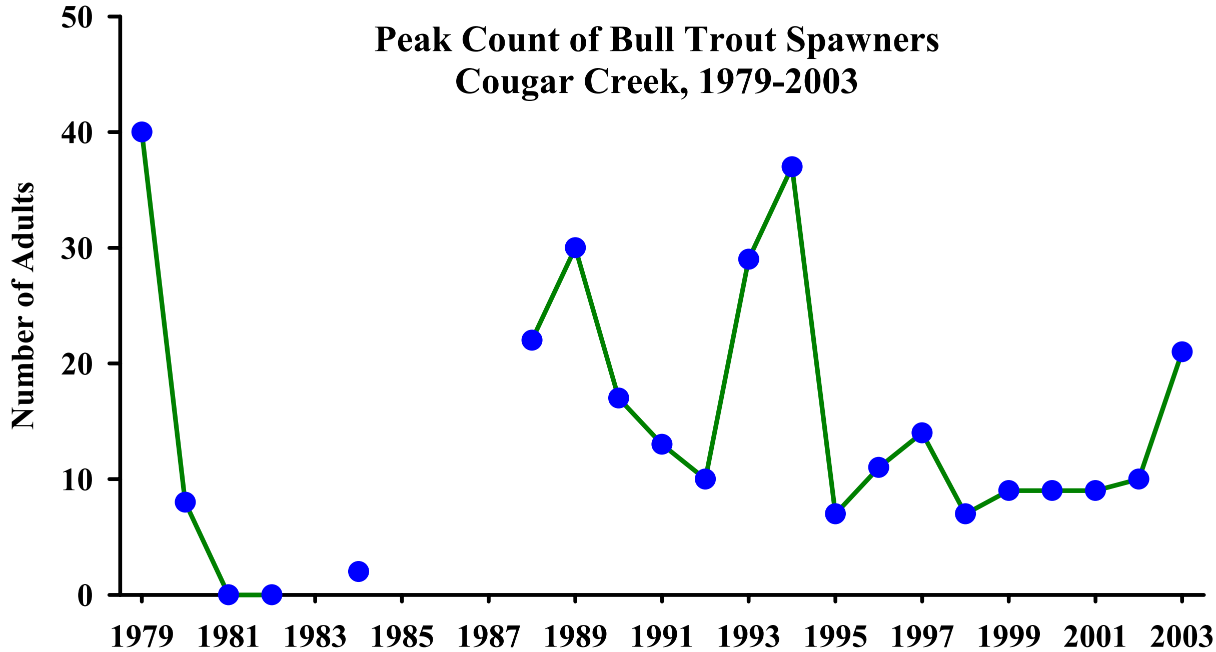

Figure 24. Annual peak counts of bull trout spawners observed in Cougar Creek, 1979–2003.

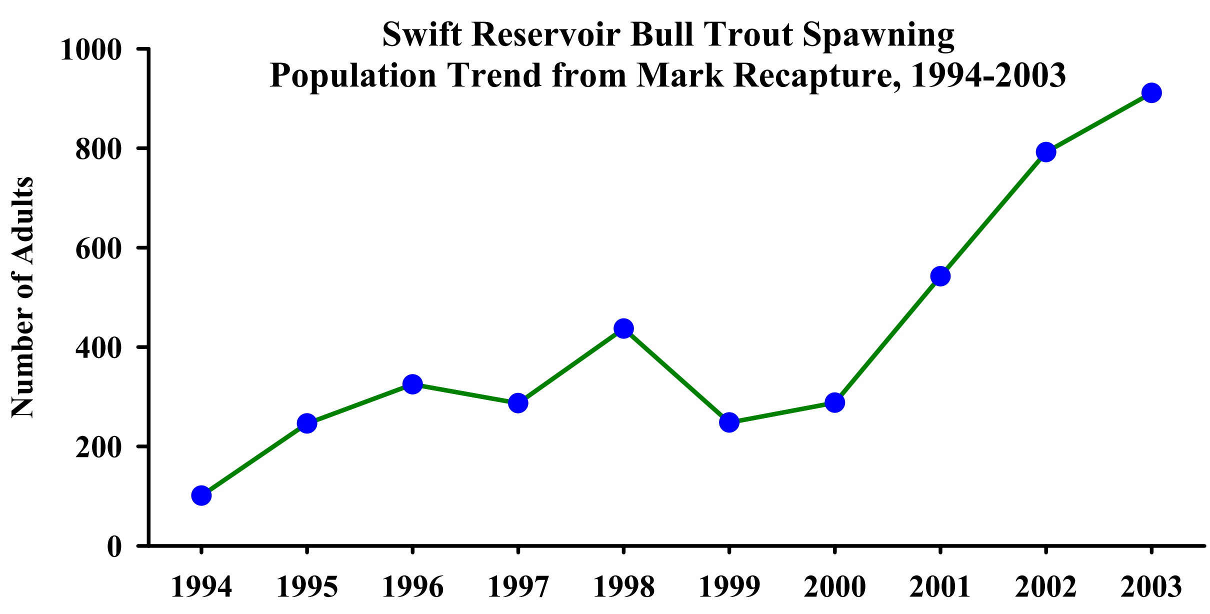

Figure 25. Spawning population estimate of bull trout in Swift Reservoir, 1994–2003 (source: Dan Rawding and John Weinheimer, WDFW).

Management Objectives

Management objectives developed for the Lower Columbia Bull Trout Recovery Unit were adopted for Lewis basin bull trout during the fish planning collaborative process as follows:

Goals: Ensure the long-term persistence of self-sustaining, complex, interacting groups of bull trout so that the species can be delisted. Maintain healthy, stable, or increasing bull trout populations that can support harvest.

Objectives: (1) Maintain current distribution of bull trout and restore distribution in previously occupied areas within the Lower Columbia River Recovery Unit (LCRU); (2) Maintain stable or increasing trends in abundance of bull trout; (3) Restore and maintain suitable habitat conditions for all bull trout life history stages and strategies; (4) Conserve genetic diversity and provide opportunity for genetic exchange.

Conceptual agreement regarding recovery objectives has been reached in the collaborative relicense process. The utilities have undertaken early implementation measures to ensure and enhance bull trout populations including securing conservation easements in Cougar Creek and the Swift Arm of Swift Reservoir, and trapping and transporting entrained bull trout from the Yale tailrace in Merwin Reservoir back into Yale Reservoir.

Additional measures to address Recovery Plan objectives are formalized in a Conceptual Agreement and are focused on:

1) providing adult and juvenile passage and connectivity through the reservoir systems,
2) habitat enhancements and limiting factors analysis,
3) a radio tracking study to determine movement and potential spawning areas,
4) public information program to protect bull trout, and
5) development of a bull trout monitoring plan and program.

CUTTHROAT TROUT

Anadromous, fluvial, adfluvial, and resident forms of coastal cutthroat trout are found throughout the Lewis River watershed (WDFW 2000, PacifiCorp 1999). The anadromous form (sea-run cutthroat trout) is currently found in the North Fork Lewis River and its tributaries up to Merwin Dam (RM 19.4) and in the East Fork Lewis River up to Lucia Falls. Fluvial and resident coastal cutthroat trout are found throughout the upper and lower watershed (upstream and downstream of Merwin Dam), and adfluvial fish have been observed in Merwin, Yale, and Swift reservoirs (WDFW 2000). Although hatchery-origin anadromous cutthroat trout have been released as smolts into the mainstem North Fork Lewis annually (Cowlitz River and Skamania River stocks), the existing Lewis River coastal cutthroat trout stock is considered native with wild production (WDFW 2000). WDFW staff believes that few genetic interactions have occurred between wild and hatchery populations While the existing Merwin Project license requires the production of approximately 25,000 juvenile sea-run cutthroat trout (up to 6,250 pounds), WDFW recently discontinued the production of sea-run cutthroat trout at the Merwin Hatchery (PacifiCorp and Cowlitz PUD 2000c).

Information describing the abundance of coastal cutthroat trout in the Lewis River basin is extremely limited. According to WDFW (2000) there is no data available describing average run size distribution in the basin. In 1998, sea-run cutthroat trout creel survey results on the Lewis River showed a catch of only 20 fish (Hillson and Tipping 1999).

Resident cutthroat trout were the most abundant salmonid species captured during PacifiCorp's 1996-1997 fish population surveys in Yale Lake tributaries. In September 1996, the Swift No. 2 bypass reach contained an estimated 924 cutthroat trout greater than 65 mm (2.5 in) in length (254 cutthroat trout per mile) (PacifiCorp 1999). Cutthroat trout fry and adults were also captured in Ole Creek, Dog Creek, Speelyai Creek, and Panamaker Creek in 1996 and 1997. No other salmonids were observed during sampling in these smaller tributaries. In 1995, the USFS observed low numbers of cutthroat trout in Cougar Creek (USFS 1995a).

Habitat enhancement efforts in the Lewis basin for steelhead and coho will also benefit coastal cutthroat populations. Additionally, cutthroat trout will likely be handled incidentally during reintroduction programs aimed at salmon and steelhead. Although passage of cutthroat trout to and from the upper Lewis basin is not a focus, an anadromous cutthroat component could potentially be part of the outcome.

PACIFIC LAMPREY

Pacific lampreys (*Lampetra tridentata*), largest of the lampreys, are an important part of the Columbia basin in a cultural, utilitarian and ecological sense. The Pacific lamprey was important to the culture of native peoples. Native Americans harvested Pacific lamprey at numerous natural barriers throughout the Columbia basin for subsistence, ceremonial and medicinal purposes.

Two other species of lamprey, the river lamprey (*L. ayresi*) and western brook lamprey (*L. richardsoni*) coexisted with Pacific lamprey in the Columbia River basin (Kan 1975). Western brook lampreys have been observed on Oregon and Washington streams (Jackson et al. 1997).

Understanding of Pacific lamprey population status in the lower Columbia is hindered by lack of data. Very little research has focused on Pacific lamprey distribution, abundance, productivity, migration survival, and habitat association. However, limited available data suggest that Pacific lamprey populations in the Columbia basin have been declining since the construction of the hydroelectric network of dams on the mainstem Columbia River. Adult lamprey counts at each of the mainstem dams are markedly lower than counts during the mid-1900s, and growing evidence indicates that Pacific lamprey have great difficulty surviving downstream passage at dams and migrating upstream past dams. Average passage over Bonneville between 1938 and 1969 was 109,000, and ranged from 26,000 to 380,000. Since lamprey counts at Bonneville Dam were reinstated in 1997, lamprey passage has averaged 39,000 and has ranged from 19,000 to 100,000 (Figure 26).

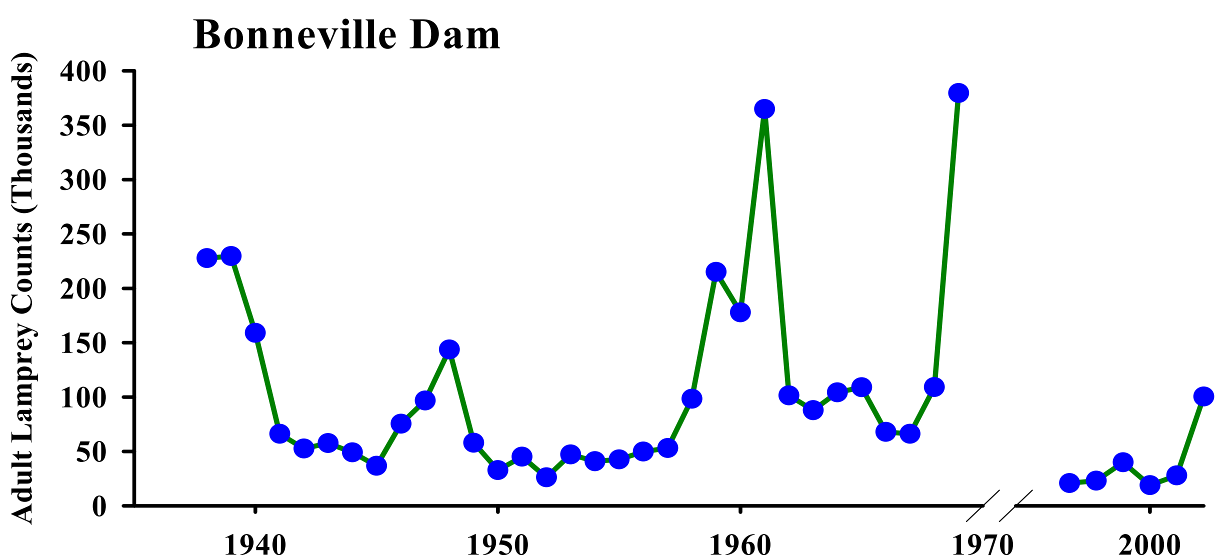

Figure 26. Annual counts of Pacific lamprey passing Bonneville Dam, 1938–69 and 1997–2002

The USFWS conducted lamprey studies in Cedar Creek (lower Lewis tributary) in 2000 and 2001. The USFWS data indicates significant lamprey presence, primarily Pacific lamprey, but also some presence of Western brook lamprey in Cedar Creek. Habitat enhancement efforts downstream of Merwin Dam could also benefit the existing Pacific lamprey population in the lower Lewis basin.

REFERENCES

10,000 Years Institute and Steward and Associates. 2001. Comparative assessment of risk to migration, salmon in the Lewis River: Volitional trap vs. trap and haul. 10,000 Years Institute and Steward and Associates.

ARG. 2002. Lewis River Study Description, July 2002.

Beamesderfer, R.C.P. 2000. Conservation risks of mixed stock fisheries for wild spring Chinook salmon from Oregon's McKenzie River based on a population viability Analysis. Appendix C. in Oregon Department of Fish and Wildlife, Fisheries Management and Evaluation Plan, Upper Willamette River Spring Chinook in Freshwater Fisheries of the Willamette Basin and Lower Columbia River Mainstream. Report to the National Marine Fisheries Service.

Beamesderfer, R.C.P. 2000. Willamette spring Chinook fisheries management and evaluation plan. S.P. Cramer and Associates, Sandy, Oregon.

Cramer, S.P. and R.C.P. Beamesderfer. 2001. Population dynamics, habitat capacity, and a life history simulation model for steelhead in the Deschutes River, Oregon. S.P. Cramer and Associates, Sandy, Oregon.

Cramer, S.P. and R.C.P. Beamesderfer. 2002. Salmon PopCycle to systematically explore the potential for successful reintroduction of anadromous salmonids. S.P. Cramer and Associates, Sandy, Oregon.

Eicher Associates. 1987. Turbine-related fish mortality: review and evaluation of studies. Prepared for EPRI, November 1987. EPRI AP-5480.

Harza. 1999. 1996 Juvenile salmonid radio-tagging study. Prepared for Tacoma Power. Prepared by Harza Engineering, Bellevue, WA.

Lichatowich, J., G. Gilmour, and K. Dubé. 2003. A conceptual foundation for the management of the Lewis River salmonid populations. June 24, 2003.

Mediation Team. 2002. Mediation Team's "straw dog" draft PDEA alternatives. Notes dated Nov. 14, 2002.

Mills, R.D. 2002. Annual coded-wire tag program, Washington missing production groups. Bonneville Power Administration, Portland, OR.

Mobrand Biometrics, Inc. 2000. Draft fish passage study working document. Lewis River Relicensing-Fish Passage Study Working Notebook. Mobrand Biometrics, Inc.

Mobrand Biometrics, Inc. 2002. Lewis River Fish Passage Analysis Model Instructions. Mobrand Biometrics, Inc.

Mobrand Biomtetrics, Inc. 2003. EDT results for the Lewis River Basin. Personal communication, Kevin Malone, Mobrand Biometrics, Vashon Island, Washington.

NMFS. 2000. Biological opinion: reinitiation of consultation of operation of the federal Columbia River power system, including the juvenile fish transportation program, and 19 Bureau of Reclamation projects in the Columbia Basin. U.S. Army Corps of Engineers, Bonneville Power Administration, Bureau of Reclamation, and National Marine Fisheries Service. Consultation Conducted by: National Marine Fisheries Service, Northwest Region. December 21, 2000.

NWFSC. 2000. White paper on volitional passage. Available on the web at www.nwfsc.noaa.gov/pubs.

ODFW (Oregon Department of Fish and Wildlife). 2002. Integration of management in ocean and Columbia River fisheries in 2002 to meet conservation requirements for Oregon Coastal Natural and Lower Columbia River Wild coho salmon. Exhibit B.5.g ODFW recommendations March 2002. Oregon Department of Fish and Wildlife.

ODFW and WDFW (Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife). 2001. Status report Columbia River fish runs and fisheries, 1938-2000. Portland and Vancouver.

Olsen, E.A., R.B. Lindsay, and W.A. Burck. 1991. Summer steelhead in the Deschutes River, Oregon. Oregon Department of Fish and Wildlife, Corvallis, OR.

OTA. 1995. Fish passage technologies: protection at hydropower facilities. U.S. Office of Technology Assessment. OTA-ENV-641. Washington DC; U.S. Government Printing Office, September, 1995. Nicolay, Robin. 2001. Relicensing hatchery needs, memo to Chuck Johnson August 24, 2001. Washington Department of Fish and Wildlife, Lewis Complex, Ariel, Washington.

U.S. Fish and Wildlife Service. 2002. Endangered Species Act – Section 7 Consultation, biological opinion for the interim operation of the Lewis River hydroelectric projects. United Stated Department of Interior, U.S. Fish and Wildlife Services. Lacey, WA.