Predictions of Coho Salmon (*Oncorhynchus kisutch*) Population Abundance in the Clearwater River, Washington Using Various Habitat-Rating Scenarios of the Ecosystem Diagnosis and Treatment Method

by

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Abstract

Fifteen Pacific salmon (*Oncorhynchus* spp.) populations in Washington State have been listed under the Federal Endangered Species Act as threatened or endangered. With 75% of Washington's land base affected by these listings, it is imperative that future population growth and natural resource management consider the habitat requirements of the Pacific salmon at a watershed scale.

The focus of this study is to evaluate a habitat-rating model that can be used in subbasin planning, known as the Ecosystem Diagnosis and Treatment method (EDT). Using coho salmon (*Oncorhynchus kisutch*) as the focal species, baseline runs were conducted of four habitat conditions; historic, current, Habitat Conservation Plan, and Properly Functioning Condition. The EDT model was used to rate habitat at the reach scale for the productivity and capacity for different coho life stages. Life history trajectories were formed from the integration of the productivity and capacity estimates of individual reaches. The integration of all trajectories that maintained some survival estimated the capacity, productivity, and life history diversity of the Clearwater River wild coho. Habitat data used for the analysis came from Washington Department of Natural Resources habitat surveys, Quinault Indian Nation habitat surveys, with supplemental resource data coming from a variety of technical reports and publications and water quality data from other agencies.

The habitat ratings of current conditions were compared to historic conditions to provide the "boundaries" for defining restored or degraded conditions (based on the assumption that current conditions are "degraded" conditions and historic conditions are "restored" conditions). Productivity estimates of the hypothesized *Habitat Conservation Plan* and *Properly Functioning Condition* scenarios were bound within the margins of historic and current productivity estimates. The model suggests that the current abundance estimate (5.1 returns per spawner) is approximately 40% of historic condition abundance estimate (12.9 returns per spawner). The yearly average of adult spawners for a 21-year period (2,380 adults from 1981-2002) was exceeded by adult equilibrium abundance estimates from EDT Historic Conditions scenario (5,333 adults) but compared more reasonably with EDT's current condition scenario (3,319 adults, equilibrium abundance with no fishery). Other adult estimates, including calculations based on summer rearing density (18,000 adults), redd density (15,360 adults), and nutrient saturation (47,400 adults) indicate far greater capacities than the average returns on record. Smolt capacity was estimated at about 109,000 in the current condition, about 71% of capacity under estimated historic conditions.

At a reach scale, factors related to sediment load and channel stability consistently showed high and extremely high ratings pertaining to their effects on survival. This is consistent with the watershed characteristics of many tributaries providing viable spawning habitat and moderate to high amounts of fine sediment due to past landslide/debris flow effects, high instream bedload, and frequently occurring lateral bank erosion in tributaries. At a larger geographic scale, the lower Clearwater mainstem ranked highest in relative importance for change in abundance under the HCP scenario.

This is consistent with the influence that the EDT's off-channel habitat factor contains to accommodate the productivity value of critical wall-base or off-channel habitats located on the lower Clearwater River floodplain terraces. Also, most life history trajectories route through the lower Clearwater making it a vital contributor to productivity and life history diversity. The best benefit, however, may be in preservation of the reach and not necessarily in restoration since coho have other factors limiting productivity than mainstem reaches, such as overwinter habitat, predation, and spawning success.

The EDT accommodated a variety of watershed data in continuous and discrete form. The EDT framework is conducive for habitat evaluation at various scales such as the stream reach or sub-basin scale. The model framework provides flexibility to assign spatially-explicit survival rates and behavior patterns to various life stages. This can be useful for long-term trend monitoring but does not necessarily address cause-and-effect relationships between land management and salmon productivity. This is likely due to the variability of non habitat-based factors influencing populations such as ocean conditions or population resilience. An analysis summary of strategic priorities for survival factors provides some preliminary hypotheses for application in long-term trend monitoring in the Clearwater River drainage.

Overall, the EDT shows promise to provide monitoring and restoration guidelines for Washington Department of Natural Resource management where aquatic and riparian resources are concerned. The EDT identified candidate preservation areas such as specific spawning areas in the Snahapish River and Miller Creek. Certainly, because of the familiarity that the expert opinion provided in the assessment, many of these priority areas of protection and restoration could have been noted in other types of assessments.

Initiating such sub-basin level planning, however, does provide a framework for cooperation of multiple landowners and resource users, especially in subbasins where there is limited resource information. In subbasins where the DNR does not maintain predominant ownership, they may find opportunities where EDT is being applied and enter into cooperative efforts with others by providing information about their landscape conditions.

Table of Contents

List of Figures viii
List of Tables x
List of Appendices xi
Definitions xii
Introduction 1
Study Area 7
Status of Coho Salmon 11
Life History and Habitat Use of Clearwater River Coho 14
The Ecosystem Diagnosis and Treatment Method 17
Model Premises 18
Model Features 21
Model Framework 22
Model Conceptual Operation 26
Model Baseline Analysis 31
Model Outputs 32
Method 33
Data Input 33
Reach descriptions 34
Hydrologic Characteristics 34
Stream Corridor Structure 38
Water Quality 39
Biological Community 40
Data Synthesis 41
Modifications 41
Model Runs 42
Life History Diversity 48
Productivity Estimates by Alternative Methods 48
Results and Discussion 52
Population Performance 52
Historic and Current Conditions 52
Alternative Scenarios: Habitat Conservation Plan and Properly Functioning Condition 55
Life History Diversity 58
Productivity Methods by Alternative Methods 59
Reach Analysis 60
Protection and Restoration Benefits for Clearwater River Coho 64
Priorities to Address Survival Factors 72
Recommendations 75
Conclusion 89
Literature Cited 93

List of Figures

Figure 1. Clearwater River study site map with main tributaries……...8

Figure 2. Clearwater and Total Queets River adult natural escapement 1979-2002.…...13

Figure 3. Clearwater and total Queets River smolt production 1979-1998……..13

Figure 4. Beverton-Holt production function….……..20

Figure 5. The Ecosystem Diagnosis and Treatment conceptual framework……...….23

Figure 6. Ecological information structure of the Ecosystem Diagnosis and Treatment method……...……27

Figure 7. Conceptual display of life history trajectories calculated by EDT to determine productivity.…..……30

Figure 8. Clearwater Natural coho stock-recruitment curves under current and historic conditions with no harvest effects……...…..53

Figure 9. Beverton-Holt population parameters for natural coho smolts in the Clearwater River under the current and historic conditions……..……..54

Figure 10. Beverton-Holt population parameters for adult natural coho in the Clearwater River under four habitat scenarios (current, Habitat Conservation Plan (HCP), properly functioning condition (PFC), and historic)… ……...…….56

Figure 11. Beverton-Holt population parameters for coho smolts in the Clearwater River under four habitat scenarios (current, Habitat Conservation Plan (HCP), properly functioning condition (PFC), and historic)…….……57

Figure 12. Clearwater River coho reach analysis for Clearwater-03B….....…….....61

Figure 13. Clearwater River coho reach analysis for Miller-4….……..62

Figure 14. Schematic representation of restoration and degradation potential of coho salmon in the Clearwater River……...…….…65

Figure 15. Relative importance of geographic areas for restoration and protection

measures for Clearwater River coho
salmon……...…….……...…….68

Figure 16. Summary of restoration strategic priorities for survival factors corresponding to geographic areas within the Clearwater watershed for coho salmon...…...73

List of Tables

Table 1. Fish species known to occur in the Clearwater River, Washington……...……10

Table 2. Hierarchical organization of Level 2 Environmental Correlates to demonstrate which Level 2 Environmental Correlates are used to translate into Level 3 Related Survival Factors……...…….…..…….…….
24

Table 3. Reach descriptions of the EDT baseline runs for the Clearwater River…….35

Table 4. Summary of EDT model runs……...……...……...43

Table 5. Matrix of pathways and indicators used for Properly Functioning Condition…45

Table 6. A comparison of estimated adult returns using various techniques……..…..50

Table 7. Summary of outputs for model runs that increased likelihood of recruitment into off-channel habitat reaches……..…....70

List of Appendices

Appendix A: The EDT Method

Appendix B: Information Structure of the EDT

Appendix C: Reach Data for Clearwater River EDT

Definitions

Beverton-Holt functions: The mathematical formulas that describe the relationships between fish survival, productivity, fecundity, and abundance.

BioRules: Model rules that translate knowledge about the environment into knowledge, or operating hypotheses, about species response. They describe the suitability of the environment for species performance. BioRules address two aspects of performance: productivity and capacity.

Biological performance: The ability of a watershed to support and sustain life as measured by productivity, capacity, and life history diversity of the diagnostic species.

Biological performance response: The predicted change in biological performance as the result of implementing a particular alternative for environmental management.

Ecosystem: The system of interactions between living organisms and their environment.

Evolutionarily significant unit: A set of populations that is morphologically and genetically distinct from other similar populations or a set of populations with a distinct evolutionary history.

Equilibrium abundance (also called Sustainable Yield): The long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological and environmental conditions without a change in biomass - the use that a renewable resource can sustain without impairing its renewability through natural growth or replenishment.

Life history diversity: The multitude of life history pathways (temporally and spatially connected sequences life history segments) available for the species to complete its life cycle.

Population carrying capacity: The theoretical maximum size of a population that can be sustained by specific environmental conditions and resources present in a particular area.

Recruit: A fish added to the exploitable stock each year due to growth and/or migration into the stock boundaries.

Stock recruitment curve: A graph of the progeny of the spawning population at the time they reach a specified age (for example, the age at which half of the brood has become vulnerable to fishing) plotted against the abundance of stock that produced them.

Survival factors: Environmental factors, termed “umbrella attributes”, in EDT analysis that have direct effects on salmonid abundance and productivity.

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Above and beyond all - thanks to my wife Elsa for support and encouragement through N years and also to my beautiful growing family who have taught me everything I ever wanted to know about productivity, life history diversity, and carrying capacity!

This thesis is dedicated to three unprecedented influences: My parents, the biggest believers in my ambitions who, with their lives, has provided the best family model I have ever seen; and my mentor, colleague, and friend Jeff Cederholm who has proven valiant in the battle for the wild salmon and has taught me not to merely look and observe, but to understand!

The man who insists upon seeing with perfect clearness before he decides, never decides.
Henri-Frédéric Amiel

Introduction

More than two-dozen "Evolutionarily Significant Units" (ESUs) of Pacific salmon are listed as threatened or endangered and many other populations have declined throughout the west coast of the United States. Certain federal agencies have legal mandates to conserve and restore salmon populations. State and local governments maintain policies to restore or maintain the habitats for these populations to persist or recover. Undoubtedly, Pacific salmon populations and their habitats remain conservation and restoration priorities in Pacific Northwest natural resource management (WS-JNRC 1999, State of WA-SRO 2002). Results from continued research and monitoring of salmon and their habitats validate the pacific salmon's varied and complex life histories. These complexities provide a challenge for effectively applying this knowledge to land and fish management decision-making, especially as changes occur in land and resource use. The dilemma of maintaining and/or restoring fish populations amidst increasing land-use pressures has created a demand for planning and decision-support tools. Land use planners and natural resource managers can use these tools to evaluate potential outcomes of proposed management scenarios.

Ecosystem-based fisheries management tools are receiving widespread application throughout the United States (Latour et al. 2003). Additionally, strong arguments are being made to support the need to incorporate knowledge of the Pacific salmon's life history and changing environmental conditions into escapement management (Cederholm et al. 2001, Knudsen et al. 2003, PFMC 2000). Several Pacific Northwest habitat and fishery resource models provide decision support for issues as they

relate to fishery and land management. Remote sensing and increasingly robust spatially-explicit habitat and productivity databases have provided promise for such applications. Some of the more recognized applications in the region include:

1) the Plan for Analysis and Testing Hypotheses (PATH) (Univ. of WA 2000);
2) the statistically-based Cumulative Risk Initiative (CRI) (NMFS-NOAA 2000);
3) the United States Forest Service and Bureau of Land Management's Interior Columbia River Basin Ecosystem Management Plan-Bayesian Belief Network (Haynes et al 1996);
4) the Columbia River Intertribal Fish Commission's COHORT model,
5) the Ecosystem Management Decision Support (Reynolds et al. 1996, Reynolds 2001);
6) the Fish Forestry Interaction Project (Alexander et al. 1998); and
7) the expert-system species habitat analysis based Ecosystem Diagnostic and Treatment (EDT) method (Mobrand et al. 1997).

These varying approaches can be categorized as either decision-analysis based, statistically-based, or expert-system based.[1]

Land management and fish management agencies have objectives that can overlap or be exclusive of each other. When various management objectives exist in a watershed because of multiple fish species, water quality concerns, or forest management, it is evident that there is no particular management model that is appropriate for all situations. Each model has its own strengths and weaknesses

1. Decision analysis techniques can vary but the logic is generally driven by decision trees based on probable outcomes of events. Statistically-based decision analysis use databases that have derived statistics and expert-based systems can use expert knowledge rather it be statistical or observational. In summary, the nature of decision-making is the ability to make the correct decision when faced with imperfect information.

depending on the particular application.

Salmon use a variety of habitats depending on their life stage and land-use planners are increasingly dependent on biologists and natural resource managers to identify these habitats and determine critical areas. Knowing the location and types of habitats that are vulnerable to impacts provide invaluable assistance for prioritizing conservation and restoration efforts. A variety of efforts related to salmon recovery are being applied throughout the region, many focusing on watershed-scale priorities. Assessing environmental conditions and relating that to assumptions on how well salmon survive in those conditions, is one way to estimate the productivity potential of a watershed. Further, salmon life history patterns, which can be numerous depending on population size and the species, can also be considered for refined productivity estimates. Population parameter estimates (number of smolts, smolts per adult, etc.) can then be derived based on a rating of habitat conditions

Salmon have been a prominent part of considerations for ecosystem-based management largely because they have been considered a keystone and indicator species for freshwater, estuarine and marine conditions (Willson and Halupka 1995; Lichatowich et al. 1995). The salmon are important for maintaining these freshwater and estuarine ecosystems. Many fish and wildlife species have developed complex relationships with the Pacific salmon and some wildlife species have adapted life history stages according to salmon presence since they provide nutrients for their reproductive success or growth and maturity (Cederholm et al. 2001). Because salmon-watershed interactions are so complex, multiple attribute models may provide reasonable interpretations about current habitat conditions. The EDT (Lestelle et al. 1996, Mobrand et al.1997) is one such

expert-system based approach. Using a heuristic (discovery-based) expert system to address complex salmon-watershed interaction can provide useful results for decision-making. The EDT has received recognition in the Pacific Northwest as a tool in watershed and salmon habitat recovery planning.

The Washington Department of Natural Resources manages their Washington forestland under the guidance of a Habitat Conservation Plan (HCP) (WDNR 1997). The HCP addresses state trust land management issues relating to compliance with the Federal Endangered Species Act. Primarily written for spotted owl (*Strix occidentalis caurina*) and marbled murrelet (*Brachyramphus marmoratus*) conservation, the HCP also contains a riparian strategy to conserve the habitats of a variety of wildlife species in western Washington, including salmonids (*Oncorhynchus* spp., *Salvelinus* spp.). Management strategies related to riparian areas propose that the stream protection provided should restore or maintain environmental conditions that support viable salmon populations. Monitoring and research of these strategies will play a vital role in validating these assumptions.

The problem of evaluating the effects of land use actions on salmon populations and their survival is difficult. Factors that influence their productivity can be highly variable or undetectable because of the complexity of salmon biology and its interaction with landscape and aquatic environmental conditions (Holmes 2001, NRC 1996, Irvine et al. 1992). Most land use actions do not affect salmon survival directly. Rather, land use actions can have negative effects on habitat variables that may or may not directly affect salmon productivity. These difficulties of assessing potential impacts of long-term management necessitate an understanding of the watershed's potential productive

capacity before determinations are made about what impacts management actions are having. This background information provides an ability to develop working hypotheses for long-term monitoring and/or impact assessment.

Generating hypotheses for long-term monitoring requires an approach that considers connectivity of habitats, maintenance of life history diversity, and watershed-specific information, including an understanding of past conditions. Because the EDT can provide this by organizing environmental data at various spatial and temporal scales, the model was selected for evaluation by Washington Department of Natural resources.

I wanted to determine if the EDT could be helpful to the WA Department of Natural Resources in their HCP implementation and monitoring. The purpose of this thesis is twofold: 1) to evaluate the analytical outputs of the EDT application on the Clearwater River and 2) determine the EDT's potential as a environmental trend-monitoring and decision support tool. The specific objective of this study is to:

1) determine if the EDT's associated capacity, productivity and restoration analysis provide a reasonable representation of the salmon population being evaluated; and

2) determine if the EDT is a reasonable method of generating hypotheses to be used in evaluating HCP management goals and objectives.

I met the objectives by first describing the EDT model framework and how Clearwater River environmental data was transferred to the data framework. I then evaluated the outputs of various scenarios. I created scenarios by modifying Habitat conditions, mainly riparian conditions, and a critical life history-specific behavior (0-age juvenile migration) within the model framework and then compared outputs to baseline results. I reviewed other productivity estimates to compare the reasonableness of the EDT productivity estimations. Finally, I made recommendations for continued work

with the EDT, in the form of hypotheses that pertaining to future work in the Clearwater River basin and similar coastal watersheds.

I selected the Clearwater River for analysis because several studies evaluating coho salmon productivity and life history and the effects of logging, as well as various habitat inventories, have been completed there during the last two decades. Analyzing a single species provided baseline information for analysis prior to considerations of a multi-species analysis.

Study Area

The Clearwater River originates from the west slope of the Olympic Mountains, flows west for 58 kilometers to its confluence with the Queets River (Winter 1992) (Figure 1). The drainage area is 390 km^2 and lies entirely within the mild maritime climatic zone (Bailey 1996). Eighty percent of the Olympic Peninsula's annual precipitation falls between October and March. The lower Clearwater Basin receives up to 310 cm precipitation annually and up to 431 cm in the headwaters. Below 300 m elevation, snow is rarely present and higher elevations are snow covered for up to 12 weeks per year (Reid 1981). Surface and ground water are the primary contributors to flow. The main tributaries are Hurst, Shale, Miller, and Christmas Creeks and the Snahapish, Stequaleho and Solleks Rivers.

Clearwater Basin geology is predominantly Quaternary deposits with multiple flood terraces in the lower gradient mainstem. Past glacial advances did not have extensive valley glaciers in the Clearwater Basin - a contrast to many nearby valleys along the western Olympic Peninsula. The general lack of glacial ice in the Clearwater Basin allowed for the formation and preservation of fluvial terraces (Wegmann 1999). The lower terraces prove to be vital components of salmonid life history containing distinct habitats such as wall-base channels (Peterson and Reid 1984) and other off-channel features. The lower 30 km of the Clearwater valley are generally alluvial-dominated reaches, with low slopes and high channel sinuosity. The upper 30

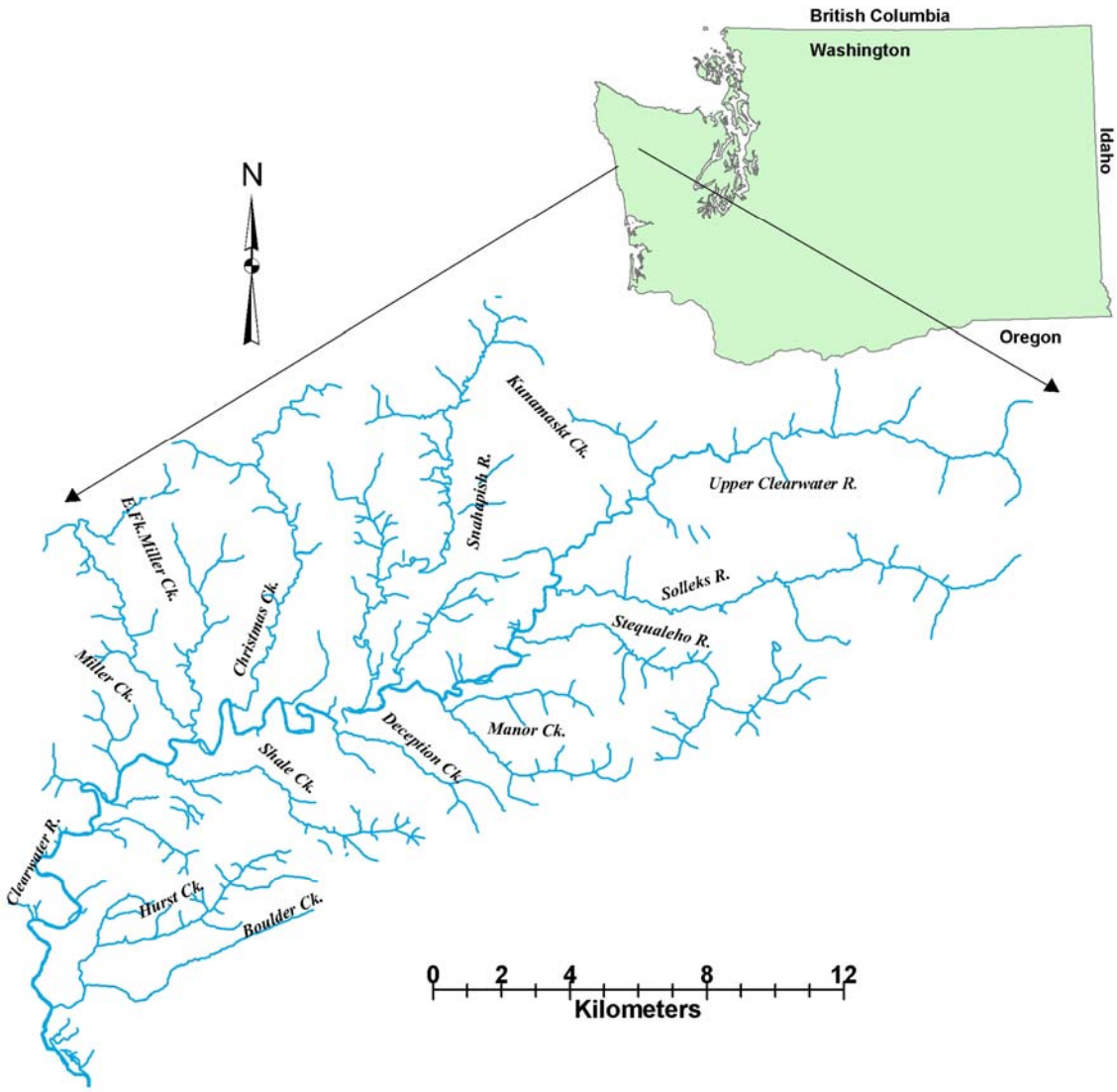

Figure 1. Clearwater River study site map with main tributaries.

km are somewhat dominated by bedrock, exhibiting channel characteristics of increased slope and decreased channel sinuosity (Wegmann 1999).

The Clearwater River basin is managed intensively for timber production by Washington Department of Natural Resources (WDNR) and private timber companies. Nearly 80% of the Clearwater basin is owned by Washington State. Timber harvest began in the Clearwater basin during the early 1950s with peak timber harvest occurring up until the mid-1980s. During this period, increased road densities, stream crossings, and road construction on steep hill slopes amplified sediment inputs to many stream channels (Reid 1981; Cederholm and Reid 1987). Historical and modern landslides have contributed to channel dynamics and varied effects on instream habitats and fish populations (Cederholm and Salo 1979a, 1979b; Cederholm and Lestelle 1974a, 1974b; Cederholm et al. 1980; Serdar 1999). Declining coho populations are likely due to changes in physical habitat due to land management activities and a fishery (Cederholm and Reid 1987).

Timber harvest still exists although not at the level of past years. Today, the basin is managed as part of the Olympic Experimental Forest (WDNR 1997). The main concerns in terms of habitat vulnerability are the large road fills with small culverts and mid-slope roads in high mass wasting potential areas (Smith and Caldwell 2001). Some restoration activity has occurred for sediment problems in the Clearwater basin such as sidecast removal projects in the Miller Creek and Christmas Creek watersheds.

Riparian conditions vary slightly between the lower Clearwater and upper Clearwater. Using Lunetta et al.'s (1997) vegetation classification derived from remote sensing imagery, the mid-seral stage (>70% conifer crown; <10% crown cover in trees∃

21” dbh) comprises about 35% of the Clearwater’s riparian area. The upper Clearwater , however, has a greater percentage (~ 30%) of late-seral stage (>70% conifer crown; >10% crown cover in trees > 21” dbh) than the lower Clearwater (< 10%). Early seral and open/hardwood comprise the remaining riparian conditions with negligible percents in a non-forest classification.

Several fish species are known to occur in the Clearwater River Basin (Table 1). Chinook and steelhead predominantly use the mainstem Clearwater for spawning. Chum salmon have been known to spawn in the lower reaches of the Clearwater. There is uncertainty about the presence of bull trout/dolly varden although they are known to occur in the mainstem of the Queets River. Coho have the most expansive distribution of the anadromous species within the basin. To provide further background for the model application to coho salmon, I have provided a population status review and life history and habitat narrative.

Table 1. Fish species known or suspected (common name italicized) to occur in the Clearwater River, Washington.

Common name	Scientific name	Common name	Scientific name
chinook salmon	*Oncorhynchus tshawytscha*	river lamprey	*L. ayersi*
chum salmon	*O. keta*	western brook lamprey	*L. richardsoni*
coho salmon	*O. kisutch*	longnose dace	*Rhinichthys cataractae*
sockeye salmon	*O. nerka*	speckled dace	*R. osculus*
rainbow/steelhead	*O. mykiss*	peamouth	*Mylocheilus caurinus*
cutthroat	*O. clarki, O. clarki clarki*	prickly sculpin	*Cottus asper*
dolly varden	*Salvelinus malma*	torrent sculpin	*C. rhotheus*
Pacific lamprey	*Lampetra tridentate*		

Status of Coho Salmon

Coho were once widespread throughout the Pacific Northwest and northern California. In a review of the status of coho salmon, Weitkamp et al. (1995) designated six Evolutionarily Significant Units (ESU) of coho salmon from the Central California Coast to the Puget Sound/Straight of Georgia. This review determined that coho have become extinct in more than half of their historical range - in the upper Columbia and inland basins of Washington, Oregon, Idaho, and California. The Olympic Peninsula ESU[1] did not warrant a listing of threatened or endangered in the review. However, large-scale habitat degradation was identified as a main contributor to reduced coho abundance on the Olympic Peninsula.

Washington State Department of Fish and Wildlife assessments determined that 37 of the 90 coho stocks in Washington have been listed as healthy and another 34 have been listed as depressed[2] (WDFW 2000). Most Washington coast stocks are healthy; however, Puget Sound and Hood Canal stocks contain most of the depressed stocks.

Queets River coho, which includes its largest tributary, the Clearwater River, is managed in components that include natural, supplemental, and hatchery runs. The Salmon River, a nearby Queets River tributary, contains a hatchery primarily to provide a pre-terminal and terminal fisheries for fall Chinook salmon and winter steelhead. An early coho salmon stock and a later native coho stock have been used for release in the Salmon River and elsewhere in the Queets system. The Clearwater has been used for

1. The geographic boundaries of this ESU are entirely within Washington, including coastal drainages from Point Grenville to and including Salt Creek (directly west of the Elwha River).
2. The term "healthy" covers a wide range of actual conditions, from robust to those without surplus production for harvest. A depressed stock is one whose production is below expected levels, based on available habitat and natural variation in survival rates, but productivity is above where permanent damage is likely.

some experimental coho supplementation. In general, the Clearwater has been minimally influenced by supplemental efforts and hatchery practices relative to more common larger-scale hatchery practices.

During the early 1980s, a series of technical workshops involving fishery management agencies occurred to establish the maximum sustainable yield (MSY) for natural coho (which includes wild and supplemental spawners). The MSY was established with a range from 5,800 to 14,500 adults. Between 1976 and 2002 the total natural run met the MSY 14 times (53%). In the recent past (1997-1999) poor marine survival may have been the primary cause for not meeting MSY escapement. Favorable ocean and coastal zone conditions are likely contributing to recent increased escapement levels throughout the coast region (Logerwell et al., 2003, Lawson et al. 2004).

Historical record highs for natural terminal run size in the Queets River occurred in 2001 (27,754 adults) and 2002 (16,119 adults) (Source: Pacific Fishery Management Council 2004). Clearwater River adult escapement has averaged 2,380 (range 427-10,556) from 1979 to 2001 including the highest runs on record in 2001 (10,566 natural adults) and 2002 (4,253), Figure 2 (unpublished data, WDFW).

Smolt production in the Clearwater River has averaged 64,859 (range = 27,314 to 99,354) from 1979 to 2003, Figure 3 (WDFW 2003; unpublished data Quinault Indian Nation Fisheries Division). Despite the high variability in freshwater and marine survival, the Clearwater coho population remains viable and is given a “healthy” rating by state fishery managers.

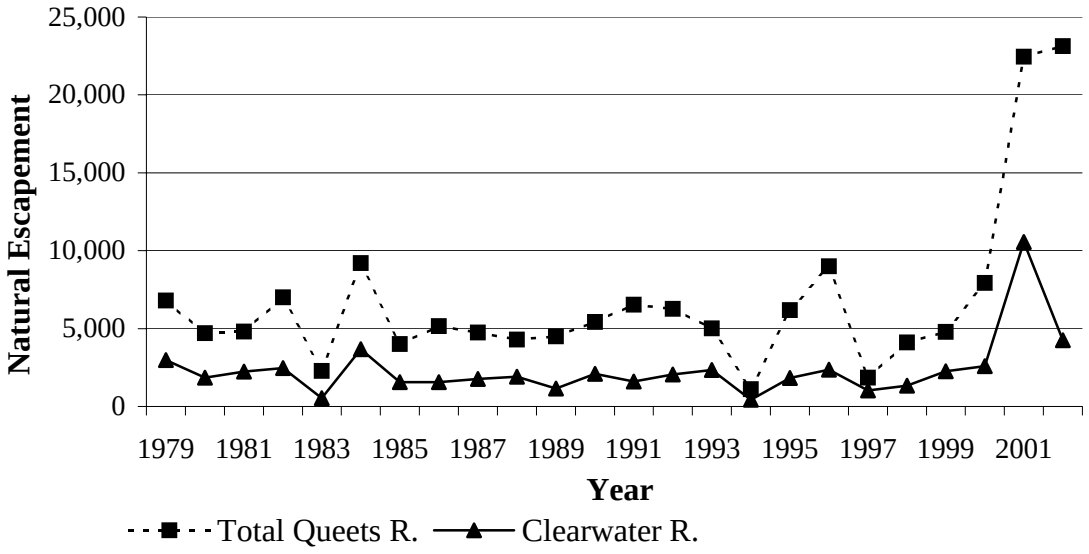

Figure 2. Clearwater and Total Queets River adult natural escapement 1979-2002, excluding harvest.
Source: Washington Department of Fish and Wildlife Fishery Management, unpublished data.

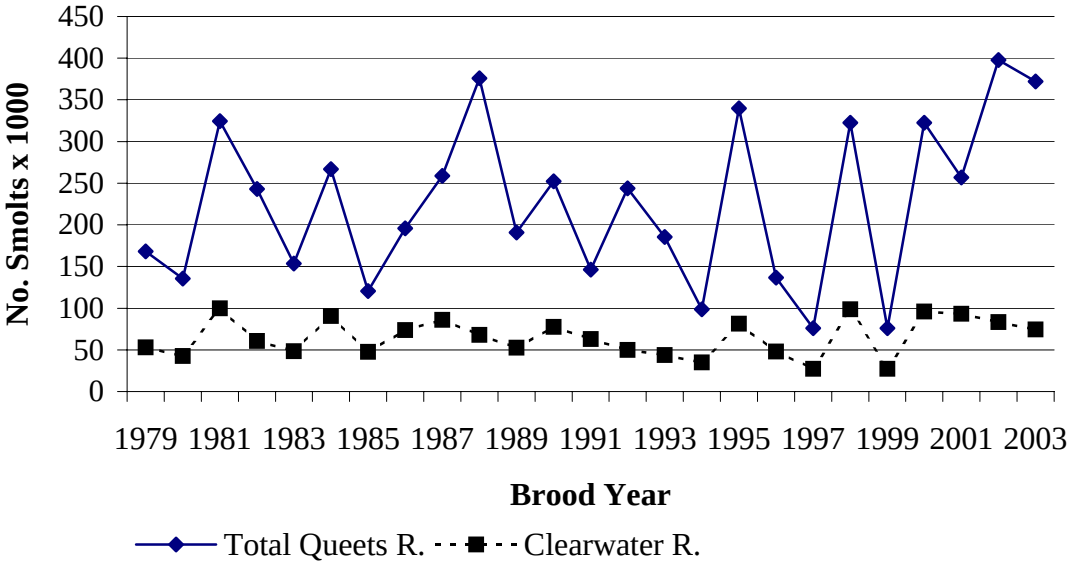

Figure 3. Clearwater and total Queets River smolt production 1979-2003.
Source: Washington Department of Fish and Wildlife Fisheries Management, Quinault Indian Nation Department of Natural Resources, Washington Department of Natural Resources, unpublished data.

Life History and Habitat Use of Clearwater River Coho

Basin–specific knowledge of coho life history patterns is important to develop and support the EDT model rules. Basin-specific information is incorporated into the EDT's environmental attributes. The many studies of the Clearwater River coho salmon over the past three decades reveal a complex life history (Cederholm and Scarlett 1982; Peterson 1982a, 1982b; Peters 1996) of a population that has been somewhat impacted by fisheries and forest management activities (Cederholm and Reid 1987). Coho use a variety of habitats depending on their life history stage. Clearwater River adult coho enter the river from October through November and spawn in tributaries through mid-January. They spawn on gravel bars and pool tailouts preferring cobble sizes 15 cm or less. Fecundity can vary depending on female body size but generally ranges between 2,000 to 3,000 eggs.

The typical egg incubation period is about 120 days and emergence of fry from the gravel can last from March through May (Tagart 1984). Newly emerged fry prefer bank features or log and brush cover out of the main current (Mundie 1969). Fry disperse downstream and rear in tributaries and the mainstem Clearwater River. High-gradient tributaries provide little of the preferred coho habitats (Cederholm and Scarlett 1982, Reeves et al. 1989, Nickelson et al. 1992). Overall freshwater rearing occurs for about eighteen months prior to their seaward migration during April and May.

Water quality is a very important factor since increased water temperature can affect embryo development and emergence period (Hartman and Scrivener 1990). Cool water is particularly critical in the summer because coho are dependent on the water temperature for regulating their own body temperature. Optimal growth and performance

of coho have been documented at between 13 and 20 degrees Celsius (McCullough et al. 2001). Stress and mortality rates increase when coho are subject to temperature above 20 degrees Celsius.

During freshets in October and November, many juveniles seek refuge by redistributing into a variety of small, low-gradient tributaries, including ponds, on the lower river floodplain (Peterson 1982a, 1982b; Scarlett and Cederholm 1984). The lower Clearwater River floodplain contains dozens of these habitat types (WDFW 1988). Although streams with good habitat retain juveniles during these freshets (Tschaplinski and Hartman 1983), this redistribution from summer habitat can be quite extensive (Scarlett and Cederholm 1984). Juveniles also move into deeper pools of the stream and feeding activity decreases (Hartman 1965, Bustard and Narver 1975). These ponds and other off-channel low-energy sites provide favorable growing conditions for the juveniles. Pond habitats generally have a 2-3 week earlier median smolt emigration rate (date that 50% of smolts have emigrated) than stream habitats (Blair and Chitwood 1996).

Smolt outmigration occurs in the spring and is generally nocturnal (Seiler et al. 1984) and coincident with spring flood events. Smolts pass through the lower Queets River and pass through estuarine areas where they are vulnerable to predation by fish, birds and mammals. Time spent in the coastal area varies and migration tendency is northward towards central Alaska waters. Sub-adult ocean phases use large areas of the Pacific Ocean (Sandercock 1991). The vast majority of adults return as 3-year old spawners. However, after the first summer at sea, a small proportion of the males reach

early sexual maturity and return that fall as two-year-old “jacks.” These jack returns have proven to be a fairly accurate predictor of adult abundance the following year.

In summary, Clearwater River coho salmon utilize many areas of the watershed for different life history phases. One particular habitat type, off-channel habitat, is an important habitat feature related to their productivity. The model runs described in the following section make consideration for these particular life history factors.

The Ecosystem Diagnosis and Treatment Method

The Ecosystem Diagnostic and Treatment (EDT) Method is an analytical model that provides a practical, science-based approach to watershed planning (Lichatowich et al. 1995; Mobrand et al. 1997). This species habitat-relationship model provides a system for rating the quality, quantity, and diversity of stream habitat for anadromous and resident salmonids. This model has been used in various Pacific Northwest watersheds, demonstrating its utility in the guidance of fisheries management and habitat restoration. Evaluation of the EDT model is ongoing as subbasin planning occurs in dozens of watersheds in Puget Sound and the Columbia River Basin. Fishery and watershed managers consider the model outputs to further their understanding of the productivity potential of a watershed and as a means to prioritize restoration areas.

The EDT method is comprised of three components:

1) a framework that organizes information to describe the ecosystem (primarily habitat),

2) an analytical model (primarily a set of rules) that analyzes environmental information and draws conclusions about the ecosystem, and

3) the step-by step procedure which describes how to make meaningful application of the model outputs concerning watershed planning and fisheries and habitat goal achievement.

In general, EDT describes how the fish would respond to conditions in a stream based on the current understanding of salmon habitat described in the literature and other regional or site-specific information pertaining to factors influencing productivity. Following is a brief overview of the EDT method with more detailed method description provided in Appendix A.

Model Premises

The basic assumptions of EDT revolve around the concepts of density dependence, habitat structure, and biological performance. In density-dependent population structures, survival for any life stage is dependent on abundance and is limited by the carrying capacity of the habitat. EDT also assumes that habitat characteristics determine biological performance. Finally, the performance of populations and species (biological performance) can be measured in terms of capacity, productivity (return/spawner) and life history diversity.

In EDT, habitat is characterized and rated in terms of productivity and capacity. This information is related through the Beverton-Holt production function (discussed below) suggesting how well individuals and populations survive given the habitat conditions. The basic survival model used in the EDT method assumes that the life history of a salmon species can be partitioned into segments of somewhat uniform habitat conditions and within those segments the survival response is constant and predictable (Appendix A). This allows habitat conditions to be analyzed relative to various fish population guidelines such as those demonstrated in model runs (e.g. Properly Functioning Condition[1], HCP, etc.) Further, each segment is defined in terms of space (a stream reach), life stage (e.g. adult migration, juvenile rearing) and time (e.g. critical month(s)). Within each stream segment, survival is described by the relationship

1. Properly Functioning Conditions create and sustain over time the physical and biological characteristics that are essential to conservation of the species, whether important for spawning, breeding, rearing, migration or other functions. The concept recognizes and accommodates the expected degraded conditions of city centers and industrialized areas and does not expect these areas to be restored to rural conditions. However, there are high expectations to modify and maintain certain ecological functions that remain crucial to salmon survival.

between productivity and capacity in a Beverton-Holt survival function:

$$S = \frac{P}{1 + \frac{PN'}{C}},$$

Where S is survival, P is productivity and C is carrying capacity for a particular life segment. N' is the number of individuals alive at the beginning of a segment.

Fisheries population management theory is mostly driven by stock-recruitment relationships (Hilborn and Walters 1992). Figure 4 illustrates the simple density dependent relationship between spawners and recruits. Density dependent population dynamics are often used to describe salmon populations where stock refers to "spawner" abundance and recruitment is "spawner progeny". The Pacific salmon characteristic of semelparity (death after spawning once) allows a direct relation between spawners and recruit abundance. Productivity (the density independent component of survival times the rate of production) is controlled by environmental attributes that are used to describe the useable habitat, which in turn defines the system carrying capacity (Figure 4).

Biological rules that are generally derived from the literature or other scientific data are viewed as hypotheses that suggest how the environmental conditions can affect the capacity, productivity and life history of the focus species. This affect is modeled in the Beverton-Holt function. Rules in the EDT analysis are specific to the species, but not necessarily how the species behaves in the particular watershed being analyzed. A main product of the rules is to provide an estimate of productivity and *Key Habitat* that corresponds to a certain reach, time, and life stage of the salmon. The rule sets for

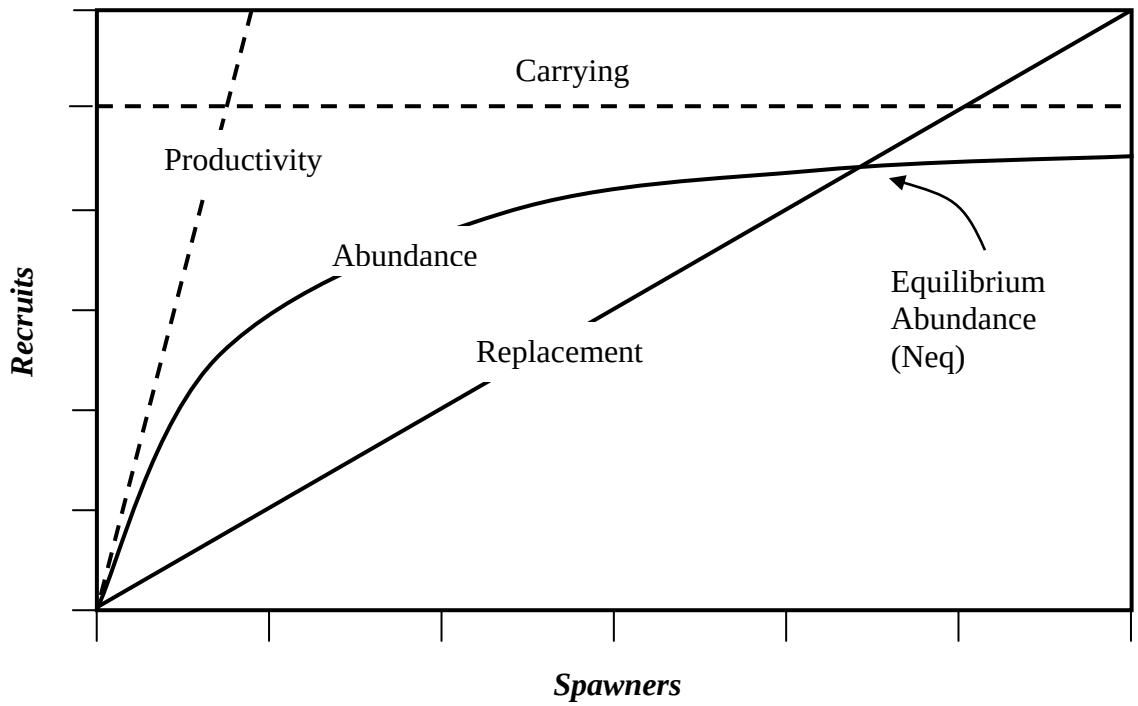

Figure 4. Beverton-Holt production function. Productivity is the density independent survival. These are biological and ecological factors that are not influenced by population size (density). There are also density dependent factors in the environment such as food and space that determine the limits of the carrying capacity along with the productivity. In a steady state of environmental conditions the population equilibrates at the equilibrium abundance[1] (Neq). This point determines the number of spawners needed to ensure replacement by future spawners. Redrawn from Mobrand et al. (1997).

productivity and key habitat are structured differently and described in Appendix B.

With these premises of the described production function, the salmon's productivity in relation to habitat conditions, and the understanding of the salmon's spatial distribution in the watershed, the EDT method can hypothesize about the basin's productivity and capacity.

1. See definitions page xi.

Model Features

The EDT provides a direct link from actions to habitat change to biological performance. Through these links hypotheses can be generated concerning the effectiveness of actions. Further, this is a basis for developing coordinated monitoring and research as part of adaptive management strategies. The EDT's functionality at multiple scales and its compatibility to terrestrial conditions provides flexibility in subbasin planning. Model runs can also consider effects of additional mortality from harvest and loss of genetic fitness.

Through a format of presenting stream conditions in a "current" condition or "historic" condition (little to no anthropogenic influences), the EDT can identify the potential productivity or restoration value for a stream under a variety of conditions. Individual stream reaches or reaches grouped into subbasins can be prioritized according to their restoration or protection value[1]. The overall result is a scientifically based assessment of conditions and a prioritization of restoration need. The EDT method maintains an open framework that facilitates input of new information and biological rule modifications.

The EDT method also includes a module for developing alternative future scenarios by defining the various management strategies and preferred range of conditions of the environmental attributes. Model outputs, described in further detail below, are succinct, spatially explicit, and graphically portrayed to facilitate discussion amongst varying disciplines and levels of expertise.

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1. Through a procedure called splice analysis, a reach can be simulated with a "restored" condition to estimate a response by the population. Protection value indicates how valuable this reach is to the overall productivity.

With these capabilities, the EDT provides a common ground for discussing salmon and watershed issues, even amidst changing policies and research objectives. An examination of the EDT method framework provides a means to understand how multiple types of information are related in a logical way to produce outputs related to fishery and watershed management.

Model Framework

The conceptual framework (Figure 5) demonstrates how information is sorted and used to describe the watershed to draw conclusions later about the watershed. Land use actions or natural events have some impact on the environment, in turn, affecting the performance of the population. The resulting information from the population performance can assist in meeting objectives associated with the watershed plan. The iterative bi-directional information flow illustrates that planning, prioritizing, and implementing actions alternate from goals to actions repeatedly. That is, actions and events across the landscape may result in environmental changes so stakeholders can review their values and objectives. When goals or preferred conditions are not met, stakeholders can change their actions to achieve desired environmental and biological conditions. The framework essentially hypothesizes biological performance in relation to its environmental characteristics. Output validation has been demonstrated in a variety of ways including consensus of involved parties on the restoration and protection benefits and prioritizations and by comparing actual production data for Yakima River Spring Chinook and Columbia River Steelhead (Mobrand Biometrics, *unpublished data*).

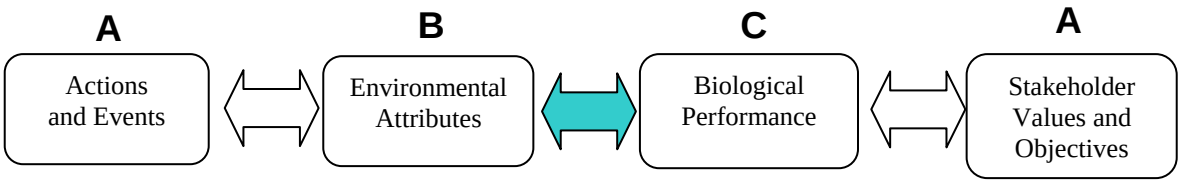

Figure 5. The Ecosystem Diagnostic and Treatment conceptual framework. The framework suggests that the proposed land use actions and events (**A**) along with stakeholder values and objectives (**A`**) are developed with an understanding of the environment's condition and function (**B**) and how its functionality affects the biological performance of the population (**C**).

The EDT framework also facilitates the documentation of spatial and temporal habitat attributes that comprise the salmon ecosystem. McConnaha (2003) discusses the multiple facets of salmon habitat including the linear continuum of the channel network, the vertical dimensions relating to stream flow and water quality, the lateral dimension that incorporates floodplain habitats, and the temporal dimension of stream disturbance and accessibility to critical habitats. The EDT framework provides the ability to make these characterizations at the reach level.

The EDT framework consists of six different databases: global, output, tables, comments, data, and operations databases contain all the physical watershed, fish biology, life history characteristics, environmental sensitivities, and reporting data. The environmental attributes used in the EDT have appeared in salmon-watershed literature and are used to describe the relationship between the biological performance and the environment[1] (Table 2). These attributes can vary over time and space depending on the

1. The environment is described using 45 attributes. The model framework classifies these into the 19 attributes categories listed in Table 2. (For instance, Habitat Diversity category would include pool area, substrate, off-channel, etc. characteristics).

Table 2. Hierarchical organization of Level 2 Environmental Correlates to demonstrate which Level 2 Environmental Correlates are used to translate into Level 3 Related Survival Factors.

Environmental Correlates (Level 2)		Related Survival Factors (Level 3)[1]
1 Hydrological Characteristics		
1.1 Flow variation	Flow - change in interannual variability in high flows	Flow
	Flow – change in interannual variability in low flows	Withdrawals
	Flow – Intra daily (diel) variation	(entrainment)
	Flow – intra-annual flow pattern	
	Water withdrawals	
1.2 Hydrologic regime	Hydrologic regime – natural	
	Hydrologic regime - regulated	
2. Stream Corridor Structure		
2.1 Channel morphometry	Channel length	Channel length
	Channel width – month maximum width	Channel stability
	Channel width – month minimum width	Channel width
	Gradient	Habitat diversity
2.2 Confinement	Confinement – hydromodifications	Key habitat
	Confinement - natural	Obstructions
2.3 Habitat type	Habitat type - backwater pools	Sediment Load
	Habitat type - beaver ponds	
	Habitat type - glides	
	Habitat type – large cobble/boulder riffles	
	Habitat type – off-channel habitat factor	
	Habitat type – pool tailouts	
	Habitat type – primary pools	
	Habitat type – small cobble/gravel riffles	
2.4 Obstruction	Obstructions to fish migration	
2.5 Riparian and channel integrity	Bed scour	
	Icing	
	Riparian function	
	Woody debris	
2.6 Sediment type	Embeddedness	
	Fine sediment (intragravel)	
	Turbidity (suspended sediment)	
3. Water Quality		
3.1 Chemistry	Alkalinity	Chemical (toxic substances)
	Dissolved oxygen	Oxygen
	Metals – in water column	Temperature
	Metals/Pollutants – in sediments/soils	
	Miscellaneous toxic pollutants – water column	
	Nutrient enrichment	
3.2 Temperature variation	Temperature – daily maximum (by month)	
	Temperature – daily minimum (by month)	
	Temperature – spatial variation	

Table 2. Continued

Environmental Correlates (Level 2)		Related Survival Factors (Level 3)[1]
4. Biological Community		
4.1 Community effects	Fish community richness Fish pathogens Fish species introductions Harassment Hatchery fish outplants Predation risk Salmonid carcasses	Competition with hatchery fish Competition with other fish Food Harassment Pathogens Predation
4.2 Macroinvertebrates	Benthos diversity and production	

1. Level 3 Survival Factors are also termed "umbrella" attributes since they capture the effects that the Level 2 Environmental Correlates have on productivity and survival.
Source: Mobrand Biometrics, Inc. 2002.

observer's objective. The EDT framework accommodates data for multiple-scale analysis and multiple scale objectives. This allows management actions and performance goals to be defined on reach, sub-basin, or watershed scales.

The biological performance of the animal is central to the EDT framework. The EDT asserts that biological performance is characterized by the elements of life history diversity, productivity, and capacity. With this concept of performance, a model structure

is available for the biological rule-based[1] analysis.

In summary, EDT is different from many productivity models by providing 45 environmental attributes for analyses. This allows sensitivities of particular attributes to be enhanced according to local knowledge base and unique characteristics about the watershed or fish populations. The EDT framework is promising for watershed management due to these features and to its user-friendly internet-based scenario building accessible by watershed managers, biologists, and persons with limited

1. Literature and/or expert-based formulae used in calculating reach productivity and capacity.

ecological modeling experience.

Model Conceptual Operation

The EDT method consists of a logical series of steps that include 1) the identification of goals and values, 2) a resource assessment, (or diagnosis), 3) identification and an analysis of treatment alternatives, and 4) the adaptive implementation of the preferred alternatives.

Figure 6 provides a graphic overview of the ecological information used in the EDT diagnosis-analysis process. The figure expands from Figure 5 (pp. 23) to display how the environment and ecology of the watershed are bordered by management (Actions) and stakeholder goals and objectives (Vision). That is, a watershed will function within its environmental constraints, and when further activities occur, those boundaries can cause further influence. The *Vision* is the conditions of a watershed that are desired for the long-term. The *Actions* within the watershed have the potential to influence the landscape conditions. The goal of effective management is to conduct activities in such a way that conditions are not degraded relative to the watershed vision.

Understanding the biological performance of a population and the requirements of its habitats throughout its life history can facilitate the decision-making of where particular actions could take place with little or no consequence to the resource. By understanding the population and its relation to the landscape, it is possible to construct biological objectives for the watershed. With that understanding, the EDT becomes a type of decision-support tool, able to spatially relate areas of activity and potential environmental change to areas where fish populations may be vulnerable to change.

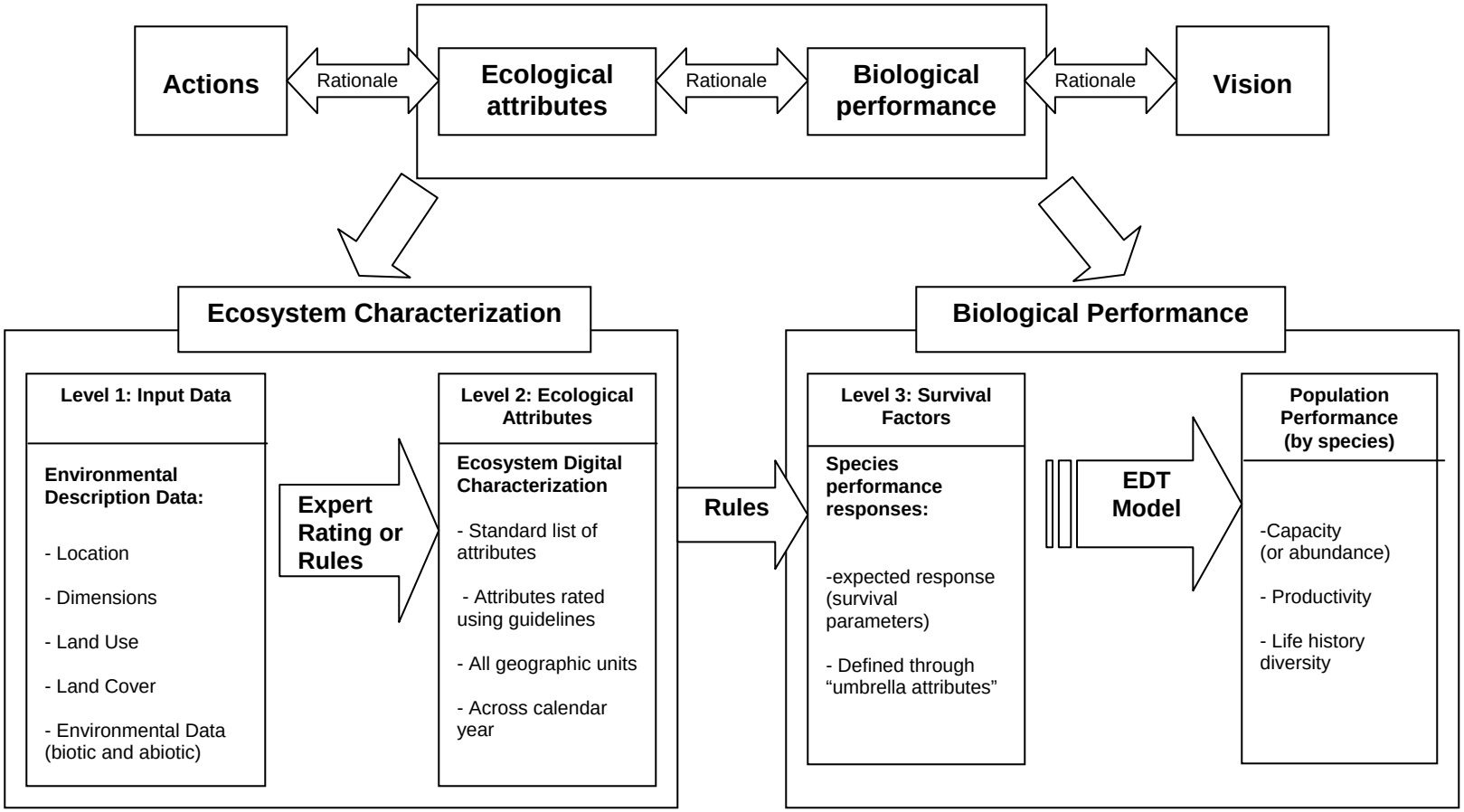

Figure 6. Ecological information structure of the Ecosystem Diagnosis and Treatment method.

Figure 6 illustrates that the capacity and productivity of the ecosystem can be explained within the context of ecological attributes and biological performance. The first step of the analysis is to perform an ecosystem characterization (lower left box) for three watershed conditions; current, historic, and properly functioning condition. This Level 1 data describes the watershed environment on a stream reach scale. Further resource diagnosis occurs with facilitation from expert ratings and/or rules. The 45 level-2 ecological attributes (Table 2 pp. 24) of each reach are rated with key months to give them temporal and spatial context. Rating criteria are categorical values from 0 to 4 to represent the condition of each environmental attribute. The values characterize a range from a degraded site to a fully functional state comparable to historic conditions.

The population's biological performance (lower right box) is then estimated by merging the watershed condition, life history characteristics, and expected population response to the environmental conditions. The biological rules facilitate translation of the Level 2 environmental data into ratings that specify the relative effects of each attribute at multiple life stages (16 life stages were used for coho ranging from the incubation period to return spawner migration). These survival factors are defined through Level 3 "umbrella attributes"[1] (see column 3 Table 2 for list of "umbrella attributes) that are species specific in their effects. In summary, Level 1 data addresses basic habitat forming processes and Level 2 data is the result of these processes that form biologically meaningful values. This consolidation of attributes addresses the cumulative effects of

1. Level 3 attributes are a limited list of watershed characteristics derived from the environmental characterization. Each attribute has their own sensitivity index (Appendix B Section 2.1) For instance, survival during egg incubation is a function of several sediment characteristics such as embeddedness, fine sediment and bed scour, which influence incubation success.

all the attributes, in turn influencing how well the population performs when the EDT method is run.

Figure 7 demonstrates how this information results in an estimation of population performance. Fish life history stages (x-axis) occur across various temporal scales (x-axis) and geographic scale (y-axis). In the figure, labeled lines are survival[1] trajectories. The figure demonstrates the diversity of life history pathways possible for a fish. The fish's productivity and capacity for each life stage is computed on the basis of key habitat quantity. One would expect varying contributions from various habitat types, each with their own emphasis towards overall productivity. A reach with high embedded fines would have far less impact on productivity during the smolt migration stage than during the incubation period since high fine concentrations are a detriment to the key habitat of intragravel environment during those key months. The relationship between the habitat conditions and the productivity is based on the rules set (BioRules – see definitions page xi.) used in the production function described earlier.

In the EDT method, a fish at a particular life stage passes through a reach and is randomly assigned a proportion of survival, termed a "hit". For example, a juvenile may have migrated from an upstream reach where habitat conditions were very good. The juvenile would leave that reach with a high relative productivity.[2] In this example, trajectory D (see Figure 7) is higher in the watershed, or in another tributary than

1. The EDT estimates productivity at each instance, or "hit" by computing a percent survival. This percent survival is the relative productivity of the fish that have tracked that particular trajectory.
2. In reality, a fish leaving a reach will either live (1.0 survival) or die (0.0 survival) regardless of fitness. But to accommodate population level estimates, a proportion of survival is given for each stage of the trajectory to ensure fish survive to the next stage. In effect, a portion of that fish represented by that trajectory moves on to subsequent life stages.

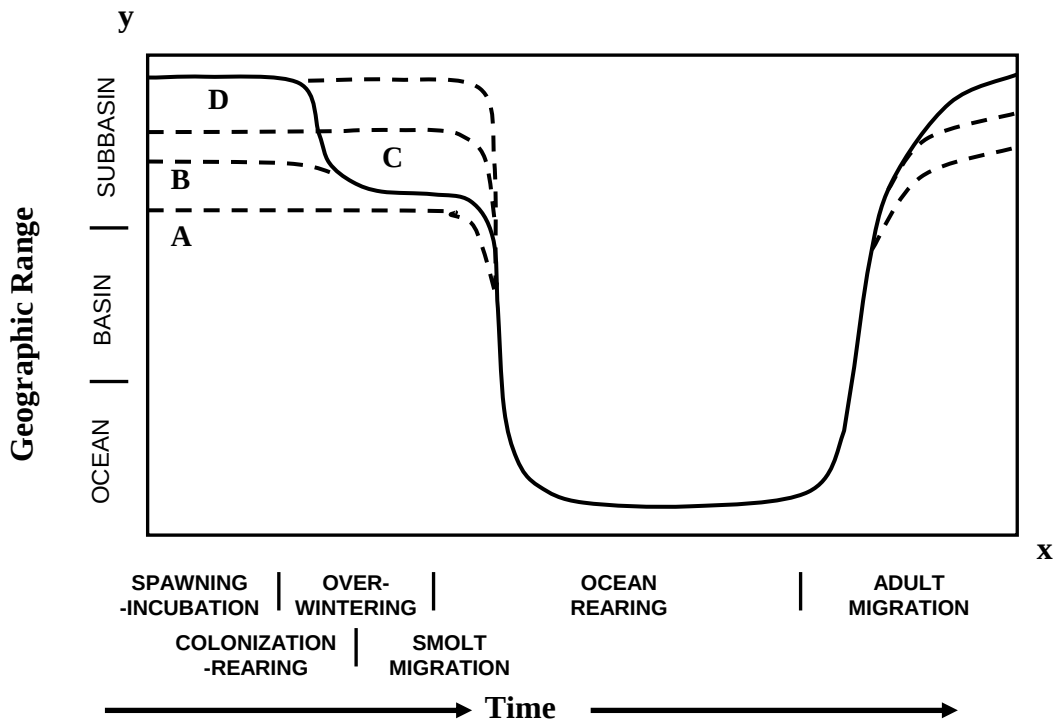

Figure 7. Conceptual display of life history trajectories calculated by EDT to determine productivity. Trajectories A,B,C, and D are diverse in their fresh water phases. The synthesis of all trajectories produces the estimated productivity for the population. Adapted from Mobrand et al. (1997).

trajectory A in early life stages. Trajectory A's incubation and early-rearing phases were in different conditions than those experienced by trajectory D. Since not all fish experience the exact same productivity within the same habitats, randomizing productivity estimates within a literature and/or or expert-based range (rules) accounts for this variability of survival. Through the ocean rearing phase, productivity is essentially the same for the whole population. This is simply because the whole population is subject to those conditions unlike the diversity of habitats and conditions available in the freshwater environment.

Each model run creates 600 trajectories, or simulated life history pathways, through the basin. The high number of trajectories created allows for some repetition and

overlap of pathways (in nature, dozens, hundreds, or perhaps thousands of individual fish can trace similar life history pathways). An effective way to visualize this concept of many trajectories is imagine pouring a bowl of cooked spaghetti noodles of various thicknesses across the ridges of the modeled watershed. The noodles will travel down various pathways. Each noodle represents a life history pathway, thicker noodles represent the more utilized pathways. Some noodles travel slower through reaches, some overlap, or some travel faster than others – all representing the diversity of ways a salmon will route itself through the freshwater environment. The model output values associated with the characteristics of these trajectories produces the productivity estimates for the basin and scenario that is being analyzed.

Model Baseline Analysis

The EDT requires building a population (database) of the stream reaches characterizing each reach with 23 environmental attributes. The scientific literature suggests that these attributes can influence salmon productivity. Once the population is built, trajectories are generated. A trajectory is essentially a relative productivity of a population. Independent trajectories (individual noodles) are combined to form an integrated trajectory (all noodles). These trajectories are combined by selecting an A or B option when running a scenario. Option A does not consider unproductive reaches. Option B considers the capacity of the reaches (suggesting that even some unproductive reaches have some capacity). The EDT output is then exported into a standardized reporting format in Microsoft® Excel or Access for interpretation.

Model Outputs

The main outputs of the EDT method in table format are trajectory data (60,000 iterations generated by analysis), survival data, performance data, and population data in the form of Microsoft® Access database tables. The principle outputs that occur in report and graphic format pertain to the population performance and strategic priorities for restoration. Several other tables are produced that are used for data translation and integration of data and rules. The format of these outputs are displayed and described in the discussion section.

In summary, the complex EDT method framework, operation, and outputs provide a package that features the most up-to-date ability to synthesize and apply current literature knowledge base, real and updated environmental data, and professional opinion. The following discussion and application of the EDT method will demonstrate the potential uses of this data.

Method

The Clearwater River analysis was a multi-step procedure that included uploading environmental data into the database, registering this data spatially, and integrating this stored data with the prescribed scenarios, survival trajectories, and sensitivity analysis (see Appendix A - Figure 6). This section describes rationale of how the ratings and their differences were derived for the historic and current environmental attributes.

Data Input

Using a Microsoft® Excel-generated data entry tool called the Stream Reach editor, I assigned each reach an index value for each of the 46 Level 2 environmental correlates. Index values, using numbers 0-4, represented the spectrum of conditions that could exist for any of the environmental attributes. I translated real numeric data into index values since the values generally were included within the range of values defined for each rating. Dissolved oxygen, for example, in a reach that maintains >8mg/l should provide for all biological functions of salmonids. An index of “0” would be assigned and an increasing index number would be assigned as oxygen values decrease. In some attributes such as peak flows, I based the index values on the variability of conditions, not necessarily on absolute values.

I characterized each segment with these index values for the current conditions, historic conditions, proper functioning condition, and hypothesized Habitat Conservation Plan. In cases where reaches did not have data or observations performed, and they had similar characteristics in terms of gradient and riparian condition derived from aerial photos, I copied attribute data from the adjacent or nearest observed reach. These

reaches are noted in the baseline database as copied from another named reach. The following sections describe the rationale for the values assigned to the environmental attributes in baseline conditions.

Reach descriptions

The foundation of the EDT database is the stream reach[1] environmental data. The Clearwater Basin EDT database includes 103 reaches (Table 3). During the summer of 2000, individual reaches were designated and measured using digital 1:24,000 USGS topographic maps and digital aerial orthophoto overlays with heads up digitizing in ArcView GIS™. Lengths of the reaches were calculated using GIS measurement tools and, where available, verified from past survey data.

Hydrologic Characteristics

I conducted a hydrologic evaluation of twenty-three sub-watersheds of the Clearwater basin and assigned an index rating based on the EDT hydrological characteristics (see Level 2 Environmental Correlates Table 2). I derived at attribute ratings by using associated hydrology data (Abercrombie et al. 1978, 1979; Amerman and Osborne 1987; Larson and Jacoby 1976, 1977), and data from WDNR geographic coverages including percent area of rain-on-snow, forest age-class, and road density. Attribute ratings were reviewed and edited by a WDNR hydrologist[2].

1. Reach breaks included tributary junctions or major physiographic changes in the channel as they relate to fish use, or specialized habitats.
2. Jim Ryan. Washington Department of Natural Resources, Land Management Division, Olympia, WA.

Table 3. Reach descriptions of the EDT baseline runs for the Clearwater River. Reaches preceded by "OC") are the off-channel pond segments used for alternative analyses.

Reach Name	Reach Length		Reach Description
	meters	miles	
Queets-1	8730	5.42	Queets River: Mouth of Queets R. to Fisher Creek
Queets-2	2308	1.43	Queets River: Fisher Creek mouth to Clearwater R.
Clearwater-01	881	0.55	Clearwater River: Clearwater R. mouth to Mule Pasture Pond
Clearwater-02A	1207	0.75	Clearwater River: Mule Pasture Pond to Dasher Pond outlet
Clearwater-02B	1359	0.84	Clearwater River: Dasher Pond to Hurst Creek mouth
Clearwater-03A	161	0.10	Clearwater River: Hurst Creek mouth to Tiemeyer Pond outlet
Clearwater-03B	917	0.57	Clearwater River: Tiemeyer Pond outlet to Morrison Pond outlet
Clearwater-04A	1143	0.71	Clearwater River: Morrison Pond outlet to Dogleg pond outlet
Clearwater-04B	1143	0.71	Clearwater River: Dogleg Pond outlet to Airport pond outlet
Clearwater-05	1791	1.11	Clearwater River: Airport Pond outlet to Wildcat Creek mouth
Clearwater-06	4029	2.50	Clearwater River: Wildcat Creek mouth to Hunt Creek mouth
Clearwater-07	1750	1.09	Clearwater River: Hunt Creek mouth to Cougar Creek mouth
Clearwater-08	975	0.61	Clearwater River: Cougar Creek mouth to Elkhorn Creek mouth
Clearwater-09A	314	0.19	Clearwater River: Elkhorn Creek mouth to Paradise Pond outlet
Clearwater-09B	314	0.19	Clearwater River: Paradise Pond outlet to Swamp Pond outlet
Clearwater-09C	314	0.19	Clearwater River: Swamp Pond outlet to Mink Creek mouth
Clearwater-10	1554	0.97	Clearwater River: Mink Creek Mouth to Shale Creek mouth
Clearwater-11	1235	0.77	Clearwater River: Shale Creek mouth to Miller Creek mouth
Clearwater-12A	1030	0.64	Clearwater River: Miller Creek mouth to Pond 1 outlet
Clearwater-12B	16	0.01	Clearwater River: Pond 1 outlet to Pond 2 outlet
Clearwater-12C	1575	0.98	Clearwater River: Pond 2 outlet to Christmas Creek
Clearwater-13	2945	1.83	Clearwater River: Christmas Creek mouth to Peterson Creek mouth
Clearwater-14A	2545	1.58	Clearwater River: Peterson Creek to Coppermine Bottom Pond outlet
Clearwater-14B	1281	0.80	Clearwater River: Coppermine Bottom Pond to Deception Creek
Clearwater-15	1128	0.70	Clearwater River: Deception Creek mouth to Snahapish R. mouth
Clearwater-16	1693	1.05	Clearwater River: Snahapish R. mouth to Bull Creek mouth
Clearwater-17	1875	1.17	Clearwater River: Bull Creek mouth to Manor Creek mouth
Clearwater-18	4237	2.63	Clearwater River: Manor Creek mouth to Stequaleho Creek mouth
Clearwater-19	2318	1.44	Clearwater River: Stequaleho Creek mouth to Solleks R. mouth
Clearwater-20A	1087	0.68	Clearwater River: Solleks R. mouth to Nancy Creek
Clearwater-20B	4165	2.59	Clearwater River: Nancy Creek mouth to Itswoot mouth
Clearwater-21	701	0.44	Clearwater River: Itswoot Creek mouth to Kunamakst Creek mouth
Clearwater-22	3414	2.12	Clearwater River: Kunamakst Creek to Wilson Creek (#0120) mouth
Clearwater-23	1113	0.69	Clearwater River: Wilson Creek mouth (#0120) to Trib # 0122
Clearwater-24	789	0.49	Clearwater River: Trib #0122 mouth to Ding-a-ling Creek
Clearwater-25	1463	0.91	Clearwater River: Ding-a-ling Creek mouth to Susie Creek mouth
Hurst-1	1245	0.77	Hurst Creek: Hurst Creek mouth to Boulder Creek mouth
Hurst-2	1591	0.99	Hurst Creek: Boulder Creek mouth to unnamed RB Trib # 0027
Hurst-3	1690	1.05	Hurst Creek: Unnamed RB Trib # mouth to Trib # 0028
Hurst-4	1245	0.77	Hurst Creek: Unnamed Trib # 0028 to coho limit (Trib # 0029)
Hurst- RB trib # 0025.5	1844	1.15	RB Trib 21.0027 (Hurst Creek): Hurst-2 end to fork in section 8
Boulder-1	3140	1.95	Boulder Creek: Boulder Creek mouth to coho limit
Wildcat-1	1053	0.65	Wildcat Creek: Mouth to unnamed Trib # 0030
Hunt-1	152	0.09	Hunt Creek: Hunt Creek mouth to Waring Creek mouth
Hunt-2	3143	1.95	Hunt Creek: Waring Creek mouth to coho limit (fork)

Table 3. Continued

Reach Name	Reach length		Reach Description
	meters	miles	
Waring-1	579	0.36	Waring Creek: Waring Creek mouth to road crossing
Cougar-1	536	0.33	Cougar Creek: Cougar Creek mouth to Cougar Creek 1/4 mile
Elkhorn-1	1017	0.63	Elkhorn Creek: Elkhorn Creek to road crossing at mainline gravel pit
Mink-1	1093	0.68	Mink Creek: Mink Creek mouth to Trib # 0039 mouth
Mink- LB trib # 0039	1579	0.98	LB Trib # 0039 (Mink Creek): Trib # 0039 mouth to fish limit
Shale-1	1128	0.70	Shale Creek: Shale Creek mouth to Iska Creek (# 0042)
Shale-2	3749	2.33	Shale Creek: Iska Creek mouth to Unnamed RB Trib # 0045
Shale-3	2499	1.55	Shale Creek: Unnamed RB Trib # 0045 to LB Trib # 0047
Shale-4	975	0.61	Shale Creek: Unnamed LB Trib # 0047 mouth to coho limit
Iska-1	884	0.55	Iska Creek: Iska Creek. mouth to coho limit
Shale -LB trib # 0047	1067	0.66	LB Trib # 0047 : Unnamed Trib # 0047 mouth to coho limit
Miller-1	701	0.44	Miller Creek: Miller Creek mouth to East Fk. Miller Confluence
Miller-2	3658	2.27	Miller Creek: Miller East/West Fk. confluence mouth to unnamed RB Trib # 0057
Miller-3	5884	3.66	Miller Creek: Unnamed Miller RB trib #0057 to Trib # 0062
Miller-4	4200	2.61	Miller Creek: Unnamed Trib # 0062 to coho limit;
MillerEFk-1	5052	3.14	East Fork Miller: East Fk. Miller Creek mouth to Gaf Creek
MillerEFk-2	2286	1.42	East Fork Miller: Gaf Creek mouth to coho limit
Gaf-1	823	0.51	Gaf Creek: Trib # 0053 mouth to coho limit
Christmas-01A	161	0.10	Christmas Creek: Christmas Creek mouth to Christmas Pond
Christmas-01B	761	0.47	Christmas Creek: Christmas Pond outlet to mainline crossing
Christmas-02	9540	5.93	Christmas Creek: Mainline crossing to Trib #0066 (Samuelson's Trib)
Christmas-03	1890	1.17	Christmas Creek: Trib #0066 (Samuelson's trib) to coho limit
Samuelsons Trib	1931	1.20	Samuelsons Trib: Christmas Creek to coho limit
Peterson-1	1692	1.05	Peterson Creek: Peterson Creek mouth to coho limit
Deception-1	396	0.25	Deception Creek: Deception Creek mouth to Prairie Creek
Deception-2	1737	1.08	Deception Creek: Prairie Creek to coho limit
Prairie-1	402	0.25	Prairie Creek: Prairie Creek mouth to coho limit
Deception-4	1219	0.76	Deception Creek: Trib # 0075 mouth to coho limit
Snahapish-1	2379	1.48	Snahapish River: Snahapish R. mouth to mainline crossing
Snahapish-2	8905	5.53	Snahapish River: Mainline crossing to West Fk. Snahapish R.
Snahapish-3	9141	5.68	Snahapish River: West Fk. Snahapish R. to Octopus Creek
Snahapish-4	2575	1.60	Snahapish River: Octopus Creek to coho limit
W.F. Snahapish-1	2398	1.49	West Fork Snahapish River: West Fk. Snahapish R. mouth to Trib #0080
W.F. Snahapish-2	1875	1.16	West Fork Snahapish River: Unnamed Trib #0079 mouth to fish limit
Octopus-1	914	0.57	Octopus Creek: Octopus Creek mouth to coho limit
Bull-1	901	0.56	Bull Creek: Bull Creek mouth to mainline road crossing
Bull-2	2725	1.69	Bull Creek: Mainline to coho limit
Stequaleho-1	3472	2.16	Stequaleho Creek: Stequaleho Creek to the Falls @ R.M. 2
Solleks-1	8130	5.05	Solleks River: Solleks R. mouth to Kloochman Creek mouth
Solleks-2	3196	1.99	Solleks River: Kloochman Creek mouth to coho limit (Grouse Creek mouth)
Kloochman-1	2811	1.75	Kloochman Creek: Kloochman Creek mouth to coho limit
Grouse-1	729	0.45	Grouse Creek: Grouse Creek to fish limit
George-1	1897	1.18	George Creek: George Creek mouth to fish limit
Itswoot-1	483	0.30	Itswoot Creek: Itswoot Creek mouth to coho limit

Table 3. Continued

Reach Name	Reach length		Reach Description
	meters	miles	
Miller-4	4200	2.61	Miller Creek: Unnamed Trib # 0062 to coho limit;
MillerEFk-1	5052	3.14	East Fork Miller: East Fk. Miller Creek mouth to Gaf Creek
MillerEFk-2	2286	1.42	East Fork Miller: Gaf Creek mouth to coho limit
Gaf-1	823	0.51	Gaf Creek: Trib # 0053 mouth to coho limit
Christmas-01A	161	0.10	Christmas Creek: Christmas Creek mouth to Christmas Pond outlet
Christmas-01B	761	0.47	Christmas Creek: Christmas Pond outlet to mainline crossing
Christmas-02	9540	5.93	Christmas Creek: Mainline crossing to Trib #0066 (Samuelson's Trib)
Christmas-03	1890	1.17	Christmas Creek: Trib #0066 (Samuelson's trib) to coho limit
Samuelsons Trib	1931	1.20	Samuelsons Trib: Christmas Creek to coho limit
Peterson-1	1692	1.05	Peterson Creek: Peterson Creek mouth to coho limit
Deception-1	396	0.25	Deception Creek: Deception Creek mouth to Prairie Creek
Deception-2	1737	1.08	Deception Creek: Prairie Creek to coho limit
Prairie-1	402	0.25	Prairie Creek: Prairie Creek mouth to coho limit
Deception-4	1219	0.76	Deception Creek: Trib # 0075 mouth to coho limit
Snahapish-1	2379	1.48	Snahapish River: Snahapish R. mouth to mainline crossing
Snahapish-2	8905	5.53	Snahapish River: Mainline crossing to West Fk. Snahapish R.
Snahapish-3	9141	5.68	Snahapish River: West Fk. Snahapish R. to Octopus Creek mouth
Snahapish-4	2575	1.60	Snahapish River: Octopus Creek to coho limit
W.F. Snahapish-1	2398	1.49	West Fork Snahapish River: West Fk. Snahapish R. mouth to Trib #0080
W.F. Snahapish-2	1875	1.16	West Fork Snahapish River: Unnamed Trib #0079 mouth to fish limit
Octopus-1	914	0.57	Octopus Creek: Octopus Creek mouth to coho limit
Bull-1	901	0.56	Bull Creek: Bull Creek mouth to mainline road crossing
Bull-2	2725	1.69	Bull Creek: Mainline to coho limit
Stequaleho-1	3472	2.16	Stequaleho Creek: Stequaleho Creek mouth to the Falls @ R.M. 2
Solleks-1	8130	5.05	Solleks River: Solleks R. mouth to Kloochman Creek mouth
Solleks-2	3196	1.99	Solleks River: Kloochman Creek mouth to Grouse Creek mouth
Kloochman-1	2811	1.75	Kloochman Creek: Kloochman Creek mouth to coho limit
Grouse-1	729	0.45	Grouse Creek: Grouse Creek to fish limit
George-1	1897	1.18	George Creek: George Creek mouth to fish limit
Itswoot-1	483	0.30	Itswoot Creek: Itswoot Creek mouth to coho limit
Kunamaskt-1	1799	1.12	Kunamaskt Creek: Kunamaskt Creek mouth to mainline Trib # 0118;
Susie-1	581	0.36	Susie Creek: Susie Creek mouth to coho limit
OC Airport	798	0.50	Clearwater River: Upper part of wetland to mouth at Clearwater R.
OC Christmas	909	0.57	Christmas Creek off-channel habitiat
OC Coppermine-Bottom	110	0.07	Coppermine Bottom off-channel habitat
OC Dasher	39	0.02	Dasher's off-channel habitat
OC DogLeg	160	0.10	Dog Leg off-channel habitat
OC Morrisons	599	0.37	Morrison's Pond off-channel habitat
OC MulePasture	27	0.02	Mule Pasture Pond off-channel habitat
OC Paradise	70	0.04	Paradise Pond off-channel habitat
OC Pond1	172	0.11	Pond 1 off-channel habitat
OC Pond2	157	0.10	Pond 2 off-channel habitat
OC Swamp1	299	0.19	Swamp Pond beaded channel off-channel habitat
OC Tiemeyers	137	0.09	Tiemeyers off-channel habitat

I rated the current conditions to indicate an increase in high flow interannual

variability between historic and current conditions. This reflects the general understanding that increases in peak flow intensity may occur in drainages influenced by large-scale logging. Other factors related to flow variation and hydrologic regime change (water withdrawals, regulated flows – dams) remained the same for current and historic conditions.

Stream Corridor Structure

Environmental data compilation involved field reconnaissance, synthesis, normalizing of pre-existing habitat data, and input from experts affiliated with the Clearwater and the EDT method. The expert team assembled for determining attribute values included EDT method developers and WDNR fish and habitat biologists with long-term familiarity of the Clearwater River. The data framework provided a mechanism for providing feedback and edits of each other's inputs.

Data was acquired from three sources 1) Quinault Indian Nation (QIN) habitat survey data occurring from 1992-1996, 2) various WDNR quantitative and observational field data from 1979-2000, and 3) field data collected in 2000. The EDT database contains a "pool tailout" category whereas other habitat data did not. To be consistent with other data sets, observations in 2000 were given a multiplier factor of .25 for "pool tailout" area when habitat data did not contain that category. Also, pool types such as plunge, scour, dam, or eddy were classified as general pools to be consistent with EDT data requirements.

I assumed that the majority of the coho habitat in the Clearwater basin was accessible in normal flow years for all coho salmon life stages. The assessment did not involve a culvert survey or exhaustive tributary survey. Obstructions may occur on a

very small scale within the coho distribution area. For this reason, I assumed no difference in the obstruction rating between historic and current conditions,.

Attributes for channel characteristics that tend to be more static (e.g. channel gradient, confinement, and channel widths) stayed the same for current and historic conditions. I made small differences in attribute ratings for channel integrity between current and historic conditions. I felt that most of the alluvial Clearwater channels would have had a dynamic nature even prior to land management. The differences were in attribute ratings for bed scour in some mainstem and low gradient alluvial channels, large woody debris abundance and functionality, habitat type, riparian function, and fine sediment/embeddedness where samples have occurred. In general, attribute ratings associated with sedimentation and/or channel stability were assigned a more degraded condition for the current condition than the historic condition.

Water Quality

Throughout the Clearwater basin, water quality related to temperature and chemical characteristics are generally considered normal and within the acceptable limits of viable salmon production. Recent water temperature investigations in the west Olympic Peninsula, including some Clearwater River locations (NOAA Fisheries, Seattle, WA, *unpublished data*) indicate that average daily maximum temperature in managed sites was 13.2 ° C compared to 11.3° C in unmanaged sites. Despite this difference I was unable to determine if conditions created by past management had influenced current water temperatures. This is due to the variability in the data and various site conditions. Nevertheless, in some mainstem reaches, slightly higher temperature ratings were assigned to current conditions than historic conditions under the

assumption that increased bedload (channel widening) and widespread canopy loss can influence stream temperature.

Chemical inputs are assumed to be the same under the current and historic model scenarios. Use of herbicide in the basin has been drastically reduced for many years. Also, past and current spraying regulations for vegetation management are eliminated or designed to minimize the inputs into riparian areas.

There does not appear to be an influence of nutrient enrichment from human activities due to the rural location of the watershed. Metals and non-metal pollutants were rated the same for historic and current conditions. Dissolved oxygen levels are not expected to be different between historic and current conditions. Turbidity, the amount of suspended solids in water from erosion and overland runoff, was given a slightly degraded ranking in most reaches of the current condition due to the history of intensive logging practices. Other turbidity-related factors (e.g. channel stability) are accounted for in steam corridor characterization (Table 2). Generally, other than turbidity factors, there does not appear to be major differences in water quality attributes when comparing historic and current conditions.

Biological Community

I considered the benthos diversity and production to be the same for the current and historic condition. A simple EPT (Emphemeroptera-Plecoptera-Tricoptera) index value was used noting that these insect families are present. Fish community richness was considered to be the same for current and historic conditions characterized with a index value that represents between eight and 17 fish taxa. The remoteness of the basin and limited influence of artificial propagation reduced the likelihood of differences in

fish community effects (fish pathogens and species introductions) between current and historic conditions. Therefore, there does not appear to be large enough differences in the biological community between historic and current conditions to warrant a rating change.

Data Synthesis

The EDT method provides various ways of entering and editing data into the model database. I compiled the original database in a Microsoft® Excel 2000 questionnaire and then exported it to a Microsoft® Access database where model operations are contained. Editing occurred in Access-based editors. The expert team reviewed and agreed on final data values for model runs.

Modifications

A key habitat for coho productivity in the Clearwater River floodplain is off-channel and wall-base channel habitat (Peterson 1982a, Cederholm and Scarlett 1982). The default EDT framework provides a coarse-scale approach using an attribute called "Off-channel Habitat Factor" expressed as an estimate of surface area contributing to a reach. This factors in the off-channel habitat's contribution to productivity and capacity. I felt that the coarse-scale of reach delineation (where off-channel ponds are located) would underestimate the influence these habitats could have on overall production. A different approach was evaluated to use available information on off-channel habitats.

This approach determined the relative contribution to fish productivity of some off-channel ponds based on morphometric (Peterson and Reid 1984) and ecological (Zarnowitz and Raedeke 1984) characteristics. Categorical values were developed based

on the attributes of pond surface area, pond accessibility, pond morphometry, and pond riparian structure. Upon further review of available data it became evident that many uncertainties existed about predation, stranding, and other fish mortality factors in the ponds to derive consistent conclusions among varying pond types. Therefore, I characterized fifteen off-channel ponds as individual reaches in baseline runs. These off-channel reaches are identified in the database reach descriptions by the prefix "OC" in the reach descriptions. These habitat types are low-gradient, slow flowing, and often have deep areas. Therefore, their habitat characterization was heavily weighted toward pool-type habitat in these reaches with prefix "OC".

These physical and ecological attributes describe the landscape that the coho salmon uses throughout its life history. A overview of coho life history information and habitat use from observations and study in the Clearwater basin is an appropriate step to confirm the suitability of the data types and biological rules applied in the EDT method.

Model Runs

I completed model runs for current conditions, historic conditions, expected conditions resulting from implementation of the Habitat Conservation Plan (HCP) conditions, and properly functioning conditions (PFC) (Table 4). The baseline current

Table 4. Summary of EDT model runs.

Diagnostic Model Runs	Scenario	Description/Reach Features	Intent
Baseline	Current	Summarized habitat data from recent observations	Predict population parameters with current conditions

	Historic	Estimated historic conditions with basic premise of improved instream habitat	Predict population parameters under hypothetical historic conditions
Alternatives	HCP	Estimated future condition under HCP management where values affected by improved riparian conditions were rated higher than current conditions	Predict population performance under HCP management
	PFC	Properly functioning condition based on National Marine Fisheries Service "habitat approach" to effects analysis[a]	Provide guidance for effects evaluation related to Endangered Species Act
Off-channel	Current Historic	25% upstream migration patterns into off-channel habitat	Determine EDT sensitivity to independent off-channel habitat values: higher than default upstream migration during juvenile rearing
	Current Historic	50% upstream migration patterns into off-channel habitats	Determine EDT sensitivity to independent off-channel habitat values: drastic off-channel recruitment

[a] (*Source:* USDOC Memorandum 1999)

condition used index values derived from habitat data within the past 15 years and from field work during this investigation. The historic condition values were derived by assumptions that there would be an increase in channel complexity, pool habitat surface area, and a slightly more stable hydrologic regime. I felt that hypothesized unmanaged conditions would predominantly reflect changes in instream habitats related to logging impacts since that has been, and still is, the predominant land use. The HCP alternative

estimated future conditions of the Clearwater basin under HCP management guidelines[1]. Habitat Conservation Plan ratings were not as high as historic conditions since there is some management influence assumed. The aquatic environment may still be experiencing the lag effects of past management practices and even though protective streamside management is occurring, recovery of historic conditions may not be possible.

The HCP ratings emphasized improved channel habitats and riparian conditions, captured in improved ratings for instream habitat features such as pool area and channel stability. Properly functioning condition values are based on the National Marine Fisheries Service "habitat approach" to effects analysis (Table 5). The PFC scenario used ratings of channel conditions that include literature values of large woody debris abundance, pool-riffle ratios of habitats and properly functioning condition. Attribute ratings for PFC are assumed to be higher than HCP ratings because of the PFC rating's tendency to represent optimal conditions.

The Habitat Conservation Plan (HCP) and Properly Functioning Condition (PFC) scenarios are hypothetical environmental conditions to compare with the EDT's current and historical conditions. The HCP objectives anticipate that aquatic ecosystem integrity would be protected, and by default, provide habitat conditions for successful

Table 5. Matrix of pathways and indicators used for Properly Functioning Condition rating. *Source*: National Marine Fisheries Service 1996.

Pathway	Indicators	Properly Functioning Condition
Water Quality:	Temperature	50-57° F

1. Although quite impossible to predict the values of instream habitat values based on future riparian conditions, the assumption is that conservation strategy goals will eventually produce higher quality instream habitat features such as deep pool habitats pawning gravel retention, and bank stability because of large tree recruitment into the channel. Attribute ratings prescribed in this scenario that are related to the in-channel environment would generally support higher productivity than current conditions.

	Sediment/Turbidity	<12% fines (<0.85mm) in gravel, turbidity low
	Chemical Contamination /Nutrients	Low levels of chemical contamination from agricultural, industrial and other sources, no excess nutrients, no Clean Water Act 303d designated reaches
Habitat Access	Physical Barriers	Any man-made barriers present in watershed allow upstream and downstream fish passage at all flows
Habitat Elements	Substrate	Dominant substrate is gravel or cobble (interstitial spaces clear) or embeddedness <20%
	Large Woody Debris	Coast: >80 pieces/mile >24" diameter >50 ft. length'; East-side: >20 pieces/mile >12" diameter>35 ft. length'; and adequate sources of woody debris recruitment in riparian areas
	Pool Frequency Channel width # pools/mile 5 feet 164 10 " 96 15 " 70 20 " 56 25 " 47 50 " 26 75 " 23 100 " 18	Meets pool frequency standards (left) and large woody debris recruitment standards for properly functioning habitat (above)
	Pool Quality	Pools >1 meter deep (holding pools) with good cover and cool water', minor reduction of pool volume by fine sediment
	Off-channel Habitat	Backwaters with cover, and low energy off channel areas (ponds, oxbows, etc.)
	Refugia (important remnant habitat for sensitive aquatic species)	Habitat refugia exist and are adequately buffered (e.g., by intact riparian reserves); existing refugia are sufficient in size, number and connectivity to maintain

Table 5. Continued

Pathway	Indicators	Properly Functioning Condition
Channel Condition & Dynamics	Width/Depth Ratio	< 10
	Streambank Condition	> 90% stable; i.e., on average, less than 10% of banks are actively eroding'
	Floodplain Connectivity	Off-channel areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession
Flow/Hydrology:	Change in Peak/base Flows	Watershed hydrograph indicates peak flow, base flow and flow timing characteristics comparable to an undisturbed watershed of similar size, geology, and geography
	Increase in Drainage Network	Zero or minimum increases in drainage network density due to roads"
Watershed Conditions	Road Density & Location	< 2mi/mi^2, no valley bottom roads
	Disturbance History	< 15% ECA (Equivalent Clearcut Area - entire watershed) with no concentration of disturbance in unstable or potentially unstable areas, and/or refugia, and/or riparian area; and for NW Forest Plan area (except Adaptive Management Areas) ≥ 15% retention of Late Seral Old Growth
	Riparian Reserves	The riparian reserve system provides adequate shade, large woody debris recruitment, and habitat protection and connectivity in all subwatersheds, and buffers or includes known refugia for sensitive aquatic species (>80% intact), and/or for grazing impacts: percent similarity of riparian vegetation to the potential natural community/composition >50%

salmon reproduction and survival. Further, EDT provides an analysis using the habitat-rating concept of PFC (NMFS 1996). The PFC concept is applied to environmental attributes and is not necessarily species-specific. That is, there are habitat requirements of Pacific salmonids in general such as cold, clean water, complex habitats, and riparian conditions conducive to forming quality habitat that comprises functional habitats. The PFC Matrix of Pathways (Table 5, pp 45) proposes values for these conditions at reach and watershed scales.

The changes I emphasized in the HCP scenario were generally with attributes that

are related to conditions that could be affected by riparian management such as substrate conditions and pool habitat area. By leaving riparian areas relatively unmanaged over time, one could expect habitat complexity to increase because of mature conifer in the riparian areas eventually depositing into the stream channels helping to increase channel stability and perform a variety of other hydraulic and habitat function. Channels that currently manifest effects from debris flows, ones that are evidenced by larger substrate and absence of large woody debris, would eventually accumulate more large woody debris. More sediment storage and in-channel structure that regulates sediment movement, are features that provide more stability to channels.

The PFC environmental attributes modeled in the EDT are constrained so that PFC cannot be better than the historic conditions. The PFC scenario emphasized changes where EDT environmental attribute index values matched PFC environmental attribute index values. For instance, the PFC large woody debris criteria for coastal watersheds are about 80 pieces per mile (characterized by greater than 24 in. diameter and greater than 50 ft. length) (see Table 5, pp 44 Habitat elements pathway). I felt that even though the EDT does not provide the numeric detail of large woody debris criteria such as volume and number of pieces, that it does provide index values that are descriptive and that pertain to somewhat equivalent overall function of the woody debris values of PFC. Adequate function and volume of large woody debris would translate into an index value of between 0 and 1 in the EDT attribute scale of 0-4. In those index values, complex arrangements of larger, channel spanning wood that influences channel diversity are the characteristics that one would expect given the PFC large woody debris characterization.

Life History Diversity

The EDT's analytical method evaluates habitat spatially and temporally within a year. Resultant life history trajectories begin and end with spawning at a reach during the known spawning periods and are combined to form a life history pattern. This life history pattern is the sequence of life stages connected together to form the whole life history of the species being evaluated (see Figure 7, pp 30). EDT outputs include a Diversity Index that calculates the percentage of life history patterns that are preserved through various scenarios compared to the historic conditions.

I repeated current and historic model runs with a modification in the life history behavior at the juvenile life stage of migrating into and rearing in off-channel habitats. The EDT considers 16 different life stages of the coho and in particular, life stage 6 (0-age migrant) was given a tendency to perform an upstream migration into reaches designated as off-channel habitats or channels that led into off-channel pond habitats. All these runs did not include additional mortality from harvest and loss of genetic fitness[1].

Productivity Estimates by Alternative Methods

The EDT-based estimates help form hypotheses about the productive capacity of the Clearwater. In many disciplines, different models applied to the same question, however, can provide varying results. Usually this is a result of varying model objectives and/or emphasis on particular variables. Prior to interpreting the EDT outputs, adult estimates were derived from other methods to provide varying perspectives of other perspectives of productivity estimates.

1. Mortality from harvest and loss of genetic fitness are standard scenario options within EDT. In the Clearwater River, these are assumed to be relatively minor influences due to minimal commercial fishery and very limited history of artificial stocking. Changes in instream habitat, channel morphology, and riparian characteristics were the emphasis of these scenarios.

Using historical escapement (number of adult spawners) estimates data, habitat abundance data, and juvenile population estimates, I estimated adult coho estimates to provide comparative estimates to EDT population performance estimates (Table 6). These values included estimates from the Washington State's Salmon and Steelhead Stock Inventory, habitat-based estimates based on highest densities ever observed during summer rearing and spawning, nutrient saturation, and alternate EDT modeled runs.

According to Quinault Indian Nation and Washington Department of Fish and Wildlife data, adult returns to the Clearwater River from 1981-2002 have averaged 2,380 adults, with a maximum of 10,566 in 2001. Based on juvenile fish population estimates from various Clearwater River tributaries, the summer rearing density-based estimate of adult return was 18,000. This estimate was calculated by multiplying the highest observed juvenile coho density (1 fish/m^2) by the water surface area during summer flows to calculate a total fry emergence abundance (5.7 million). I assumed 20% survival from emergence to summer rearing based on unpublished data with the assumption of 20% survival from emergence to summer. Based on eggs necessary to attain these fry numbers, female population egg contribution was estimated (27.2 million) to derive the number of females needed to produce this amount of eggs. The overall population estimate used a 1:1 sex ratio. This estimate is somewhat comparable to the redd density-based estimate (15,360) and EDT off-channel modified estimate (15,132). I derived the redd density estimate of juvenile coho salmon by multiplying the highest density of redds

Table 6. A comparison of estimated adult returns using various techniques with EDT estimates for comparison. Except for redd density estimate, estimates do not include fishery effect.

Method	Data Source	Definition	Adult returns
Salmon and Steelhead Stock Inventory	SASSI, WA Department of Fish and Wildlife	Based on spawner surveys 1981-2002	Average: 2,380 High (yr. 2001): 10,566
Summer Rearing Density[a]	Quinault Indian Nation unpublished habitat data	Calculated maximum summer rearing density based on surface area	18,000
Redd Density[b c]	Quinault Indian Nation spawner surveys	Calculation based on highest spawning density observed (20 redds/km)	15,360
Salmon Carcass Loading[c]	Bilby et al. 2001	Calculation based on diminishing uptake of $\delta^{15}N$ (loading of .15 kg/m^2 carcass)	47,400
EDT Capacity estimate	EDT Model Runs	Baseline template (Historic)	5,781
EDT Capacity estimate	EDT Model Runs	Baseline template with 50% upstream migration of 0 age migrants.	15,132

a. Based on coho density of 1 coho/m^2. Source: Brian Edie (unpublished data)
b. Calculation source: Cederholm and Dominguez 2003. Stable isotope tracers, such as $\delta^{15}N$, trace nitrogen (N) from spawning salmon through aquatic trophic systems. Marine-derived N in its isotopic form is heavier than N from other sources and spawning salmon contain higher proportions of the marine-derived N.
c. Derived from highest redd density on record; estimate of 7,680 that included a 50% exploitation rate.

observed on record (20 redds/km) with the average number of juveniles expected to be produced from the redd. I calculated the salmon carcass loading adult return estimate based on diminishing uptake of marine-derived nutrients. Based on Bilby et al (1996), diminishing uptake occurs when the aquatic and terrestrial system drastically reduces its utilization of the available marine- derived nutrients traced via N^{15} stable isotopes. When a system reaches uptake capacity, marine derived nutrients reach a point of "saturation". This does not suggest that ecological benefits have maximized, only the nutrient benefit of that local area.

I conducted an additional EDT capacity estimate scenario that assigned an upstream migratory behavior into 50% of the downstream migrant juveniles. I was not sure if the default juvenile migration behaviors in the model would capture the upstream migration of juvenile coho that migrate into wall-base or off-channel ponds for overwintering or temporary refuge from winter flooding.

In summary, the EDT is capable of running many different scenarios with several options for variations within those scenarios. This is one of the model's biggest strengths. Describing all the potential scenarios is beyond the scope of this thesis. Instead, by evaluating the outputs from a few distinct scenarios, potential productivity from within the basin can propose hypotheses for long-term trend analysis. For instance, periodic intensive monitoring to determine actual coho productivity estimates (adult or smolt) can be compared to ongoing EDT predictions that are updated according to current habitat conditions. Also, with differing values among the scenarios, the EDT's sensitivity to varying environmental conditions can be observed.

Results and Discussion

Population Performance

Historic and Current Conditions

Model runs were completed for the current and historic conditions. Model results estimated the coho spawning population size at equilibrium abundance in the current condition to be 3,319 fish (Figure 8). The average spawning population size in hypothesized historic conditions is about 5,300 fish. This output suggests that current abundance is about 60% of historic abundance. Population productivity was estimated to be 5.1 adult recruits per spawner for the current condition and 12.9 recruits per spawner for historic conditions. The life history diversity value[1] indicated that about 96% of the historic life history pathways can be successfully used for production in the current condition.

The EDT estimated smolt output (estimated at the mouth of the Clearwater River) to be 87,067 smolts for the current condition and 140,506 smolts for the historic condition (about 62% of estimated historic abundance) (Figure 9). Smolt capacity (number which the system could support) for the current condition is about 70% of that for the historic condition (108,791 versus 152,733 smolts). Smolt productivity (measured as smolts per spawner) showed the greatest decline from historic conditions, the current condition being about 40% of the historic condition.

1. The EDT life history diversity value results from the calculation of the number of sustainable life history trajectories under an alternative scenario relative to the number under the historic scenario. A high percentage of preservation indicates fish are accessing available habitats that are key to their survival.

Parameter	Historic	Current
Capacity (adult recruits)	5,781	4,122
Productivity (recruits per spawner)	12.9	5.1
Equilibrium abundance	5,333	3,319

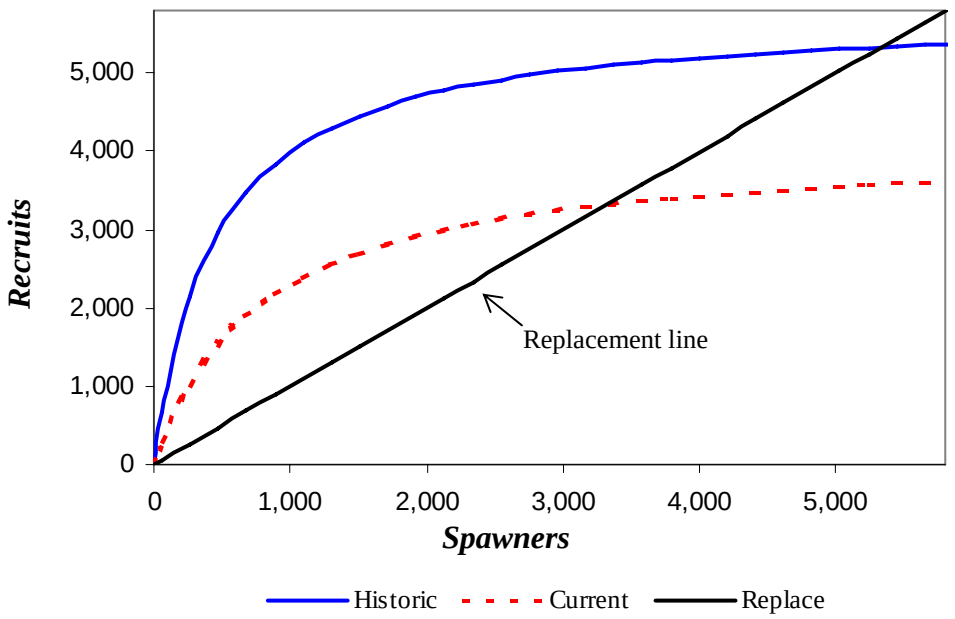

Figure 8. Clearwater Natural coho stock-recruitment curves under current and historic conditions with no harvest effects. Equilibrium abundance[1], where the production curve crosses the replacement line is 3,319 adults under the current conditions and 5,333 under historic conditions.

1. See definitions page xi.

Parameter	Historic	Current
Capacity (no. smolts)	152,733	108,791
Productivity (smolts per spawner)	329.1	131.4
Number of smolts at Adult Neq	140,506	87,067

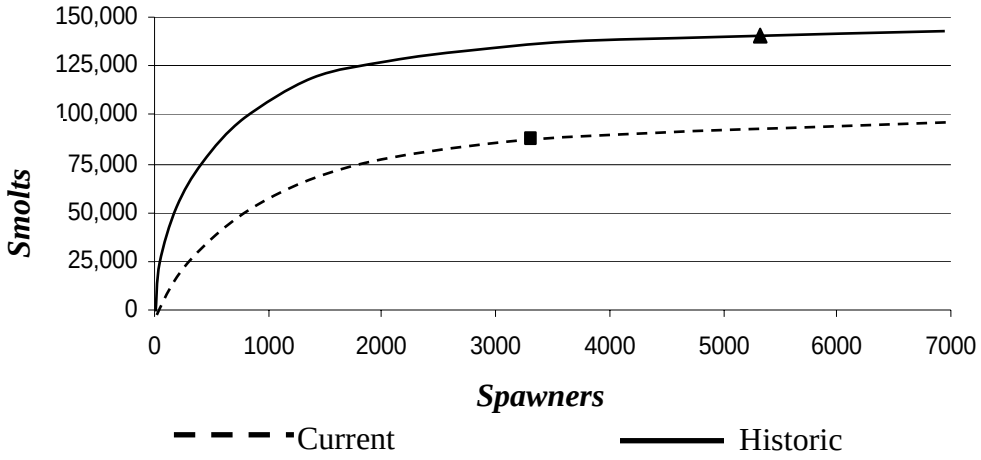

Figure 9. Beverton-Holt population parameters for natural coho smolts in the Clearwater River (measured at the Clearwater River mouth) under the current and historic conditions. Markers on the spawner recruit curve, ▲ and ■, indicate the location of adult equilibrium abundance (number of smolts at net equilibrium (Neq) adults).

Alternative Scenarios: Habitat Conservation Plan and Properly Functioning Condition

Figure 10 displays the adult capacity and productivity estimates for the HCP and PFC scenarios bounded by the baseline estimates (current and historic conditions). For the HCP scenario, model results estimated the average net equilibrium abundance natural coho spawning population size to be 4,051, an increase of 732 fish. Productivity increased from 5.1 adults per spawner in the current condition to 8.3 adults per spawner (Figure 10). The abundance estimate indicates that HCP conditions would be 75% of the abundance expected from historical conditions.

HCP scenario model results for smolts were similar. The EDT estimated smolt output (estimated at the mouth of the Clearwater River) to be 107,029 smolts (76% of estimated historic abundance) (Figure 11). Smolt capacity (number which the system could support) for the current condition is about 80% of that for the estimated historic condition (122,166 versus 152,733 smolts). Smolt productivity (measured as smolts per spawner) showed the greatest decline from historic conditions, the current condition being about 40% of the historic condition.

The HCP and PFC scenario results were similar with the PFC scenario slightly higher that the HCP for abundance and productivity. For the PFC scenario, model results estimated the average net equilibrium abundance natural coho spawning population size to be 4,602, an increase of 1,283 fish. Productivity increased from 5.1 adults per spawner in the current condition to 9.2 adults per spawner. The abundance estimate indicates that PFC conditions would be 89% of the abundance expected from historical conditions.

Parameter	Current	HCP	PFC	Historic
Capacity (adult recruits)	4,122	4,610	5,161	5,781
Productivity (recruits per spawner)	5.1	8.3	9.2	12.9
Number of adults at Adult Neq	3,319	4,051	4,602	5,333

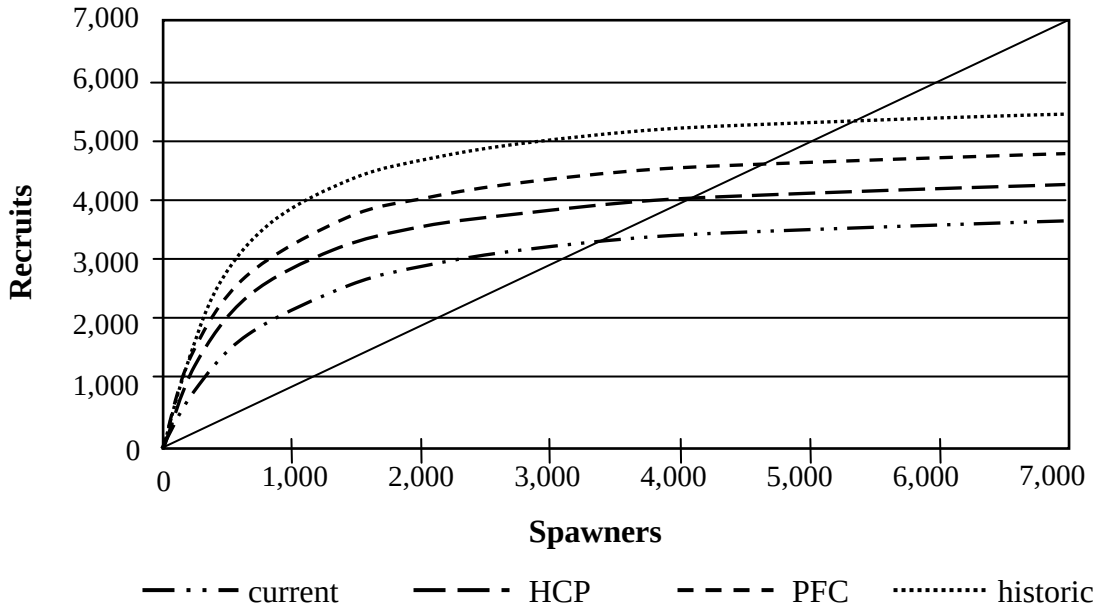

Figure 10. Beverton-Holt population parameters for adult natural coho in the Clearwater River under four habitat scenarios (current, Habitat Conservation Plan (HCP), properly functioning condition (PFC), and historic). Equilibrium abundance reported in the table is where the production curve crosses the replacement line.

Parameter	Current	HCP	PFC	Historic
Capacity (no. smolts)	108,791	122,166	136,376	152,733
Productivity (smolts per spawner)	131.4	213.2	236.2	329.1
Number of smolts at Adult Neq	87,067	107,029	121,506	140,506

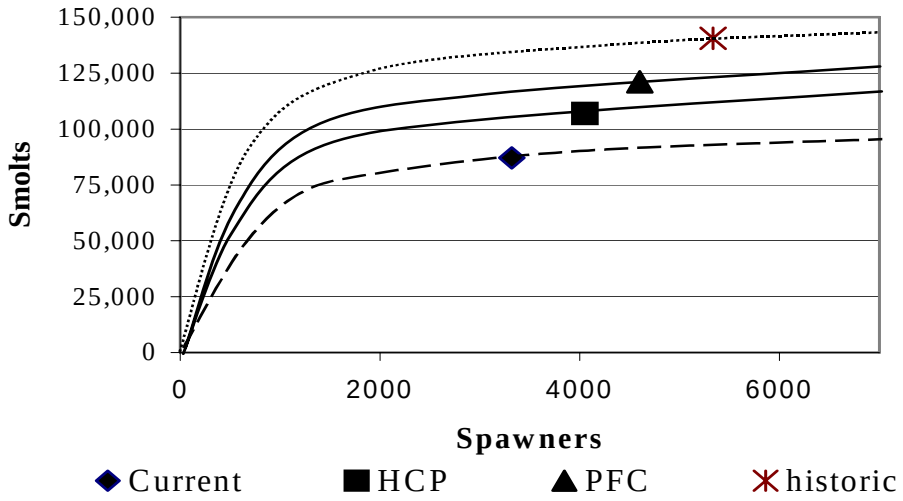

Figure 11. Beverton-Holt population parameters for coho smolts in the Clearwater River under four habitat scenarios (current, Habitat Conservation Plan (HCP), properly functioning condition (PFC), and historic). Symbols on the spawner recruit curve indicate the location for adult equilibrium abundance (Neq).

The PFC scenario model results for smolts were similar. The EDT estimated smolt output (estimated at the mouth of the Clearwater River) to be 121,176 smolts (86% of estimated historic abundance) (Figure 11). Smolt capacity (the estimate of smolts the watershed could produce) for the current condition is about 89% of that for the estimated historic condition (136,376 versus 152,733 smolts). Smolt productivity (measured as smolts per spawner) under the PFC scenario is about 72% of estimated historic productivity (236 smolts/spawner versus 329 smolts/spawner historic condition).

Life History Diversity

Baseline model runs predicted that 100% of the life history patterns would be preserved under the PFC and HCP scenarios and that 96% of the life history patterns are preserved under current conditions. This high preservation would be expected since minimal physical or temperature barriers to habitats were documented in the baseline database, essentially making all habitats available. These findings are a very reasonable reflection of what would be found out in field observations. In the Clearwater basin, very limited occurrences, if any, exist of factors that tend to influence the life history diversity pathway modeling such as development, channel modifications, water quality problems, and other practices that can segregate habitats from each other. In a timber management area, stream crossing barriers likely have the biggest effect on life history diversity. In the Clearwater basin, tributaries with coho use are minimally affected by road crossing barriers.

Productivity Methods by Alternative Methods

The main reason I conducted these alternative estimates was to create other estimates to compare to the EDT estimates. There are several ways to estimate watershed productivity and with varying perspectives of what a healthy, abundant salmon run is, I considered it reasonable to provide other estimates. These estimates have a wide range with most exceeding the EDT-historic condition adult return estimate.

Over the past several years, evidence has mounted about the contributions of marine derived nutrients from spawning salmon to freshwater productivity. These nutrients can influence aquatic productivity of the stream where they spawn (Larkin and Slaney 1997), provide a nutrient source for their progeny (Bilby et al. 1996), and provide nutrient sources for many wildlife species (Cederholm et al. 2001, Hildebrand et al. 1996). The adult estimate based on diminishing uptake[1] of marine-derived nutrients (as indicated by stable isotope ratios ($\delta^{15}N$ and $\delta^{15}C$)) from salmon carcass loading was 47,400. This estimate was based on full use of available spawning habitat in the Clearwater River.

Conversely, the EDT-historic estimate (5,781 adult returns) at least doubled the average of 20 years of spawning estimates (2,380 adult returns), even with ten percent fisheries exploitation. The high variation of these estimates could be due to biases of particular techniques, or simply that accurately calculating productivity is more complicated than fundamental or traditional calculations. Field spawner surveys have

1 Diminishing uptake occurs when the aquatic and terrestrial system drastically reduces its utilization of the available marine derived nutrients traced via N^{15} stable isotopes.

been shown to produce bias in estimates (Symons and Waldichuck, 1984, Dangel and Jones 1988, Dunham et al 2001). Also, uncertainty in how the stream affects site-level productivity can bias productivity estimates (Dunham and Vinyard 1997).

Reach Analysis

Summaries for EDT reach analysis (Figures 12 and 13) include the information to derive the restoration/preservation benefits (Figure15). Additionally, the reach summaries provide information on productivity changes at varying life stages and hypothesize the relative loss or gain to productivity and abundance according to how a survival factor is impacted.

Figures 12 and 13 are two samples of the 91 outputs of reach evaluations. They are compared to demonstrate how EDT indicates the various effects that different environmental conditions could have on different life stages. Figure 12 is the output from a reach in the lower Clearwater River named Clearwater-03B. The reach is located between the Tiemeyer Pond outlet and the Morrison Pond outlet. Note that there are not significant productivity changes through any of the life stages and not much potential impact or gain on survival by impacting the attributes (EDT produces a key, see lower right of Figure 12, with circle markers of increasing circle size to indicate relative losses or gains to impacts). The overall restoration benefits category and restoration potential rank high however, because those ratings are based on the effect over the entire geographic area[1]. In this case, the lower Clearwater contains the majority of off-channel habitat, a valuable habitat type for coho salmon. The accumulation of key habitat, by

1. Geographic areas are individual reaches grouped to form a management area. They may or may not be physically similar but protection and restoration recommendations can be assigned at this larger scale.

Geographic Area:	Lower Clearwater mainstem			Stream:	
Reach:	Tiemeyer Pond outlet to Morrison Pond outlet			Reach Length (mi):	0.57
				Reach Code:	Clearwater-03B
Restoration Benefit Category:1/	A	Productivity Rank:1/	1	Potential % change in productivity:2/	48.3%
Overall Restoration Potential Rank:1/	1	Average Abundance (Neq) Rank:1/	1	Potential % change in Neq:2/	23.8%
(lowest rank possible - with ties)1/	18	Life History Diversity Rank:1/	5	Potential % change in diversity:2/	0.2%
Preservation Benefit Category:1/	A	Productivity Rank:1/	1	loss in productivity with degradation:2/	-36.6%
Overall Preservation Rank:1/	1	Average Abundance (Neq) Rank:1/	1	% loss in Neq with degradation:2/	-48.9%
(lowest rank possible - with ties)1/	18	Life History Diversity Rank:1/	1	% loss in diversity with degradation:2/	-21.2%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	0.3%	-0.4%	8																
0-age active rearing	Mar-Oct	0.3%	-8.1%	2							•									
0-age migrant	Oct-Nov	2.0%	-0.1%	6																
0-age inactive	Oct-Mar	0.2%	-9.5%	3																
1-age active rearing	Mar-May	0.2%	-4.4%	4																
1-age migrant	Mar-Jun	90.3%	0.0%	1							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	92.0%	0.0%	5																
Prespawning holding																				
All Stages Combined		92.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Figure 12. Clearwater River coho reach analysis for Clearwater-03B. The analysis compares current conditions versus historic potential with emphasis on restoration or maintenance/improvement of historic life histories.

Geographic Area:	Miller Creek			Stream:	
Reach:	Unnamed Trib # 0062 to coho limit;			Reach Length (mi):	2.61
				Reach Code:	Miller-4
Restoration Benefit Category:1/	A	Productivity Rank:1/	2	Potential % change in productivity:2/	29.0%
Overall Restoration Potential Rank:1/	2	Average Abundance (Neq) Rank:1/	2	Potential % change in Neq:2/	12.2%
(lowest rank possible - with ties)1/	18	Life History Diversity Rank:1/	6	Potential % change in diversity:2/	0.0%
Preservation Benefit Category:1/	B	Productivity Rank:1/	3	loss in productivity with degradation:2/	-14.0%
Overall Preservation Rank:1/	3	Average Abundance (Neq) Rank:1/	3	% loss in Neq with degradation:2/	-15.6%
(lowest rank possible - with ties)1/	18	Life History Diversity Rank:1/	2	% loss in diversity with degradation:2/	-13.6%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	2.0%	-2.0%	6							●						●			
Egg incubation	Oct-May	2.0%	-41.6%	1	●												●			
Fry colonization	Mar-May	2.0%	-6.9%	3	●				●	●	●						●			●
0-age active rearing	Mar-Oct	1.7%	-8.3%	4	•		•		●	●	●				•	•	•			○
0-age migrant	Oct-Nov	1.7%	-1.9%	8							●						●			
0-age inactive	Oct-Mar	1.7%	-10.3%	2	●				●	•	●									•
1-age active rearing	Mar-May	1.7%	-5.5%	5	•		•		●	•	●									○
1-age migrant	Mar-Jun	1.7%	-0.2%	9							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	2.0%	0.0%	10													•			
Prespawning holding	Oct-Dec	2.0%	-1.7%	7					•		•						●			○
All Stages Combined		2.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	●	○
Extreme	●	○

Figure 13. Clearwater River coho reach analysis for Miller-4. The analysis compares current conditions versus historic potential with emphasis on restoration or maintenance/improvement of historic life histories

including an off-channel habitat factor for these reaches, causes this geographic area to have the highest restoration potential. This same ranking and logic holds for preservation potential since the off-channel areas are functional in the current conditions.

Information included on the reach analysis summaries includes a breakdown of estimated productivity changes at the various life stages during key months. For instance, Figure 12 indicates that productivity during the spawning, incubation, and fry colonization life stages are relatively unaffected. Coho generally do not spawn in the lower Clearwater River, hence these life stages would be unaffected by changes in conditions from historic to current. In contrast, spawning tributaries will have greater sensitivity to environmental impacts as discussed below for Miller Creek. Stream segment routing can be evaluated as well. In regards to juvenile migration, the model detected that 90% of the trajectories of 1-age migrants moved through this reach[1]. Ninety-two-percent of the prespawing migrants passed through this reach.

The Miller 4 reach analysis (Figure 13) proposes more abundant and dynamic changes between current and historic conditions than observed in Clearwater-03B. These two sample reaches differ in many ways that could explain these differences. Miller-4 is a longer reach (2.6 mi) providing greater habitat area and diversity since it is a smaller channel and used by the early life stages of coho. Miller-4 provides abundant spawning gravel. Degrading sediment load characteristics indicate a potential for extreme losses, most notable in the egg incubation stage where productivity changes[2] are predicted at

1 In figure 12, see column labeled "% of life history trajectories affected" for life stage "1-age migrant".
2 Percent change in productivity is the change resulting from environmental conditions different than the historic environmental conditions.

- 41%. Stream segment routing indicates a small percentage of the trajectories make it up this far into Miller Creek. Note that pre-spawning migrant and holding passed 2% of the modeled trajectories. The Miller Creek geographic area is still ranked high in the overall preservation and restoration benefits likely due to its association with the greater Miller Creek subbasin.

Review of the 91 reach analyses showed a pattern of neither loss nor gain for certain attributes. This is due to the assumption that some attributes would be relatively unaffected by the type of management that has occurred. Attributes related to intensive fishery and hatchery activities such as competition, poaching, pathogens, and other effects such as chemicals, oxygen, and withdrawals were given similar ratings in the current and historic conditions database. Activities that would influence these attributes are absent or nominally present on the Clearwater River.

Protection and Restoration Benefits for Clearwater River Coho

A primary EDT output is a description of the protection and restoration benefit related to activities in a geographic area. Environmental conditions of geographic areas can migrate back and forth across an environmental continuum (McConnaha 2003). The conditions hypothetically migrate between reference conditions, in this case, degraded conditions to historical conditions (see top portion, Figure 14), derived from EDT historic scenario. Watersheds can vary in productivity from year to year due to many reasons.

Reference conditions enable watershed managers to continue observing year-to-year changes within an environmental continuum of degraded, recovering, or properly

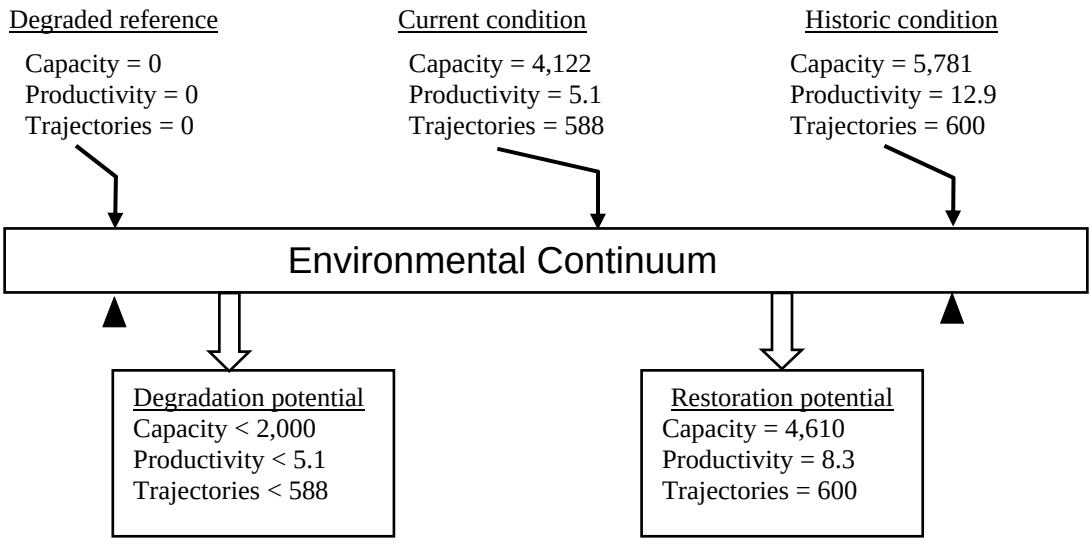

Figure 14. Schematic representation of restoration and degradation potential of coho salmon in the Clearwater River. Restoration potential (values based on PFC estimate) is the difference between performance under the restored reference conditions and performance under the current conditions. Conversely, degradation potential is the distance between coho performance under degraded conditions and performance under the current conditions. Adult returns that are less than the past 20-year average estimate are suggested as the criteria for degradation. (Modified from McConnaha 2003).

functioning watersheds, or ones that approach their productive capacity. From knowledge of the current condition and a hypothesis of its potential, managers can guide planning that maintains productivity levels at a desirable place on the environmental continuum.

Figure 14 demonstrates that the restoration potential of the Clearwater River is the location on the continuum between the current condition and the historic condition[1]. This assumes that current conditions are below potential productivity values and that watershed managers will be satisfied with less than historic conditions. These are

[1] Higher values of capacity and productivity than those in the current condition suggest trends toward restored conditions.

practical and reasonable assumption for most Washington Rivers because of past and continued management activities. To achieve conditions any place on that continuum away from the current condition toward the historic condition is to address restoration in the Clearwater basin. For example, the values used for the restoration potential are derived from the Properly Functioning Condition scenario. Managers need to decide where on that continuum is acceptable for populations to recover and persist amidst effects of fisheries and land management.

Conversely, the degradation potential is the location on the continuum between the current condition and the degraded condition (exemplified by zero capacity and productivity). The modeled current condition is closer to the restoration potential than the actual spawner estimates have been over the past twenty years (2,380 adults). In fact, this 20-year average is only about 60% of what EDT estimates could be produced under current habitat conditions. Several reasons could explain this including variability in spawner estimation, fishery effects, or model calculations of expected productivity under current conditions - that is, EDT predicting habitat to be more productive than actual.

Recall that the EDT reach analysis summarizes the relative magnitude of effects that changes in habitat conditions could have on specific life stages (Figures 12 and 13). To create a larger spatial scale of analysis, individual reaches are combined to form geographic areas. The relative importance for restoration and protection measures provided by these outputs can be viewed as hypotheses for salmon conservation and restoration. Each geographic area is assigned a protection and restoration benefit ranking based on the cumulative influence that each reach contained in the geographic areas has on abundance, productivity and life history diversity (Figure 15). The hypothesis is that

the higher a geographic area is ranked the more influence that area has under a protection or restoration management alternatives.

The protection and restoration benefits for Clearwater River coho in 18 geographic areas are displayed in Figure 15. Categories A through D are automatically assigned by model outputs based on the relative significance the areas have to productivity and abundance, or they can be modified by model users to customize priority areas. For instance, Figure 15 assigns only two geographic areas to Category A, Lower Clearwater mainstem and Upper Snahapish River. Since these were the two predominantly affected areas, they were assigned their own high priority category.

The relatively larger percent change represented by shaded bars in the "Change in Abundance With" column (Figure 15), suggests that the Lower Clearwater mainstem and Upper Snahapish River have the highest percent change in abundance if those reaches were degraded or restored depending on the habitat response form the management action. The EDT analysis recognized the relative significance of that percent change and assigned a high protection benefit rank (number 1 and 2). That is, based on the capacity of the habitat under historical condition, these geographic areas of the Lower Clearwater River and Upper Snahapish River heavily influence overall watershed abundance and productivity. Therefore, maintaining their functionality is a high priority.

Similarly, the restoration benefit rank proposes a prioritization of which geographic areas might benefit the most from restorative efforts. Figure 15 indicates that the Lower Clearwater mainstem and Miller Creek have the greatest restorative potential.

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category/rank		Category/rank		Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
Queets River	B	8	D	15						
Lower Clearwater mainstem	A	1	A	1						
Mid Clearwater mainstem	B	4	B	3						
Upper Clearwater mainstem	C	9	C	10						
Off-channel Ponds	E	18	E	18						
Misc Lower Clearwater Tribs	B	4	C	10						
Hurst Creek	B	7	B	6						
Shale Creek	B	6	B	7						
Miller Creek	B	3	A	2						
Christmas Creek	C	11	B	7						
Deception Creek	D	16	D	14						
Lower Snahapish River	C	13	C	9						
Upper Snahapish River	A	2	B	4						
Snahapish Tribs	D	14	D	12						
Bull Creek	D	14	D	13						
Stequaleho Creek	D	17	D	15						
Solleks River	C	11	B	4						
Misc Upper Clearwater Tribs	C	10	D	17						

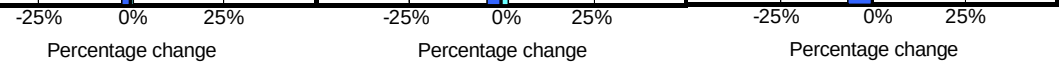

Figure 15. **Relative importance based on historic potential of geographic areas for restoration and protection measures for Clearwater River coho salmon.** Areas are ranked and assigned to benefits categories according to potential ("A" category is highest) to affect population performance. Contributions of performance measures to ranking are graphed. Note that off-channel ponds are included as a separate group. Restoration/degradation effects were captured in the Lower Clearwater mainstem geographic area where off-channel habitat factor is influential on these reaches. This diagram does not reflect potential contributions strictly from off-channel ponds since baseline runs did not recruit significant amounts of juveniles into these habitats during modeling.

The Upper Snahapish also has similar restorative potential.

Note that the off-channel habitat geographic area indicates little to no change in restoration or protection benefits. During baseline model runs, few trajectories reached into the off-channel ponds since the model contained a higher likelihood of predicting continued downstream direction during juvenile migration life stages. Since the model "underutilized" these specific habitats, they received a low restoration benefit ranking. The value of off-channel habitats, however, was compensated for in the off-channel factor, a value described during the reach description process (Level 2 Data). In addition to being a reach where many freshwater portions of life histories pass, the lower mainstem geographic area has high protection and restoration value because this is where the majority of the off-channel habitat types are associated.

To address the tendency for the model to minimize upstream juvenile migration, four model runs were conducted with altered upstream migration probabilities (Table 7). At the 0-age migrant juvenile life stage (EDT code = L6), a 25% and 50% probabilities of upstream movement were assigned to that specific portion of the trajectory. This meant that if a fish passed through a reach that had access to an off-channel habitat area, it was prescribed a 25% chance in one simulation and a 50% chance in another simulation, to migrate up into the off-channel ponds.

Uncertainty exists about what percentage of juvenile outmigrants enter into these ponds, but relatively high values (25% and 50%) were assigned to ensure recruitment and determine if the model showed population response by juveniles migrating into these habitats. Off-channel pond evaluation in the past suggests that the rearing capacity of

Table 7. Summary of outputs for model runs that increased likelihood of recruitment into off-channel habitat reaches. Baseline runs that were conducted under different options showed no difference at 25% probability of upstream movement for 0-age migrants. In the test run of 50% probability of upstream movement for 0-age migrants, productivity (smolts/spawner) increased nearly 900% under historic conditions. Capacity, however, experienced only a 13% increase with the enhanced off-channel migration scenario.

Run Descriptors	Options	Scenarios	Productivity	Capacity	Equilibrium Abundance
BASELINE 0 off-channel habitat 25% upstream migration of 0-age migrants	AA[a]	Current	5.13	4,122	3,319
		Historic	12.91	5,781	5,333
	BB[a]	Current	5.13	4,122	3,319
		Historic	12.91	5,781	5,333
TEST Non-zero habitat and 50% upstream migration of 0 age migrants	AA	Current	73.37	4,438	4,378
		Historic	128.3	6,545	6,494
	BB	Current	56.7	11,416	4,378
		Historic	113.54	15,132	6,494

a Option AA does not consider unproductive reaches.
Option BB considers the capacity – even some unproductive reaches have some capacity.

the ponds were never approached (C. Jeff Cederholm, WA Dept. of Natural Resources, personal communication). With the support of high numbers of adults predicted from estimates (refer to Table 6), a viable hypothesis is that the Clearwater basin has not reached capacity of spawning adults in the management record, therefore it has not achieved maximum production of fry, the candidates for pond use.

To compare the model response to the effect of off-channel habitat use, a baseline run was made with no off-channel habitat factor added to the lower Clearwater River and off-channel use was dependent on upstream migration of the 0-age migrants into off-channel habitats. Baseline runs that were conducted under different options showed no difference at 25% probability of upstream movement for 0-age migrants. In the test run of 50% probability of upstream movement for 0-age migrants, productivity

(smolts/spawner) increased nearly 900% under historic conditions. Capacity, however, experienced only a 13% increase with the enhanced off-channel migration scenario.

In summary, the EDT default off-channel habitat factor associated with reaches provides a realistic, although generic, representation of that particular habitat type. Although up to 20-25% of smolt production can come out of wall-base pond habitats in the Clearwater River (Peterson and Reid 1984), “forcing” recruitment into the ponds may not adequately represent what happens during juvenile rearing phases. Peterson (1985) recognizes high inter-annual variability in pond recruitment. Peterson (1985) also documented a considerable difference in average smolt size among six wall-base channel ponds and suggests in some cases this could be related to density related growth suppression. However, there is no indication that ponds will continue to “recruit” until they are full. Evaluating data on juvenile over-winter survival in relation to pond characteristics showed no pattern of survival. Since there is limited information on what percentage of juveniles of the population rear in these habitats and on their mortality rates, the default EDT off-channel key habitat characteristics appears to provide the appropriate habitat type (survival characteristics similar to what is attained in complex pool habitats) for the appropriate season (winter).

Priorities to Address Survival Factors

The EDT analysis summarizes and prioritizes the various survival factors that contribute to coho productivity. Recall that survival factors are the "umbrella attributes" derived from Level 2 data (see Table 2 page 23). For instance, habitat types, riparian function, and channel structure are general attributes that are accounted for in a survival factor called "habitat diversity". Figure 16 provides a summary of restoration strategic priorities for the survival factors corresponding to geographic areas of Clearwater River wild coho salmon.

The channel stability and sediment attribute classes rank highest for the Clearwater river coho. The reduction in smolts per spawner from historic to current conditions is likely a response to the relatively large effect the channel stability and sediment attributes have on coho salmon. Transport of high sediment volumes and embeddedness conditions are chronic ailments in many Clearwater tributaries. Cederholm and Reid (1987) suggested that sediment–related habitat degradation could be the largest contributor to Clearwater River coho mortality. The somewhat consistent pattern of extreme and high ratings of sediment load and channel stability factors across most geographic ranges is likely due the similarities among subbasins and the widespread distribution of coho. The land use is limited primarily to timber management. The assessment had little to no changes between historic and current conditions for attributes relating to survival factors such as obstructions, competition from other species,

Clearwater Coho

Restoration Strategic Priority Summary

Geographic Area	Channel stability1/	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load
Queets River	•				•	•	•	•					
Lower Clearwater mainstem	●		•		●	•	●				•	•	●
Mid Clearwater mainstem	⬤		●		●	●	●				●	●	⬤
Upper Clearwater mainstem	●		●		●	●	●				●	●	●
Misc Lower Clearwater Tribs	●		●		●	●	●			●	●	●	⬤
Hurst Creek	⬤		●		●	●	●				●	●	●
Shale Creek	●		●		●	•	●			●	●	●	⬤
Miller Creek	●		●		●	●	●				●	●	⬤
Christmas Creek	●		●		●	●	●				●	●	⬤
Deception Creek	⬤				●	●	●				●	●	⬤
Lower Snahapish River	●				●	•	●				•	•	●
Upper Snahapish River	●				●	●	●				●	●	⬤
Snahapish Tribs	●		●		●	●	●				●	●	⬤
Bull Creek	●				●	•	●				●	●	⬤
Stequaleho Creek	●				●	●	●				●	●	⬤
Solleks River	⬤				●	•	●				●	●	⬤
Misc Upper Clearwater Tribs	⬤		●		●	•	●				●	●	⬤

1/ "Channel Stability" within estuary refers to "Channel Landscape", which represents the presence of the estuarine zones.

None ▭ Small • Moderate ● High ⬤ Extre

Figure 16. Summary of restoration strategic priorities for survival factors corresponding to geographic areas within the Clearwater watershed for coho salmon. Channel stability and sediment load factors are the predominant influences on salmonid productivity in nearly all geographic areas. This output chart is a principal product of EDT that can serve as a hypothesis generation tool for monitoring or restoration

chemicals, poaching/harassment and water withdrawals.

With this type of information, managers can begin to address the environmental

attributes that have the greatest affect on the population. In the Clearwater River, much work had been accomplished on the effects of fine sediments on the incubation environment and changes in habitat brought on by increased bedload from debris flows, input from roads and landslides. The outputs confirmed what has been generally known about the Clearwater Basin. However, knowledge of conditions within particular geographic areas can assist decision-making about where management or restoration may occur and provide systematic guidance for recovering areas that appear to have more influence on overall productivity.

Recommendations

This thesis presented an overview and an application of the Ecosystem Diagnosis and Treatment method on a forested landscape of the Olympic Peninsula. The study provided the opportunity to evaluate how a species-habitat model framework could be used to present the habitat linkages and their relative influences on productivity and capacity. The analysis has also provided a means to identify and rank particular stream reaches and geographic areas for their restoration and conservation potential. The responses to the following topical questions are comments about the strengths and weaknesses of the EDT pertaining to the question topic.

Does the framework and function of Ecosystem Diagnosis and Treatment (EDT) provide a reasonable means of evaluating potential productivity and abundance?

The EDT is capable of providing a framework of analysis that is scaleable to reach or subbasin levels and adaptable to a changing and/or increasing knowledge base. The integration of modified biological rules is a key part of using EDT effectively (see Appendix B – Information Structure). Biological rules can be modified as data is gathered about effects of the environment on different life history stages. Literature and expert-opinion based biological rules are used to calculate the productivity and capacity estimates. The coho biological rules used in the model are derived from the EDT model developer's familiarity with coho in the Queets and Clearwater River, from the literature base related to coho life history, and from the literature base of other disciplines related to watershed functionality. Because of the extent and species-specificity of the rules base, the effects of environmental conditions on coho productivity are reasonably

represented in the model operations.

Determining synergistic effects of environmental variables, however, remains a difficult task for modelers, and other fish and habitat researchers. The EDT's procedure of using "umbrella attributes" (Level 3 survival factors) is a reasonable means to address the overall impact to the fish and habitat resource rather than just describing a habitat change. This allows one to hypothesize an effect on productivity regardless of the source. For instance, Pacific salmon are vulnerable to excessive fine sediment at various life stages regardless if the source is from road runoff, highly eroding banks, overland flow, or failing culverts.

The stream reach editor and scenario generator interface, which is available with internet-based capabilities, is a helpful mechanism for watershed scientists and resource managers to stay current with model updates and receive consultation from model developers and data stewards. This is vital to accommodate the data acquired during long-term habitat and fish population trend monitoring. The EDT framework, although developed in tabular database format, is readily adaptable to an Arc/Geographic Information System (GIS) framework (unpublished map data, Northwest Habitat Institute, Corvallis, OR). In Washington State, an internet-based interactive mapping system, "SalmonScape", incorporates the EDT-derived restoration and preservation rankings of geographically-referenced streams. This allows resource professionals to access online information to assist in watershed planning decisions.

The EDT estimated the capacity for adult spawners under current conditions to be

4,122. The Washington Department of Fish and Wildlife estimates the escapement of Clearwater coho to average about 2,400 (from 1981 to 2002). The EDT suggests that the Clearwater could support an additional 1,500 to 2,000 adult spawners to approach the spawner capacity for the system in its current condition. This appears to be a reasonable representation of the Clearwater's current production status - that it is underseeded[1] (as suggested by Cederholm et al. 1980) because of the fishery and degraded habitat. Smolt output data and escapement data (Figures 2 and 3, pp 13) indicate that on above average smolt output years, the brood year adult counts were generally average. This suggests that factors other than spawning success are controlling the smolt production and that the population is sensitive to habitat conditions. Washington Department of Fish and Wildlife managers suggest that winter and summer flow characteristics are major influences on smolt productivity (D. Seiler, WDFW, personal communication and unpublished data) in some coastal and Puget Sound streams. Further, Peters (1996) suggests that coho production in the Clearwater may be limited more often by insufficient numbers of juveniles to fully seed available habitat. The lack of mainstem rearing habitat, in the form of cover and other refugia could also be limiting productivity even during years of adequate adult escapement.

Model results for the historic conditions are about half the estimate of what the EDT would produce for Puget Sound streams under similar habitat conditions. The

1. In an underseeded basin, a higher number of returning spawners results in an increased number of smolts. In a fully seeded basin, an increasing number of returning spawners produces a relatively negligible increase in the number of smolts.

difference can be largely explained by the differences in marine survival; Puget Sound estimates range between 10 and 20% whereas model assumptions for the Clearwater analysis were about 4% (Mobrand Biometrics 2003). This demonstrates the ability of EDT to incorporate varying sets of biological rules depending on the river system and variation in the population's life history and migration timing characteristics.

The EDT produced reasonable estimates of salmon productivity. The outputs compared best with estimations calculated by WDFW annual spawner surveys. Under historic conditions, the EDT estimated similar productivity levels estimated by Cederholm and Dominguez (2003) based on useable habitat area. The outputs also compare favorably with alternative production estimates from the Pacific Fishery Management Council (2002).

Other ecologically-based estimation methods such as summer rearing density (18,000 adults), redd density (~15,000 adults), and diminishing nutrient uptake (~47,000 adults) far exceeded EDT estimates, even under the historic condition scenario (5,781 adults). This disparity in estimates could mean that our ideas about historic abundance or about how many fish are needed to sustain healthy fish runs are far underestimated. Gresh et al. (2000) calculated that the Washington coast salmon biomass is between 1.5 and 4.5 percent of historic biomass. Those calculations are for all salmon species. However, assuming that coho populations are reduced in the same proportion in terms of fish numbers, then historic high estimates could approach 53,000 based on a hypothesis that current runs average 4.5% of historic run sizes. These high estimates may be

unrealistic for a coastal system that historically experienced regular flood events and lower marine survival compared to Puget Sound or large interior river systems. The disparity in numbers does suggest that traditional run-size targets formed to replace or restore populations may not be considering some important ecological factors.

What is the potential for the EDT to be used as a hypothesis generation tool for long-term watershed monitoring?

The EDT species-habitat model provides a useful tool for the niche of ecosystem modeling. At the subbasin scale, planners can benefit from hypotheses development by using hypotheses as a decision support tool. For instance, actions that address the overall goal for the watershed may have a greater impact in one area than another. Guidance from the restoration/degradation rankings could suggest to managers that more precautions are needed around particularly-sensitive areas or provide a mechanism for managers to re-evaluate proposed actions and alternatives. For example, the analysis determined that the Upper Snahapish River provides a relatively high amount of production capacity. This would be an area where watershed protection or stream enhancement efforts could be targeted.

The EDT restoration strategic priority summary provides a realistic framework for developing hypotheses for long-term monitoring. The priority summary provides a relationship between 1) the specific umbrella attributes (survival factors) having the largest effect on the modeled population, and 2) the geographic area of this occurrence. With this information (Figure 16 pp 74) the following examples of hypotheses could be generated:

1. Sediment load dynamics in Miller Creek is having a direct effect on survival to emergence.

2. Reduction in key habitat due to channel destabilization in Hurst Creek is affecting overwinter rearing potential in Hurst Creek.

3. The diversity of habitat in certain Snahapish tributaries influences life history diversity in the Snahapish River subbasin.

4. Food availability in the Snahapish River mainstem is not as influential to productivity as food availability in other reaches.

These hypotheses may not necessarily provide the absolute guidance of structuring a monitoring or research activity, but it begins the logical process of asking more direct questions. For instance, the sediment load dynamics in hypothesis 1 is a very generic statement. The hypotheses provide guidance for further inquisition such as: Where are the recurring use spawning reaches?, what are the substrate characteristics that make this reach vulnerable to changes in sediment load characteristics?, or, what types of channel stability factors are present at the reach level? These are questions that are more relevant to the direct effects on fish because fish may be present in these particular reaches. However, there is still a lack of spatial context to the hypothesis. Providing a spatial context to a hypothesis makes a more practical evaluation tool: For example,

> Lack of channel structure in reach Miller-02 has resulted in channel disconnect from the floodplain and coarsening of the substrate.

One would then make the observations and perhaps begin to develop prescriptive hypotheses such as:

> Placement of channel spanning structures at strategic locations of reach Miller-02 will result in gravel retention and floodplain connectivity, or,

activities to promote recruitment of channel-spanning conifers will provide the long term structure necessary to re-establish channel connectivity.

The syntax of these hypotheses are not specific outputs of the model, but can be developed from the model outputs.

The EDT expert-system based approach fills gaps in the data with expert opinion. Expert opinion is generally a weaker basis for scientific prediction than is a mathematical relationship that is validated with quantitative empirical data. However, at larger spatial scales, a mathematical relationship cannot reliably predict the effects of management on salmon (ISAB 2001). Because of this, the EDT approach is a reasonable and practical method for providing tentative hypotheses to management applications that may need to be addressed quickly.

What are the limitations of using the EDT as a hypotheses generating tool and monitoring framework for Washington State HCP lands?

Coho salmon management is very difficult in general because of their widespread habitat use, aggregated populations, and fishery effects (Bradford et al 2000). Assessment of adult spawner counts provides other difficulties (Irvine et al. 1992). That is why a preferred management strategy is to use index streams and extrapolate to other areas of the stream network. Although the BioRules embedded in the model are sufficient to produce a response in fish population performance, the EDT is not necessarily a fish management model to be used to predict future abundance. The strength of the model is in using the coho-habitat relationships rules to produce outputs to be treated as hypotheses.

The EDT uses a fish population relationship (Beverton-Holt production function) and assumes the coho population is in equilibrium with a steady-state environment. This static scenario is not generally the case in dynamic environments. The population not only experiences the variation from within its own population, but also adapts to external influences on the population.

Further complicating the relationship between habitat and productivity in the Clearwater River is the occurrence of historical record high numbers of returning adults in recent years. This suggests that other factors are overriding any negative effects that habitat conditions are having on the population performance. Mainly this influence comes in the form of ocean-atmosphere climate variability described as the Pacific Interdecadal Oscillation (Francis and Mantua 1996, Mantua et al. 1997, Hare and Mantua 2000, Anderson 2000, Pearcy 1996). This evidence suggests that large marine ecosystems of the North Pacific are influenced by these marine climate shifts making it difficult to resolve the interaction of human-caused activities and natural factors when evaluating the decline and recovery of fish populations. The EDT can accommodate the changing values of marine productivity based on survival by assigning different values and conducting model runs. This can produce a range of potential productivity for the Clearwater coho, but there is still uncertainty as to how much influence on the whole population that the marine survival factor has considering that other habitat disturbance is occurring.

There are environmental factors that the EDT model addresses that are in their

early stages of understanding either within a scientific discipline, or at the sub-basin-specific level. For instance, information is growing concerning the influences of marine-derived nutrients (salmon carcass as vectors) on salmon productivity and survival. Sub-basin-specific effects on productivity from inter annual flow variation have not been evaluated in the Clearwater River. Dynamic life history strategies that comprise resilient populations could tamper the potential negative effects of non-average flow conditions.

Other exogenous variables can have influence on actual fish populations. These don't nullify the utility of the EDT model, but rather help to identify the data needs that are essential for representing population characteristics.

What is the benefit of using the EDT method for long-term monitoring and fish population conservation or recovery over other types of limiting factors analysis, watershed analysis techniques, or simply local knowledge and expert opinion?

Every approach to watershed assessment and planning, fish recovery, and monitoring has its own advantages and objectives. The heuristic, or discovery-based, approach of the EDT model services the growing knowledge base of Washington State's watersheds. By using the EDT framework, agency, academic, and citizen groups active in watershed management have a means to consolidate information. A framework accessible and understandable by many stakeholders within a watershed is a great benefit to basin land-use planning. In the absence of data derived via the scientific method, there is the ability to add information ad hoc and incorporate local, observational knowledge into assessments.

Another benefit to the understanding and monitoring of watershed productivity is

that the EDT model necessitates an understanding of the specific freshwater life history pathways of the species of interest. Species-specific life histories are reasonably represented based on habitat characteristics; however, known preferred habitats and their use by particular life stages may be more accurately represented via editing baseline information and/or trajectory table editing. The ability to update biological rules and emphasize the relative contribution that certain reaches have toward productivity serves as a long-term productivity and capacity analysis while the landscape undergoes changes from management activities.

Some caution needs to occur when interpreting outputs of the model. The large number of parameters of the EDT can be considered a strength as well as a weakness depending on how the outputs are used. The complex interaction from biological and physical factors can compound the error of results if there is no empirical data to validate the outputs. Outputs concerning potential productivity and capacity should be considered general and not as absolute targets for determination in a success/failure type context (for instance setting fishery management goals). Recall that the EDT provides a prediction of effects of habitat changes over large areas based on spatial habitat data. Further, the finer-scale of analysis (geographic area and reach-level) that EDT provides seems to have more practical application to subbasin planning issues management than performing as a fishery management model.

The alternative estimation calculations provided in this thesis showed high variability from other types of estimation methods but EDT values were within

reasonable range of values derived from the other methods. Recall that EDT current condition estimates were most similar to actual spawner survey estimates. Further work on the Clearwater EDT should involve creating more environmental scenarios to determine the range of productivity the model would estimate given the potential conditions the environment would experience under HCP management.

What are the recommendations to Washington Department of Natural Resources Habitat Conservation Plan Managers in regards to use of the EDT?

The Washington Department of Natural Resources (WDNR) manages their western Washington timberlands under guidance of the Habitat Conservation Plan (HCP). State ownership occurs across a variety of landscapes and many watersheds support salmon runs. A clear goal of the HCP is to maintain and/or restore salmon runs. Therefore, it is important to understand the historic context of the salmon runs before large-scale changes occurred across the landscapes predominantly in the late 1800s and thereafter.

The population performance of Clearwater River natural coho estimated by the EDT model showed a change in values that was consistent with the modeled changes in habitat conditions. The productivity and capacity estimates for HCP and Properly Functioning Condition scenarios showed a change when plotted within the boundaries of the current conditions and hypothesized historic conditions (Figure 14 pp 65). The data values entered in the model suggest that the current habitat conditions are somewhat degraded although it is difficult to compare since historical data is lacking. For measuring adult salmon, trend monitoring of the adult population beginning with

estimates from model outputs as the hypotheses, is an appropriate use of the EDT model in the Clearwater River. Eventually, ongoing smolt and adult enumeration can be spatially integrated in the model and finer scale validation monitoring can occur. Watershed level productivity data is available, but acquiring data of site-specific spawner densities from fishery managers would be most useful in validating the EDT at a sub-basin scale. These figures could be used as benchmarks for trend monitoring of fish productivity. As with most models, the more precise the data inputs are that influence the outputs, continued habitat surveying in conjunction with fish population estimates will serve to validate the rules and cause-effect relationships of the EDT model.

One of the main benefits of the EDT model is that it allows the building of diverse actions and their cumulative effects can be analyzed. A recent development in the EDT outputs not analyzed in this thesis is the ability to normalize the maximum potential restoration benefits based on stream length. Since not all habitats are equal in productivity, this analysis provides a view of the relative contribution to overall productivity. For instance, a 300-meter reach that provides high quality spawning gravel has a greater influence on overall productivity than a 3 km bedrock reach. This allows land managers to focus on specific areas of highly sensitive or highly productive habitat. Field habitat and spawner data would suggest the same things, but where such information is absent the EDT is helpful in identifying these reaches through other means such as geomorphic assessments or remote sensing. With these areas identified, conservation areas may be included in addition to the HCP management strategy. In

areas where the EDT predicts less influence on the productivity and capacity, alternative management strategies could be applied and monitored. These could be labeled lower risk management areas since there is a hypothesized lower risk of affecting fish productivity. Further determinations would need to be made about the actions on downstream productivity.

The WDNR could benefit in continued applications of the EDT in the Clearwater, or in other basins under landscape-level management. Further applications and analysis of outputs can be used to set thresholds for productivity and habitat conditions. For instance, if historic conditions suggest that a particular reach has the potential to maintain 60-70% pool habitat, monitoring might reveal that the percent has been averaging 40-50% in recent years. The changing habitat conditions could serve in trend monitoring applications. Independent habitat surveys over time could serve a similar but limited purpose – applying the long-term data to EDT scenarios and using the EDT data framework is amendable to a program approach to the monitoring. The population statistics produced by the EDT model can also serve as trend monitoring statistic. Smolt output estimates can be calibrated according to estimates produced by ongoing habitat surveys conducted by the Quinault Indian Nation.

The WDNR would need to devote regular staff time to EDT applications for the full benefits of EDT operations. The many facets of the model, the interdisciplinary approach, the large HCP landscape, EDT internet-based scenario-building capabilities, and the need for familiarity with the model's capabilities require ongoing commitments.

More model runs need to occur with a variety of habitat changes in order to determine which particular attributes would be helpful to create site-specific monitoring hypotheses. The Quinault Indian Nation will be conducting an EDT analysis of the Queets River using Clearwater River information. Washington Department of Natural Resources should stay abreast of this large-scale project which will utilize the Clearwater River EDT habitat databases.

Conclusion

The continually growing field of ecological modeling, especially those pertaining to decision support, is challenged by attempting to incorporate dynamic organism's life histories across landscapes. Further, these landscapes are often disturbed, and therefore lacks an understanding of how a population's productivity would function in fully intact ecosystems. Forest land management must take into account that estimates and scenarios from ecological modeling are not absolutely accurate or complete. These estimates are starting points of understanding.

The Ecosystem Diagnosis and Treatment (EDT) is a good model that can provide a reasonable representation of salmon productivity and habitat capacity. For large scale salmon recovery it is proving to be a viable tool for managers and salmon recovery workers to assemble basin information and strategize long-term recovery strategies.

The EDT can provide guidance for restoration and conservation in a subbasin area. Serving somewhat as an inventory of potential areas to initiate restorative or similar actions, the outputs can save a tremendous amount of money that would otherwise have occurred with comprehensive field inventories. Certainly, there is no substitute for confirming habitat conditions by observing them, but remote sensing, digital modeling, and similar techniques are providing adequate information for at least preliminary outputs that can be a starting point of restoration efforts.

The EDT's sensitivity analysis provides a valuable tool for identifying sensitive reaches. By indicating the sensitive reaches, priority for protection of those reaches can

be assigned. Further research or evaluation can also occur in these reaches to validate the outputs, building confidence in the outputs while providing the ability to apply the findings to similarly geographic/geomorphic streams. In basin planning, management agencies may develop particular rules pertaining to these sensitive areas.

The EDT can serve as a mechanism to provide feedback over time when a landscape is under a particular management strategy. Having an information feedback loop is a vital part of adaptive management strategies. An effective adaptive management strategy must be able to incorporate new information about conditions in order to determine the success of the current actions and the EDT data framework is set up to perform these types of comparative evaluations of year to year habitat conditions. The EDT's data framework also provides a means whereby data can be reviewed by period, season, or annually depending on if a particular variable is more influential at certain times of the year. Year to year comparisons of data and modeling scenarios with predicted year-to-year or season-to-season changes provide further detail about habitat capacity.

The expert opinion basis for attribute ratings allows operation of the model without extensive data from field observations. This is both an advantage and disadvantage of the model. The advantages outweigh the disadvantages, however, because the assemblage of the information can initiate the subbasin planning process providing initial guidance for salmon recovery. Subsequent efforts, such as field reconnaissance, can validate the estimated values and provide a higher level of

confidence in the outputs.

Some applications of the EDT that emphasize particular environmental categories may not fully benefit from the capabilities of the EDT. For instance, State land management guided by Washington Department of Natural Resource's Habitat Conservation Plan (HCP) intends to restore and conserve aquatic habitats. The general assumption is that the conditions that the HCP provides will adequately protect riparian and aquatic environments under the Washington State Habitat Conservation plan. Since there are many factors affecting salmon populations, the year-to-year variation of channel conditions may not necessarily be related back to the riparian management. Therefore, using EDT as a means to provide cause-and-effect relationships between particular environmental categories is not recommended. Indeed, this is not the intent of EDT, but rather to develop expected trends in productivity. In this context, EDT can serve watershed-level tracking of habitat conditions, and coupled with basin fish productivity data, can lead to effective basin planning and management.

In basins with a limited number of influences (i.e. Clearwater habitat is most influenced most by effects of logging), there is a need to ensure that those specific environmental attributes are sensitive enough in the model and not de-emphasized by the fact that the majority of other attributes are functional. The EDT provides the ability to develop watershed and species-specific biological rules that improves the EDT process and its outputs.

This flexibility is mainly due to the large subbasin scale that model development

occurred in. The model provides smaller scale outputs, such as reach and geographic ranges, but is most informative for larger basins where the stream reaches and geographic areas are considered as a whole.

The Ecosystem Diagnosis and Treatment model, outputs, and applications will persist as a species-habitat management tool in Pacific Northwest environment for many years. The EDT model's effectiveness is dependent on the knowledge base of the watershed being evaluated. This strength is maintained in the EDT's ability to update the knowledge base and accommodate changes to biological rules. This will help EDT maintain its favorable position in sub-basin planning within a context of adaptive management.

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APPENDIX A

The Ecosystems Diagnosis and Treatment Method

The EDT Method

August 1999 - Draft

Mobrand Biometrics, Inc.

Table of Contents

The EDT Method 1
Conceptual Framework 1
Framework Principles 1
Framework Function 3
Environmental Attributes 5
Biological Performance 5
Life History Diversity 8
Productivity 9
Capacity 10
Analytical Model 12
Biological Rating of Environmental Attributes 14
Trajectory Generation and Sampling 15
Benchmarks 16
Step-by-Step Procedure 17
Identification of Goals and Values 17
Diagnosis 17
System organization, definition, and scale. 18
Information compilation. 19
Data translation. 19
Life history analysis. 19
Identification of Alternatives 19
Analysis of Treatment Alternatives 20
Adaptive Implementation of Preferred Alternatives 20
Literature Cited 21
Appendix A 25
Appendix B 31

The EDT Method

The EDT method was designed to provide a practical, science-based approach for developing and implementing watershed plans. The method provides decision makers with the technical information needed to develop plans that will achieve their goals.

The EDT method consists of three components:

- *Conceptual Framework*—a way of organizing information to describe a watershed ecosystem in order to apply scientific principles to the understanding of that ecosystem
- *Analytical Model*—a tool used to analyze environmental information and draw conclusions about the ecosystem
- *Step-by-Step Procedure*—a procedure that explains how to apply the conceptual framework and analytical model to develop plans that achieve goals.

Conceptual Framework

We begin our discussion of the conceptual framework by introducing the principles that form the foundation for the framework and then describing its function. Then we take a close look at the central components of the framework—environmental attributes and biological performance.

Framework Principles

There is an emerging theme in the literature that calls for fish and wildlife management that is both *rational and consistent with an ecosystem approach* (Nehlsen et al. 1991; Lee 1993; Lichatowich et al. 1995; Williams et al. 1997).

By *rational* management, we mean a science-based approach to management based on a system of logic (rationale) that explains how intended actions will be transferred into desired outcomes.

Ecosystem (or watershed) approach refers to the growing realization that management actions should be made in a holistic context that considers interrelationships within the watershed (Simenstad et al. 1992; Doppelt et al. 1993; Williams et al. 1997). Without a holistic, watershed context, it is difficult to prioritize actions and assess their possible combined or cumulative effect. An ecosystem approach is needed to address resource issues from a broader viewpoint than can occur with a management focus on just one or a few species (Haskell et al. 1992; Lichatowich et al. 1995). An ecosystem approach to management promotes coordinated efforts, taking into consideration biological diversity and integrity leading to a balance of sustainable benefits to society (Angermeier 1997).

The inherent complexity of ecosystems, however, makes it difficult to describe and evaluate them. One way deal with this complexity is to look at the ecosystem through the eyes of one or more diagnostic species (Mobrand et al. 1997). A diagnostic species that is properly chosen helps us make inferences about the ability of a watershed to sustain a broad range of natural and social values. See Appendix B for a discussion on the concept of the diagnostic species.

The conceptual framework for the EDT method was developed with an aim toward utility for salmon management but also with the important goal of maintaining consistency with an ecosystem approach. The framework accomplishes this by viewing salmon as the indicator, or diagnostic, species for the ecosystem. The salmon's perspective—its perception of the environment—becomes a filtered view of the system as a whole. Within the limitations of the salmon's perspective and our ability to interpret it, this approach provides a framework for formulating strategies for salmon in the context of watershed management.

Although the framework was designed to have sufficient dimensional complexity to accommodate temporal, spatial and biological detail, it is simple in concept. Conceptual simplicity is important because unless ideas can be communicated clearly and without ambiguity, nothing is gained.

The usefulness of this type of framework should be measured by how well it generates insights into ecological patterns and relationships that might otherwise be missed or glossed over (Bunnell 1989; Lee 1993). As a theoretical construct, it is a caricature of nature against which to test and expand human experience (Walter 1986).

The foundation for the conceptual framework is well described by the following principles endorsed by the Multi-species Ecological Work Group (1999):

1) The abundance and productivity of fish and wildlife reflect the conditions they experience in their ecosystems over the course of their lifecycle.

2) Natural ecosystems are dynamic, evolutionary and resilient.

3) Ecosystems are structured hierarchically.

4) Ecosystems are defined relative to specific communities of plant and animal species.

5) Biological diversity accommodates environmental variation.

6) Ecosystem conditions develop primarily through natural processes.

7) Ecological management is adaptive and experimental.

8) Human actions can be key factors structuring ecosystems.

Framework Function

Watersheds and ecosystems are by nature hierarchical (O'Neill et al. 1986). Concepts and terms must be consistent at all levels in the hierarchy. Therefore, the EDT framework was designed so that analyses made at different scales—from tributary watersheds to successively larger watersheds—might be related and linked. Ultimately, conditions within these watersheds can be linked to those within the Ocean.

This function of the conceptual framework enables us to consider conditions for sustainability that link all components of an extensive and complex life history, such as that exhibited by salmon, over successively larger spatial scales. It is the key to our ability to assess the cumulative effects of concurrent actions spread across the geographic range of salmon.

In its simplest form, the conceptual framework is a pathway for linking potential land use actions (or natural events) to outcomes that may be relevant to values such as harvest opportunity (Figure 1). It provides a rationale for how actions and events are transferred into resource outcomes.

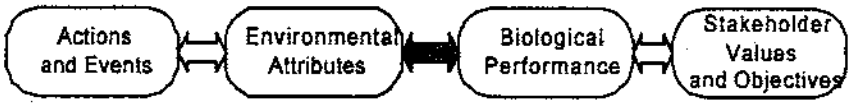

Figure 1. The EDT framework.

The framework consists of a sequence of relationships. The flow of logic proceeds as follows.

- Land use actions (or a natural event) within the ecosystem have some effect on attributes, or conditions, of the environment. These attributes may be abiotic (such as sediment loading or water temperature) or biotic (such as increases in abundance of a particular species by hatchery outplanting).
- These changes in environmental attributes, in turn, affect how populations within the ecosystem perform (i.e., survive and function).
- The resulting performance of populations creates an outcome that has direct relevance to objectives such as those associated with harvest and endangered species recovery.

The flow of information through these relationships is bi-directional—the process of planning, prioritizing, and implementing actions is a cycle that proceeds from goals to actions repeatedly. The implications of events and land use actions flow in the opposite direction as well.

The purpose of this type of logical construct is to promote a better understanding of these relationships. Too often actions are presumed to translate more or less directly to objectives without a clear rationale of how their effects flow through the ecosystem. This framework requires explicit consideration of possible pathways. The framework explains possible consequences in a manner consistent with existing knowledge and information, and it requires that all assumptions necessary to watershed planning are identified—thus it becomes a vehicle for learning and communicating.

At the core of the framework are relationships between environmental attributes and biological performance. The term *biological performance* refers to the way in which a population manifests itself in space and time under a given set of *environmental* conditions. There is a wide array of possible performances (Warren et al. 1979) for species like salmon over the range of conditions that have existed in the Pacific Northwest. The EDT model interprets these relationships from

the perspective of the diagnostic species. An understanding of the diagnostic species concept is important to the discussion of the core elements of the conceptual framework—environmental attributes and biological performance. See Appendix B for a detailed discussion of diagnostic species.

Environmental Attributes

In the conceptual framework, environmental attributes are the link between actions and biological performance. The environmental attributes defined and used in the EDT method are those that traditionally appear in the literature to describe the relationship between biological performance and the environment (see Table 1).

Environmental attributes vary over time and space. For the purpose of describing the biological performance of the diagnostic species, we must select appropriate time and space scales. This selection is made difficult by that fact that people typically view the world at different space and time scales (Walters 1997).

Harvest managers are concerned with short-term (e.g. annual) variations in abundance and distribution of fish, often on a relatively coarse spatial scale like a watershed. Habitat managers tend to focus on a smaller spatial scale (e.g. stream reach) and longer time frames such as multiple salmon generations.

If we hope to link these different perspectives, we must develop a "telescoping" approach. We must be able to zoom in on details (in terms of space, time and life history stage) and pan out to a broader perspective in a consistent way. To accomplish this, the conceptual framework incorporates a hierarchic structure where actions, attributes, performance, and goals can be defined on a variable scale.

Biological Performance

Biological performance is a central feature of the framework. It is defined in terms of three elements—life history diversity, productivity, and capacity[1] as shown in Figure 2. These elements of performance are characteristics of the ecosystem that describe persistence, abundance, and distribution potential of a population.

[1] We use the terms productivity and capacity as defined by Hilborn and Walters (1992). Capacity is the maximum population size for one or more life history segments. Capacity and productivity are not independent.

Table 1. Habitat attributes rated for all life stages, reaches and months.

Attribute	Abbreviation in model	Definition
Channel stability	Chan	Stability of the reach with respect to its streambed, banks, and its channel shape and location.
Chemicals	Chem	Concentrations of toxic substances or the presence of toxic conditions. Substances include chemicals and heavy metals. Toxic conditions include low pH.
Competition (with hatchery fish)	Comp	The relative abundance of hatchery produced animals of the same species as the diagnostic species that compete with the diagnostic species for food or space within the stream reach.
Competition (with other species)	Compo	The relative abundance of other species in the stream reach that compete with the diagnostic species for food or space.
Flow	Flow	Amount of stream flow and the pattern and extent of flow fluctuations within the stream reach.
Food	Food	Amount, diversity, and availability of food that can support the diagnostic species.
Habitat diversity	Hab	The extent of habitat complexity within a stream reach.
Harvest	Harv	Harvest of the diagnostic species by humans. Here, this applies only to poaching.
KeyHabitat	KeyHa	The primary habitat type used during a life stage.
Nutrient load	Nutr	The concentration of dissolved nutrients due to natural or man-induced causes.
Obstructions	Obst	Physical structures that impede movement of the diagnostic species within a stream reach, such as dams, waterfalls, or other structures.
Oxygen	Oxy	Mean concentration of dissolved oxygen in the stream reach's key habitat used by the diagnostic species.
Pathogens	Path	The abundance, concentration, or effect of pathogens in the stream reach. For example, the presence of a fish hatchery or large numbers of livestock along the reach could cause unusually high concentrations of pathogens.
Predation	Pred	The relative abundance of predators that feed upon the diagnostic species.
Riparian condition	Rip	The state of the vegetation component of the narrow strip of land bordering the stream where vegetation species occur that are dependent on the stream or its adjacent water table.
Salinity	Salin	Concentration of salts within the reach (if applicable).
Sediment load	Sedi	The amount of sediment present in, or passing through, the stream reach. This only applies to fine sediment.
Temperature	Temp	Water temperature in the stream reach. Density-independent survival is affected by rapid fluctuations, or by prolonged conditions near the extremes of tolerance.
Withdrawals	Wdrwl	Water withdrawals from the stream reach.

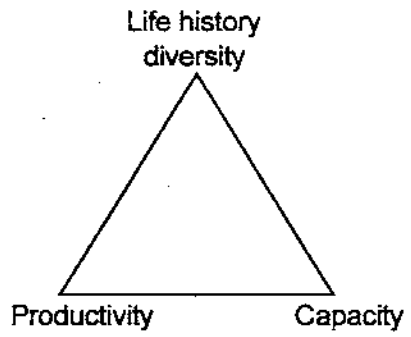

Figure 2. Elements of biological performance.

The performance of indicator species, from a broader ecosystem perspective, may also reflect the potential for species diversity. This conceptualization of performance provides a structure for applying *biological rules* that affect the survival characteristics of populations. We use existing theory to link each of these elements to environmental conditions.

In population dynamics, change is determined by four processes: birth, death, immigration, and emigration. These processes are regulated through *density-independent* and *density-dependent* mechanisms. These mechanisms are affected differently by environmental conditions (Moussalli and Hilborn 1986). As we examine some of these differences, it is important to also remember that population responses are a result of interactions between the two mechanisms.

A density-independent process is one in which the *rate* of response is not affected by population density; although in the case of mortality, the number of deaths goes up as population size increases. In contrast, a density-dependent process is one in which the *rate* of response varies according to population density due to competition for limited food and space resources; the number of deaths also goes up as population size increases.

The combination of these two processes results in the total mortality rate of a population at any given size. The effect of density-dependent mortality is low at low population densities, whereas the density-independent mortality rate is constant across all population densities. It is important to note that the density-independent mortality rate regulates the *rate* of loss that a population can sustain; it is the determinant, for example, of the rate of harvest that a population can sustain.

The identification of these two distinct mechanisms, density-independent and density-dependent, is useful in explaining the way in which various environmental conditions affect population

performance. Habitat or environmental *quality* tends to affect density-independent processes (Moussalli and Hilborn 1986). A deterioration in habitat quality will therefore tend to increase density-independent mortality. For example, sedimentation of a salmon spawning bed will tend to operate in a density-independent manner, causing an increase in mortality rate at all population sizes. In this case, the quality of the spawning bed is determined by the amount of fine sediment passing through, or entrained by, the substrate.

In contrast, habitat *quantity* tends to affect density-dependent processes (Moussalli and Hilborn 1986). The amount of habitat available becomes increasingly important as population densities increase (i.e., as competition for limited resources increases). In a parallel example to the one above, the quantity of spawning beds available to a salmon population could be expected to contribute to the mortality of eggs as spawner densities increase to the point where some spawners dig their nests at the same sites as slightly earlier spawners. In this case, superimposition of nests causes mortality to eggs already deposited. But at very low spawner densities, the chance of superimposition is very small.

These mechanisms of density independence and dependence operate within the three elements that comprise performance. The mechanisms explain how changes in the quality and quantity attributes of the environment affect biological performance. We next take a closer look at each of the three elements of that performance: life history diversity, productivity, and capacity.

Life History Diversity

This element represents the multitude of pathways through space and time available to, and used by, a species in completing its life cycle. A salmon life history consists of a favorable spatial-temporal distribution of a chain of habitats to enable its continuity (Thompson 1959). The life history encompasses many more or less distinct developmental life stages, each having its own set of environmental requirements (Bjornn and Reiser 1991). Species like salmon often exhibit a variety of life history patterns as a result of their adaptability to a heterogeneous and fluctuating environment. These life history patterns can be correlated with environmental variables on a spatial-temporal basis (Wevers 1993; Lichatowich and Mobrand 1995).

Populations that can sustain a wide variety of life history patterns are likely to be more resilient to the influences of environmental change. Diverse life history patterns dampen the risk of extinction or reduced production in fluctuating environments (den Boer 1968). Not all life history patterns will be affected uniformly by natural or man-caused perturbations. Thus a loss of life history diversity is an indication of

declining health of a population (Lichatowich and Mobrand 1995) and perhaps its environment.

The life history diversities of existing natural salmon populations can be described by the range of distributions and pathways that are used successfully by these populations. A pathway can be conceptualized as a trace—or trajectory—in space and time available to members of a population (Figure 3).

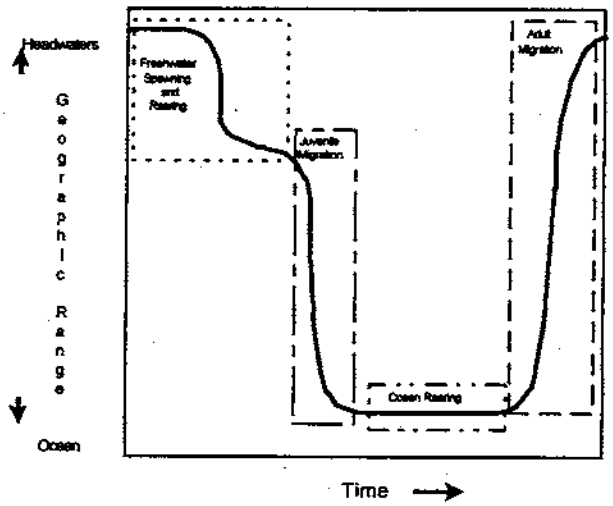

Figure 3. The concept of a life history trajectory across the "space-time landscape."

We use the term life history pattern to mean a collection of similar pathways. A successful life history pattern is one that is brought to *closure*—some individuals following the pattern survive through all life stages and return to their natal spawning ground (Sinclair 1988). A sustainable life history pattern is one that remains successful over the range of prevailing environmental and man-induced mortality conditions.

Productivity

This element of performance represents the density-independent reproductive rate (or success) of a life history pattern over an entire life cycle. It is probably the most critical measure of the resilience of a life history pattern. It determines the rate of loss that can be sustained. Productivity can be likened to how far a rubber band can be stretched before breaking.

Surprisingly little attention has been given to the subject of salmon productivity within the literature (Hankin and Healey 1986; Moussalli and Hilborn 1986). Hankin and Healey (1986) suggest that biologists

have devoted a disproportionate amount of effort to estimating habitat carrying capacity; greater need exists, they assert, to better understand productivity, especially as stocks decline.

The term is widely used in ecological and fisheries literature where its meaning varies greatly. Classical ecological usage usually relates to trophic productivity. In the fisheries literature, it sometimes refers to total stock size.

The term *productivity* as applied in the EDT framework, follows precisely the recommendations of Moussalli and Hilborn (1986) and Hilborn and Walters (1992). It refers to density-independent survival, as well as to what is often called the basic biological productivity of a population (i.e., the average number of eggs per surviving adult).

Productivity of salmon populations consists of distinct components (Figure 4), each of which can have a significant effect on the overall value. The two major components are reproductive potential and density-independent survival. Reproductive potential is the total number of eggs per adult spawner. This term is further divided into two sub-components: average fecundity of females and average sex ratio of the spawning population. Density-independent survival is also divided into subcomponents: freshwater and marine.

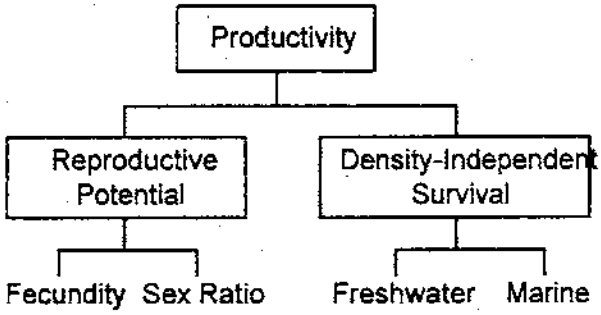

Figure 4. Components of productivity.

An important property of productivity is that its components are multiplicative. From a strictly productivity-based perspective there is no bottleneck—no single limiting factor.

Capacity

There is clearly some upper limit to the number of organisms that an environment can support due to finite amounts of space, food, or other needed resources (Ricklefs 1973). Capacity is the element of performance that determines the effect of this upper limit on survival and distribution. It is the parameter that regulates the density-dependent population responses.

Superficially, the concept of capacity seems simple and easily envisioned. A room can hold only so many people; a tract of land can grow only so much wheat; a fish pond can be stocked with only so many fish. But the concept applied to an ecosystem is more elusive, particularly as it relates to species with complex life histories like salmon (Frissel et al. 1997).

There have been numerous attempts to quantify or characterize the capacity of natural salmon systems (Burns 1971; Marshall 1980; NPPC 1991; Nickelson et al. 1993; Beechie et al. 1994). Most of these efforts are based on a capacity concept that focuses on a single life stage in isolation of others, as set forth by Burns (1971):

> *"Carrying capacity is defined as the greatest weight of fishes that a stream can naturally support during the period of least available habitat...The stream's carrying capacity limits the number and weight of salmonid smolts ultimately produced."*

Following the lead of Moussali and Hilborn, we generalize and broaden the notion of capacity. We are most interested in the capacity over the full salmon life cycle. This cumulative population maximum is a function of both the productivities and capacites of all component life history segments (Moussali and Hilborn 1986).

The model uses an expression for cumulative capacity derived from a Beverton-Holt multistage spawner-production relationship (Beverton and Holt 1957). This particular production function has both intuitive and mathematical appeal. It provides a logical and reasonable structure for framing interactions of density-independent and -dependent processes under various environmental conditions. Moussali and Hilborn (1986) postulate that other standard production functions have similar characteristics.

The capacity for a population must be considered over the entire life cycle of the animal. To exclusively consider capacity at the close of an intermediate life stage ignores the effects of subsequent stages on population survival. While cumulative productivity is the same no matter where we define the beginning and end of a complete life cycle, cumulative capacity does depend on this choice.

A logical reference point along the timeline of life history, for defining the unit of capacity for salmon populations, is at reproduction. For salmon, spawning is the point where one generation ends and another begins. It is the point of minimum abundance in the life cycle and, therefore, represents the total amount of genetic material passed from one generation to the next. This point along the life cycle is also most representative of the values ascribed to salmon populations by society over the long term. It is adult salmon, and not juveniles, that relate most directly to societal values such as harvest.An interesting and

important conclusion that emerges from this full life-cycle perspective is that a population may be close to capacity (in the cumulative sense) without a single component life stage being *fully seeded*. Thus diagnoses indicating that habitat *is under-seeded* or fully seeded, unless analyzed from a full life-cycle perspective, can be very misleading. We refer the interested reader to the EDT Primer (Lestelle et al. 1996) for further discussion of the concept of capacity as used in the model.

Analytical Model

The analytical model is the tool used to analyze environmental information and draw conclusions about the ecosystem. The model computes biological performance based on environmental attributes (Figure 5).

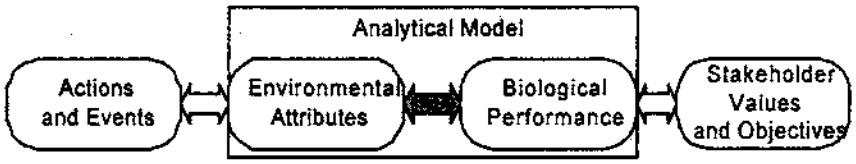

Figure 5. The analytical model in the context of the conceptual framework.

The model incorporates an environmental attributes database and a set of mathematical algorithms that compute productivity and capacity parameters (Figure 6). The analytical model is a scientific rather than a statistical model—an important distinction.

Statistical models are based on correlations between actions and outcomes. They do not attempt to explain why; they simply predict the future based on past observations. Statistical models allow estimation of confidence limits and other statistical properties of the predictions. They are limited, however, to our range of experience.

Scientific models—such as the EDT analytical model—are, on the other hand, based on knowledge and assumptions about how natural systems work. Scientific models *do* attempt to explain relationships and therefore are more appropriate to analyze the consequences of broad combinations of actions that extend beyond our experience.

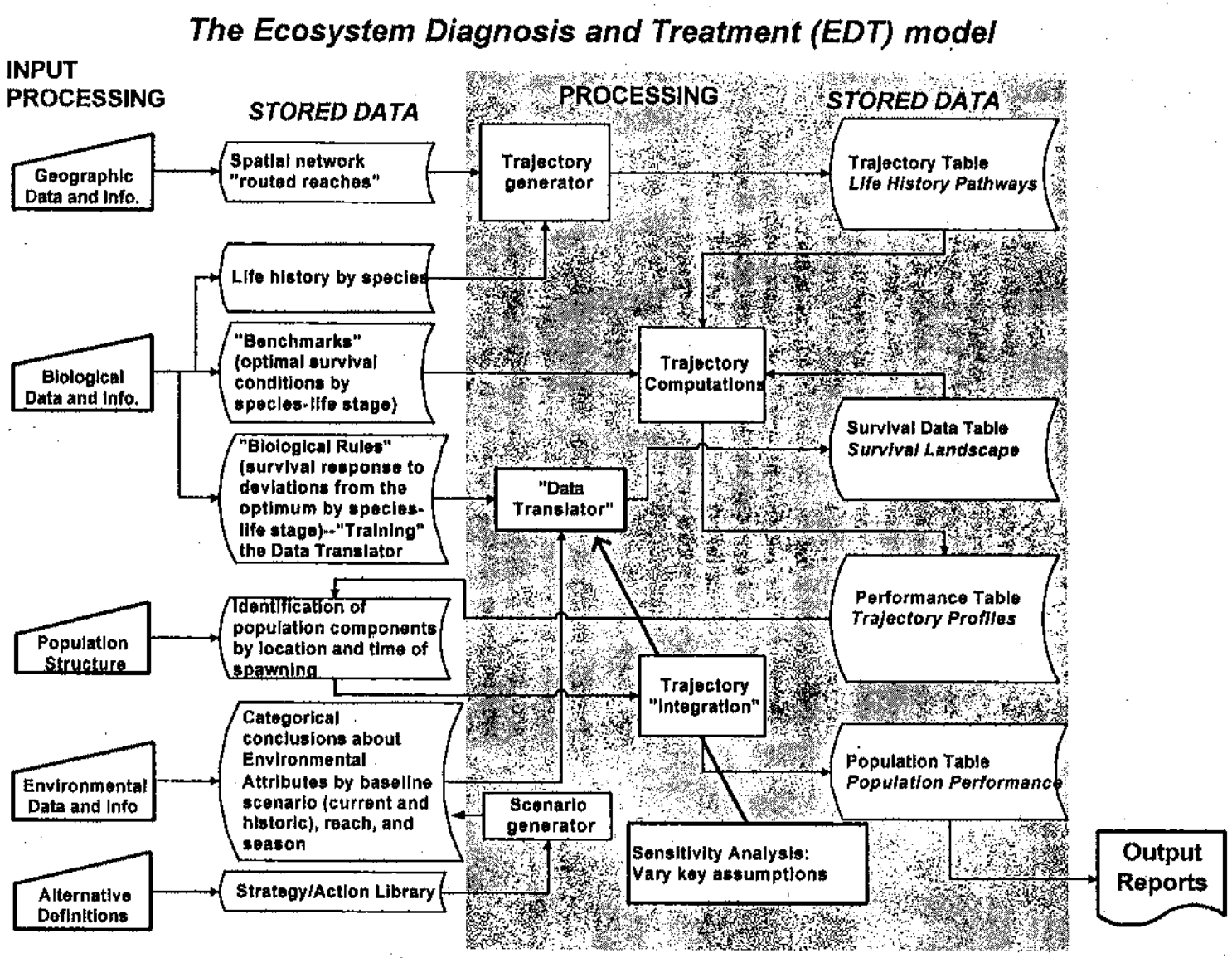

Figure 6. Overview of the EDT analytical approach.

Scientific models are not in themselves hypotheses that can be tested with data. They generate hypotheses that might be tested through observations. Validation of a scientific model means establishing its applicability and utility to the problem at hand. The standard the scientific model should achieve is whether it better meets this purpose than alternative models. Therefore, the way to challenge a scientific model is to propose a better one. Without a scientific model, we have no scientific basis for analyzing a problem.The EDT analytical model provides qualitative insights and understanding about how natural events and human actions affect biological performance. This, according to Hilborn and Mangal (1997), is the ideal use of models. The EDT analysis is based on a habitat, life history approach. The habitat is described in terms of survival conditions along the pathways (waterways) that the fish utilize from birth to death. By habitat, in this context, we mean all conditions within the environment of the fish that affect its behavior and survival (i.e., harvest, dams, ocean conditions). The EDT model computes survivorship of populations along the life history pathways across the habitat. The EDT model input consists of habitat ratings and life history pathways; the output is abundance, productivity, life history diversity, and distribution of fish populations.

The algorithms used to calculate population parameters are based on the Beverton-Holt survival function (after Beverton and Holt 1957). In Appendix B, we derive some of the key relationships used in the model.

Biological Rating of Environmental Attributes

Environmental attribute ratings are derived from observed environmental conditions based on information and knowledge from the scientific literature or from experts in the field of habitat and fish biology. The model captures this knowledge as a set of *biological rules*.

The most efficient way to generate environmental attribute ratings is to apply the rules directly to observed data. This data translation may also be accomplished through a *manual* process, where the ratings are supplied by a panel of experts familiar with the watershed and with the biology of the diagnostic species. Biologists summarize data and reports and then rate habitat, by reach and month, for each of the attributes—relative to benchmark conditions by life stage. The manual data translation process has educational value for the participants.

Trajectory Generation and Sampling

Pacific salmon species are able to survive in a wide range of habitat types—from Alaska to California; and they are able to cope with dynamic variations in environmental conditions over time. An important component of their survival strategy is diversity of life history. However wide this diversity of life history might be, there are limitations imposed by the biology of the species. We refer to these limits as the genetic boundaries of the species. As the environment within a watershed varies, the range of life history diversity available to the species enables it to cope with these variations.

Not all trajectories within the genetic boundaries are used with equal frequency. Within the genetic boundaries, the frequency of use is partly a function of habitat conditions and partly a reflection of the opportunistic nature of the species.

We do not know how quickly—or to what extent—trajectories adapt to the habitat, but we believe that the relationship between life history diversity and habitat is important to the survival of the species. The analytical model includes a mechanism for addressing our limited understanding of these relationships. As a starting point, we suggest a process for generating and subsampling trajectories that produces results that are consistent with what we do know.

The process consists of the following steps:

1) Define the starting point of each trajectory as the moment of spawning.

2) Start trajectories at uniform time and space intervals within assumed historic ranges for the watershed.

3) Identify a set of broad life history patterns (e.g., three patterns for fall chinook).

4) Identify, for each life history pattern, windows in time and space through which trajectories must pass (e.g., a time window for entering the river mouth).

5) Identify biological limits for travel speed and life stage durations.

6) Generate a large number of trajectories at random, subject to above the constraints (this creates a *pool* of trajectories).

7) Sub-sample the trajectory pool in proportion to those frequencies, to the extent that we have *a priori* information about the frequency of life history patterns (independent of habitat conditions).

8) Include at least one trajectory originating from each reach in the sub-sample.

9) Use the same sample of trajectories when comparing different scenarios.

10) Test the sensitivity to the sample, as time and resources allow, by re-sampling from the pool.

Benchmarks

The EDT method associates survival with habitat. The productivity and capacity values derived in the EDT process are characteristics of the environment by time and location as interpreted *through the eyes of salmon* by species and life stage (Mobrand et al. 1997). It is a shaping of survival conditions over time and space, as salmon might experience them in completing their life cycle. The shaping of survival is done with reference to a defined set of *benchmark* conditions.

From the literature, we can identify habitat requirements by life stage for the species. We can take it a step further and describe optimal conditions and the expected survival and density limits by life stage. When viewed at a fine enough time scale, this information tends to be generic (i.e., not site specific). The EDT process defines the reference benchmarks in terms of these optimal conditions. Thus benchmark descriptions of habitat conditions, associated productivities, and maximum densities by life stage are obtained from the literature describing conditions that are *as good as it gets.*

The systematic shaping of survival conditions is intended to assure that productivity and capacity values for each life history segment along a trajectory are (a) bounded by the biological limits of the species; (b) scaled consistently across time, space, and life stage; and (c) scaled consistently with the benchmark values.

Step-by-Step Procedure

The step-by-step EDT procedure tells you how to apply the conceptual framework and analytical model to develop watershed plans that lead to achievement of goals.

The procedure consists of five steps:

1) Identification of goals and values

2) Diagnosis

3) Identification of treatment alternatives

4) Analysis of treatment alternatives

5) Adaptive implementation of preferred alternatives

These steps were designed to provide technical support to a structured decision-making process. We will discuss each of these steps below.

Identification of Goals and Values

Watershed goals for fish resources are derived from social, cultural, political and legal considerations in a policy environment. The EDT process does not presume agreement on all values and goals; it only requires that potential goals and values be identified.

These goals and values provide the currency whereby the outcomes of alternatives are described. The EDT analysis clarifies which goals are technically compatible and which are in conflict. The analysis of alternatives will highlight trade-off options associated with each alternative.

The EDT technical analysis enables us to provide policy makers with sets of alternative action plans (treatments) that meet as many of a their stated goals as possible. When not all goals can be met concurrently, we can determine what the trade off options are.

Diagnosis

Through diagnosis we determine why certain watershed goals are not being met. We accomplish this, in part, by comparing the three states of the watershed: the Patient, the Template, and the Benchmark. This type of watershed evaluation was

developed by Lichatowich et al. (1995). It is called a Patient-Template Analysis (PTA).

The Patient refers to the current state of the watershed. The Patient condition is based on the best and most current environmental data and information available.

The Template refers to a hypothetical potential state where conditions are as good as they can be *within* the watershed. The Template is sometimes approximated with a reconstruction of historic conditions. The Template is intended to capture the unique characteristics and limitations of the watershed due to its combination of climate, geography, geomorphology, and history. Sedell and Luchessa (1982), Langston (1995), and Wissmar (1997) argue the importance of historical information to our understanding of the environment today and in the future.

The Benchmark refers to the hypothetical state where conditions are as good as they can be *anywhere* for the diagnostic species Benchmark values serve as a known reference point drawn from the literature.

The purpose of the PTA is to make statements about the salmon performance potential supported by an explicit set of assumptions and consistent with the available information about the watershed. The PTA describes salmon performance for the Patient and Template in terms of productivity, capacity, and life history diversity.

The PTA highlights the differences between present and potential conditions within the watershed from the salmon's perspective. It explains those differences through a set of environmental attributes that describe the environment as it affects salmon performance. We can then use this comparison to formulate a diagnosis—an assessment of current conditions (for salmon) relative to the potential.

There are four steps in the PTA:

1. System organization, definition, and scale.

The watershed-population system is organized within a spatial-temporal grid consistent with the range of life histories for salmon. Spatially, the watershed is partitioned into stream reaches. Stream reach boundaries and time scales are defined so that within a reach-time stratum we can assume that environmental attributes affecting salmon survival are relatively constant.

2. Information compilation.

Information is assembled and summarized to describe Patient and Template conditions in the watershed. The purpose of this step is to identify the best available information and make it available for the data translation step that follows. This step basically produces a watershed analysis. Information is obtained from many and diverse sources such as published and unpublished studies, habitat surveys, environmental databases, environmental monitoring programs, aerial and ground level photographs, and maps. When a thorough watershed analysis has been completed before, it can be an excellent information source. Both historic and current conditions need to be captured in this compilation.

3. Data translation.

The data and information assembled must now be translated into the input format required by the model. This step converts environmental data into ratings that specify the relative effects of each environmental attribute on life stage survival for the species. This step is done by applying a set of *biological rules* that relates survival to environmental attributes. Once this step is completed, the baseline dataset for the Patient and Template is ready to be analyzed.

4. Life history analysis.

The final step in the PTA is to evaluate the Patient and Template habitat data from a salmon life history perspective. The analysis consists of three parts: 1) Definition of life history patterns and selection of sample trajectories; 2) Assumptions about population genetics, age structure, fecundity, and marine survival; 3) Computation and display of performance measures.

Identification of Alternatives

After the diagnosis, it is time to identify potential actions to achieve watershed goals. Candidate actions are tailored to solve problems that were identified in the diagnosis.

Basin plans are comprehensive, long-term plans for entire watersheds—they consist of suites of actions designed to meet watershed goals. One of the main benefits of the EDT method is that it allows us to build diverse suites of actions and analyze their *cumulative* effects.

The analytical model contains a library of generic strategy and event blocks as starting points for defining watershed-specific actions from which alternative future basin plans can be built.

Analysis of Treatment Alternatives

Following the identification of candidate actions, an analysis of trade-offs is performed to compare benefits and risks of individual or suites of actions. Benefits and risks are expressed relative to goals and values. In the analysis of treatment alternatives, we want to know what the trade-offs among the alternatives are. One alternative may have a high likelihood of achieving some of the goals while other goals are at risk.

The analytical model can be used to compare multiple alternatives with respect to the benefits and risks to productivity, capacity, and life history diversity of the diagnostic species.

All aspects of natural resource management involve uncertainty. Conceptualization of ecological relationships and functions, diagnostic analyses, and selection of treatments incorporate assumptions that create uncertainty—and uncertainty poses risk.

Adaptive Implementation of Preferred Alternatives

Our understanding of ecosystems, and the responses of those systems to intervention, is inevitably incomplete. Our ability to measure progress toward management goals accurately and timely is limited. Adaptive management, supported by the EDT method, provides the means to proceed with implementation while managing and containing risks due to uncertainties.

Because of uncertainty, it is necessary to incorporate in the implementation of watershed plans flexibility so that unsuccessful strategies and unattainable objectives can be replaced with more suitable ones. We also need, however, stability and accountability to ensure that sound strategic decisions are made that lead toward achievement of long-term resource goals.

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Appendix A
Analytical Approach

We use the conventional method of moment approach to estimate parameters. Statistical properties of these estimators are not discussed here; we refer the interested reader to the general literature on the subject. Based on preliminary simulations, we hypothesize that the model produces reasonable results for populations which follow the Ricker production function as well.

The Basic Survival Model

A fundamental assumption of the model is that the life history of a salmon species can be partitioned into segments within which a) habitat conditions are relatively uniform, and b) the survival response is constant and predictable.

Segments that meet these conditions are defined in terms of space (e.g. stream reach), life stage (e.g. egg incubation), and time (e.g. month). The model further assumes that, within each segment, survival is adequately described by a two-parameter, Beverton-Holt survival function:

$$S = \frac{P}{1 + \frac{PN}{C}}, \qquad \text{(Equation 1)}$$

where P is productivity (low density reproductive success) and C is carrying capacity for the "uniform" life segment. N is the number of individuals alive at the beginning of the segment.

The Multistage Recursion Formula

Moussali and Hilborn (1986) showed that if survival in a sequence of life stage segments along the life history is either density independent or follows a Beverton-Holt survival function, then so does the full sequence. They showed further that "cumulative" productivity and capacity for a sequence of N segments with productivities p_i and c_i can be computed as:

$$P_N = \prod_{i=1}^{N} p_i \,, \qquad \text{(Equation 2)}$$

and

$$C_N = \frac{P_N}{\sum_{i=1}^{N} \frac{P_i}{c_i}} \,, \qquad \text{(Equation 3)}$$

which leads to the useful recursion:

$$C_N = \frac{p_N}{\frac{1}{C_{N-1}} + \frac{p_N}{c_N}} \,, \qquad \text{(Equation 4)}$$

If the N segments comprise the entire life cycle, we can now, for example, predict the equilibrium abundance, Neq, from:

$$Neq = C_N\left(1 - 1/P_N\right), \qquad \text{(Equation 5)}$$

We refer to a sequence of uniform life history segments that begins and ends with the spawning life stage as a life history trajectory. In the next section we talk about how productivity and capacity values for trajectories are used to calculate parameters for a population in a watershed.

Estimating Population Productivity from Life History Trajectories.

Our objective is to find the parameters of the Beverton-Holt production function that best describe survival characteristics of a defined population within a watershed. Suppose that we know the productivity values, P_t 's, for all life history trajectories within the genetic boundaries[2] of the species. If we also know the relative frequency of use, W_t, of each trajectory, then we suggest that a reasonable estimator of the population productivity P is given by:

$$P = \frac{\sum_t P_t W_t}{\sum_t W_t} \,. \qquad \text{(Equation 6)}$$

It seems reasonable that, in the long term, the frequency of use of the different trajectory pathways would be related to both

[2] By genetic boundaries we mean the range of life history patterns, i.e., spawning time, life stage durations, travels speeds, etc., observed for the species.

quality and quantity of habitat available. The equilibrium population size, which can be calculated for each trajectory, is a function of both. The model in fact assumes that the weights (W_t) are proportional to the equilibrium population size (Equation 5) of each trajectory, in other words:

$$W_t \propto Neq_t = C_t\left(1 - 1/P_t\right), \qquad \text{(Equation 7)}$$

where C_t is the capacity for trajectory t. The population productivity parameter is thus estimated from the trajectory productivities and capacities by:

$$P = \frac{\sum_t C_t(P_t - 1)}{\sum_t C_t\left(1 - 1/P_t\right)}. \qquad \text{(Equation 8)}$$

In practice, the estimate is, of course, based on a sample of trajectories. The question of how this sample is derived is discussed in a later section. The weighting procedure for estimating productivity reduces the sensitivity to the sampling scheme. We next look at the estimator for population capacity.

Estimating Population Capacity from Life History Trajectories

The capacity, C_t, associated with a single life history trajectory assumes that the length of the spawning reach is one meter. For every meter of potential spawning habitat we can estimate the capacity for trajectories associated with that particular stream segment, m, by simply computing their average:

$$C_m = Average(C_{t \in m}), \qquad \text{(Equation 9)}$$

and the population capacity for a watershed can be estimated as the sum of all C_m for all non-overlapping meter segments. If the distribution of potential trajectories is uniform throughout the watershed, then the population capacity parameter for the watershed can be estimated as the average trajectory capacity, C_{avg}, multiplied by the length of spawning habitat in meters, M.

$$C = C_{avg} M. \qquad \text{(Equation 10)}$$

Note that the stream width and the quantity and quality of habitat within the meter band are included in the trajectory capacity, C_t. The model estimates capacity from a sampling of

trajectories. The estimate of C is sensitive to the sampling procedure.

Life History Diversity from Trajectories.

Let us assume that there exists a set of life history trajectories, $\{t \in T\}$, that meets the condition that they are consistent with the genetic limitations of the modeled species. If the productivity, P_t, for trajectory t is greater than one, then spawners that choose this trajectory will make a positive contribution to the next generation (i.e., more than one offspring will return to spawn). If, on the other hand, P_t is less than one, the net contribution of those spawners will be a population loss. We define trajectories where P_t is greater than one as sustainable. We define the percentage of all trajectories within T that are sustainable as the Life History Diversity Index, D.

$$D = \frac{(\# t \in T : P_t \geq 1)}{(\# t \in T)}. \qquad \text{(Equation 11)}$$

The computations so far have been based on the assumption that we can estimate the cumulative (i.e. full life cycle) productivity, P_t, and capacity, C_t, for a life history trajectory. Next we describe how the model estimates these trajectory parameters.

Estimating Trajectory Productivity and Capacity from Habitat Ratings

A life history trajectory consists of a sequence of segments, like beads in a chain. Each segment consists of one time, space and life stage stratum. Within each segment we assume that environmental conditions and the induced biological responses are constant. Each segment thus meets the conditions of the basic survival model described above.

The computation of productivity and capacity for a trajectory requires two main steps: first, the computation of productivities and capacities for each segment; and second, combining the segment parameters into full life cycle or cumulative values. We will describe the second step first.

Assume that trajectory t can be partitioned into N uniform segments, and let $p_{t,i}$ and $c_{t,i}$ be the productivity and capacity parameters for segment i of trajectory t. From Equations 2 and 3 we have:

$$P_t = \prod_{i=1}^{N} p_{t,i}\,, \qquad \text{(Equation 12)}$$

and

$$C_t = \frac{P_t}{\sum_{i=1}^{N} \frac{P_{t,i}}{c_i}}\,, \qquad \text{(Equation 13)}$$

where

$$P_{t,i} = \sum_{j=1}^{i} p_{t,j} \qquad \text{(Equation 14)}$$

Now the question remains: how do we estimate the segment p's and c's? We are now looking at a uniform stream reach, over a time period when no significant change in habitat conditions occurs, and we are considering one fixed life stage. The productivity parameter for the segment is the low-density survival over the duration of the segment. We assume that this density independent survival parameter is strictly a function of the *quality* of habitat perceived by the given species and life stage. Specifically, the productivity is given by:

$$p_{t,i} = r_{t,i} b_i\,, \qquad \text{(Equation 15)}$$

where b_i is a "benchmark" (reference) productivity value for the life stage obtained from the literature adjusted for the duration of the current trajectory segment[3]. The benchmark values represent optimal survival conditions for the species. The factor $r_{t,i}$ is a relative productivity multiplier that adjusts the benchmark value to the habitat quality conditions of segment t,i. This multiplier is computed from:

$$r_{t,i} = \prod_{a} (1 - h_a / 4)^{2.7}\,, \qquad \text{(Equation 16)}$$

where h_a is a rating for habitat quality attribute a. The model captures habitat quality in terms of 18 such attributes. Each is given a rating between 0 and 4, where 0 implies no effect (no

[3] Appendix A includes a set of algorithms used in the model to adjust productivity and capacity values for the varying durations of the trajectory segments. Note that while the habitat data have discrete (monthly or weekly) time steps, the trajectory durations are continuous variables. A trajectory segment may last a fraction of a week or many weeks.

contribution to the multiplier) and 4 implies a lethal effect (multiplier becomes zero).

The capacity parameter for the trajectory segment is computed from reach width, percent of key habitat (within the reach), a food quantity rating, segment productivity, and benchmark productivity and density for the life stage. The calculation is iterative. First the weekly benchmark density at the beginning of the segment is back calculated, correcting for change in size of fish during the life stage (the model includes a size vs. density function). Segment capacity is then calculated as the cumulative capacity for the segment duration using Equation 3 above, including a multiplicative adjustment for percent of key habitat, reach width and food factor (see Appendix A for details).

Data Translation

Biological attribute ratings (h_a above) are derived from observed environmental conditions based on the accumulation of information and knowledge available from the scientific literature and or from experts in the field of habitat and fish biology. The model captures this knowledge in the form of a set of *biological rules*. The most efficient way to generate biological attribute ratings is to apply the rules directly to observed data. Earlier versions of the EDT, accomplished the data translation through a "manual" process, where the ratings were supplied by a panel of experts familiar with the watershed and with the biology of the diagnostic species. Biologists would summarize data and reports and then rate habitat, by reach and month, for each of the attributes – relative to benchmark conditions by life stage. The "manual" data translation process has educational value for the participants.

Appendix B
Diagnostic Species

Watershed management actions should be built on, or be consistent with, ecosystem-directed strategies that promote or maintain ecologically healthy watersheds. A management strategy based on an ecosystem perspective provides a scientific basis for evaluating, coordinating, and prioritizing watershed actions in a consistent manner. An ecosystem strategy is holistic; it recognizes that biotic and abiotic components of a watershed are interconnected. Hence, it must consider the long-term and collective consequences of many activities throughout a watershed.

An ecologically healthy watershed may be defined as one capable of supporting and maintaining a balanced, integrated, adaptive biological system having the full range of elements and processes expected in the natural habitat of the region (Angermeier and Karr 1993). This definition of ecological health underscores the importance of planning that considers the entire biotic community and emphasizes sustainability.

A primary management goal is to ensure the sustainability of valued renewable natural resources. The most important challenge facing environmental management is to foster a balance between short-term human needs and ecosystem sustainability (Ruckelshaus 1989; Lee et al. 1992).

Sustainability is defined as the process of change in which the continued exploitation or protection of resources, the direction of investment in land and water, and associated institutional changes are consistent with future as well as present objectives for perpetuating environmental qualities and socioeconomic functions of ecosystems (WCED 1987). Human communities generally desire that resource-based values and objectives associated with the water and land of a watershed be sustainable, even within the context of watersheds that have undergone major changes to accommodate human needs.

The concept of sustainability must also recognize that ecosystems are constantly evolving. The management concern we raise when we worry about sustainability is the direction

and rate of this evolution. All valued natural resources may not be concurrently sustainable in all watersheds.

Certain species or populations that are dependent on the relative stability of ecological processes over a large portion of a watershed can be used to help diagnose conditions for sustainability. The shift toward ecosystem management that has occurred in recent years is a move away from a conventional, single-species approach to a whole system, multi-species framework (Grumbine 1994). This shift poses a problem: How do we assess the condition of ecosystems, given their inherent complexity? The use of appropriately selected indicator or diagnostic species provides a way of coping with this complexity (Soule 1987; Karr 1992; Lee 1993).

Instead of trying to understand all dimensions of an ecological whole, the use of indicator organisms that are sensitive to an important cross-section of those dimensions gives needed focus for an assessment (Lee 1993). Implicit in this concept is the assumption that a species that is sensitive to a wide variety of ecosystem conditions is useful as a pulse on the system.

Desired conditions for the entire ecosystem may be achieved through actions guided by the needs of populations that fill representative (umbrella species) or key (keystone species) functional roles within the ecosystem (Walker 1995). This approach may currently be the most effective way to achieve ecosystem sustainability (Olver et al. 1995; Walker 1995). The EDT method uses the term *diagnostic species* to emphasize that it is a device to aid in diagnosing and treating watershed conditions.

Migratory salmonid species, like salmon, are highly suited as diagnostic species. Their freshwater life history depends upon streams, the arterial system of the watershed. Streams are generally regarded as a good reflection of overall watershed condition since water drains downhill, bringing with it characteristics created by conditions upstream. Salmonids are sensitive to these characteristics (Bjornn and Reiser 1991). Because fish are often primary determinants of ecosystem structure (Brooks and Dodson 1965; McQueen et al. 1986), conditions shaping their survivability and life history are important to that structure.

Certain salmonid species (e.g., chinook, coho, and steelhead) utilize extensive portions of the watershed, from the mouth of the river to the headwaters of many of its connected branches. To complete their life cycles, individuals of these species

experience the condition of the river from the spawning grounds, often located high in the watershed, to the estuary.

Hence the completion of their life cycle depends upon the connectivity of the stream network over various life stages (Lichatowich and Mobrand 1995). These life stages, which can number seven or more (e.g., prespawning, spawning, incubation, colonization, active rearing, inactive, and juvenile migration), have different habitat requirements (Bjornn and Reiser 1991); therefore, sustainable life history patterns require the existence of diverse habitats.

Migratory salmonids have another important, unique role—they connect ecosystems through their extensive migrations. For example, chinook that spawned historically in the upper Cispus subbasin (as in Yellowjacket Creek) utilized not just this stream, but the lower Cispus, the mainstem Cowlitz River, and the Columbia River before moving into the Pacific Ocean. There, they traveled extensively for several years prior to the return to their natal stream. The concept of ecosystem management ultimately must recognize that watersheds (or ecosystems) are not isolated (Maser and Sedell 1994); conditions in one can have profound implications for the sustainability of resources in another. Moreover, salmon are among the few species that cycle nutrients between all these environments (Kline et al. 1993; Bilby et al. 1995; Willson and Halupka 1995).

The potential magnitude of nutrient cycling by salmon and its role in ecosystem function have long been acknowledged (Juday et al. 1932; Donaldson 1967); but, in general, their importance has received scant attention by scientists (Willson and Halupka 1995). Recent findings suggest that nutrient cycling may be very important to the structure and stability of some watersheds, supporting the conclusion that salmon should be considered a keystone species in these systems (Bilby et al. 1995). A keystone species is one that plays a critical role in maintaining the biological integrity of the ecosystem to which it and many other species belong; the loss of such species leads to cascading changes in ecosystem structure (Paine 1969; Paine 1995).

This potential keystone role is seen in the importance that anadromous salmonids have had historically, and continue to have in many areas, as critical nutrient sources to numerous species (Willson and Halupka 1995). The enormous influx of biomass to freshwater systems that can occur through anadromous adult salmonids and their progeny can be heavily

exploited by mammal, bird, and fish species, affecting the distribution, survival, and reproduction of these non-salmon species.

The findings by Bilby et al. (1995), and their on-going work, provide evidence that the capacity of salmon streams to support fish may be progressively declining due to reductions in nutrient loading caused by diminishing numbers of spawning salmon.

In addition to serving as indicators of the quality of watersheds, salmon species symbolize the vitality of the Pacific Northwest to human communities (Jay and Matsen 1994). Salmon are integral to the heritage and present-day values of people throughout the region. In a sense, they are an icon of the quality of life in the area.

APPENDIX B

Information Structure of EDT

Appendix B

Information Structure of EDT

by

Mobrand Biometrics, Inc. October 2002

This document describes the conceptual structure used to organize and analyze information as part of the EDT analytical procedure.

1.0 Components of Population Performance

To understand the kinds of information utilized and how it is applied, it is important to understand what the analysis aims to produce. Information is translated through the procedure to address two aspects of fish population performance: productivity and capacity. These two parameters define a theoretical stock-production (S-P) relationship, illustrated using a Beverton-Holt production function in Figure 1. The S-P curve displayed here is an example of what a relationship might look like between the number of fish at the beginning of a life stage and those surviving to the end of the stage.

Productivity is equivalent to the concept of intrinsic productivity discussed in McElheny et al. (2000) to describe viable salmon populations with respect to the Endangered Species Act. It is survival without density dependence effects, i.e., the approximate rate that would occur when competition for resources among the population is minimal. In Figure 1, it is the slope of the S-P curve at its origin. Productivity is a function of the quality of the environment.[1]

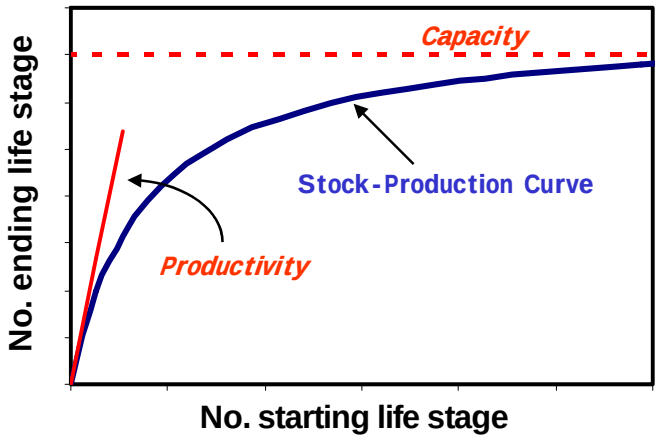

Figure 1. Example stock-production relationship.

Operating quite differently, environmental capacity limits how large a population can grow given finite space and food resources, depicted by the asymptote in Figure 1. It controls the extent that density dependence is operative at different population levels. Capacity is a function of the quantity of key habitats and food resources available.

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[1] / Productivity measured across a full life cycle also incorporates sex ratio, fecundity, and fitness.

Sets of rules are used by the EDT method to derive productivity, key habitat, and food parameter values from environmental information—these serve as inputs into the EDT model.[2]

2.0 Ecological Information Structure

Information used to derive biological performance parameters is organized through what is called the Ecological Information Structure. It structures information through three levels of organization. Together, these levels can be thought of as an information pyramid in which each builds on information from the lower level (Figure 2). As we move up through the three levels, we take an increasingly organism-centered view of the ecosystem.

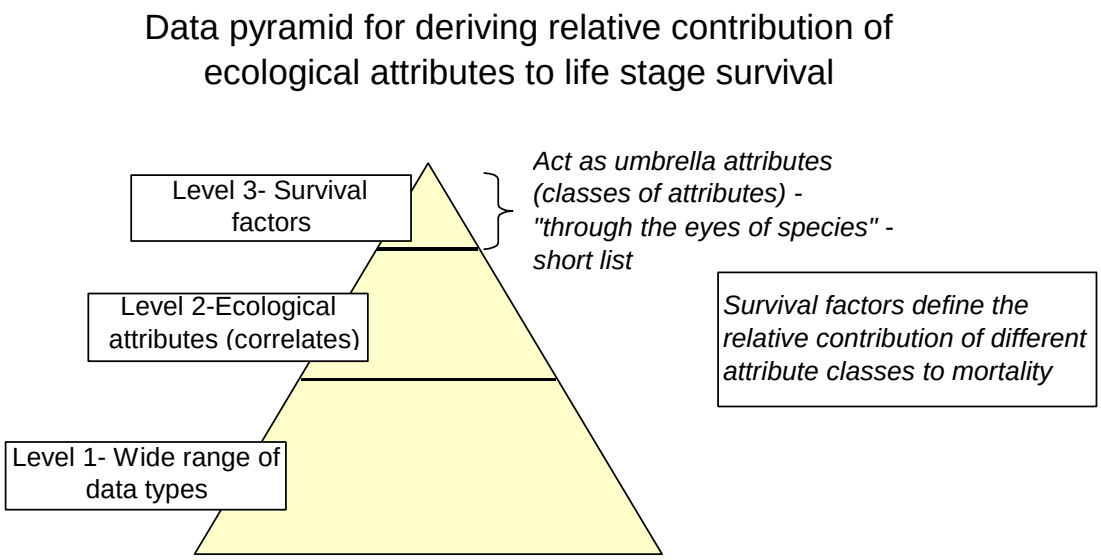

Figure 2. Data/information pyramid—information derived from supporting levels.

Levels 1 and 2 together characterize the environment, or ecosystem, as it can be described by different types of data (Figure 3). This provides the characterization of the environment needed to analyze biological performance for a species. The Level 3 category is a characterization of that same environment from a different perspective: “through the eyes of the focal species" (Mobrand et al. 1997). This category describes biological performance in relation to the state of the ecosystem described by the Level 2 ecological attributes, or correlates.

[2] / In EDT, food is both a component of environmental quality (thereby affecting productivity) and quantity (since food is assumed to affect both density-independent and –dependent mortality.) Regarding its role in affecting density-dependent mortality, the food parameter is used in conjunction with the key habitat parameter in estimating capacity.

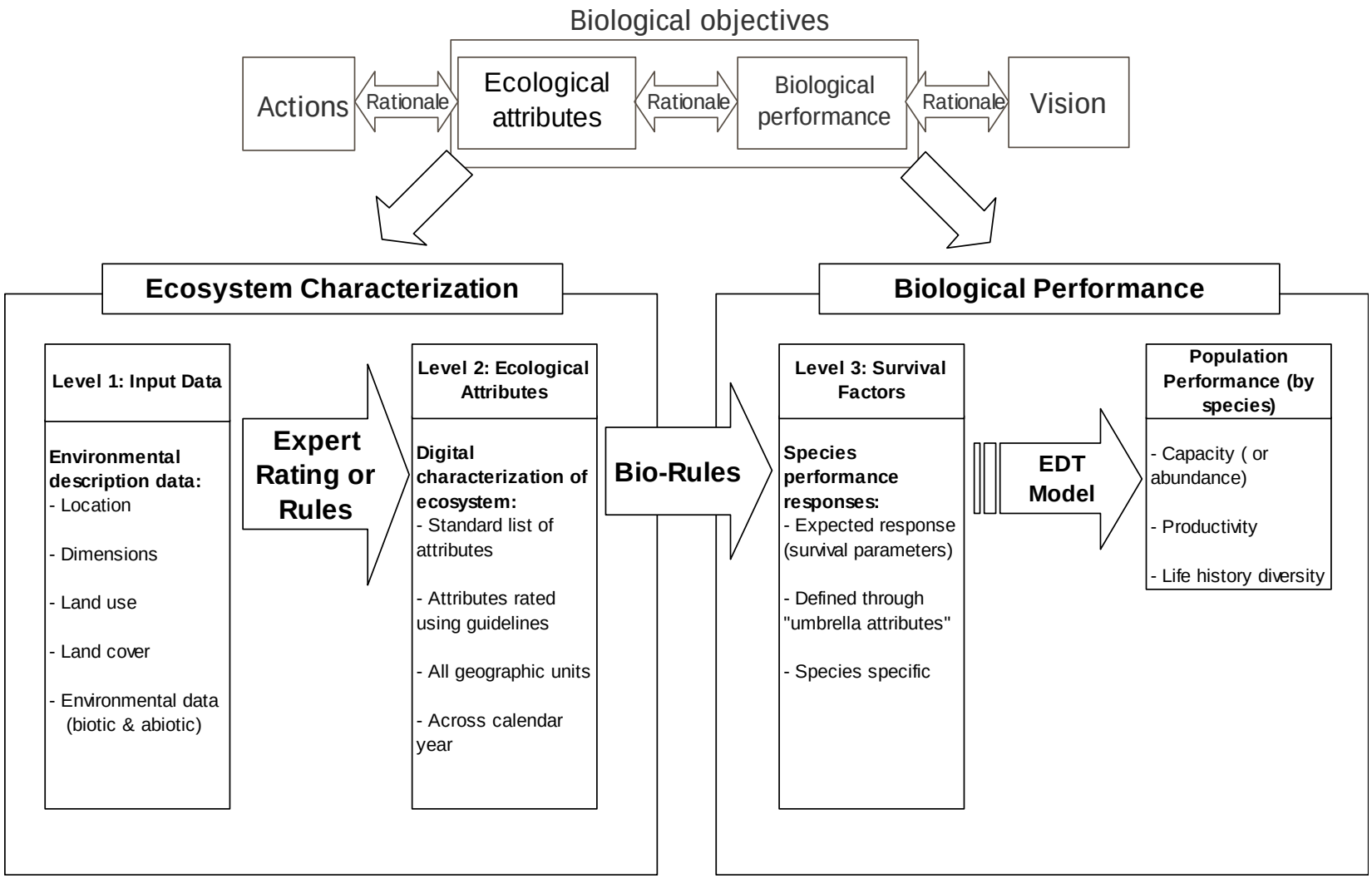

Figure 3. Ecological Information Structure.

The Information Structure begins with a wide range of environmental data (Level 1 input data) such as flow, lithology, sediment load, temperature, physical habitat, land use and ownership, elevation, slope, and so on. Included is information on the spatial and temporal structure of the data. These data exist in a variety of forms and pedigrees. Some watersheds are data rich, others might be comparatively data poor. The Level 1 includes the fundamental elements that enter into habitat forming processes. These data are the basis for the more refined description of the environment in Level 2.

Level 2 then creates a generalized depiction of the aquatic environment, essentially as a set of conclusions derived from the Level 1 information. Level 2 attributes are termed Environmental Correlates (Table 1) in the sense of Morrison et al. (1998) to describe the environment in regard to species of interest, in this case native salmonids (the terms correlates and ecological attributes are used interchangeably in this document). The Level 2 correlates specify physical and biological characteristics about the environment relevant to the derivation of productivity and capacity for specific species in Level 3. In concept, a set of Level 2 correlates can be described for analyzing the environment with respect to any species.

The Level 2 characterization describes conditions in the watershed at specific locations, times of year (specific months), and by scenario (historic, current, or a future scenario). Thus values assigned for each correlate represent assumed conclusions by site, month, and scenario. These assumptions become operating hypotheses for these attributes under specific scenarios. Where Level 1 data are sufficient, Level 2 conclusions can be derived directly or through simple rules. However, in other cases, experts are needed to provide knowledge about geographic areas and attributes where Level 1 data are incomplete. Regardless of the means whereby Level 2 information is derived, the characterization it provides can be ground-truthed and monitored over time through an adaptive process.

Each Level 2 correlate is characterized using ratings on a scale of 0 to 4, spanning a spectrum of conditions. Generally, there is a consistent direction to the attribute ratings, where 0 or low values will tend to correspond with pristine environmental conditions and higher values tend toward managed conditions. This pattern varies for several attributes, however. Table 2 gives examples of the index values for three correlates, all addressing a different aspect of sediment load within the stream system. Integer values represent the midpoint of conditions for attributes when a range of conditions is associated with one value.[3] The indexing system allows users to specify either continuous or integer values for the attributes, depending on the appropriate level of precision for particular stream reach given the available data. In the examples shown in Table 2, non-integer ratings for any index value between 0-4 have meaning. Where information is coarse, integers would be appropriate, indicating that a reasonable characterization is contained somewhere within the range corresponding to the integer rating. Conditions associated with index values for all Level 2 Correlates are **described in Appendix A-4.**

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[3] When generating Level 2 attribute values for the basin, integer values frequently mean that only a broad categorical conclusion can be reached about an environmental attribute, as reflected in the range of values shown for the sediment examples. In these cases, the rule would interpret an integer to represent the midpoint.

Table 1. Organization of Level 2 Environmental Correlates by categories of major stream corridor features. Corresponding salmonid Survival Factors (Level 3) are shown associated with groups of Level 2 correlates (other associations may also be used in conversion rules). Associations can differ by species and life stage.

Environmental Correlates (Level 2)		Related Survival Factors (Level 3)
1 Hydrologic Characteristics		
1.1 Flow variation	Flow - change in interannual variability in high flows	Flow Withdrawals (entrainment)
	Flow - changes in interannual variability in low flows	
	Flow - Intra daily (diel) variation	
	Flow - intra-annual flow pattern	
	Water withdrawals	
1.2 Hydrologic regime	Hydrologic regime - natural	
	Hydrologic regime - regulated	
2 Stream Corridor Structure		
2.1 Channel morphometry	Channel length	Channel length Channel stability Channel width Habitat diversity Key habitat Obstructions Sediment load
	Channel width - month maximum width	
	Channel width - month minimum width	
	Gradient	
2.2 Confinement	Confinement - hydromodifications	
	Confinement - natural	
2.3 Habitat type	Habitat type - backwater pools	
	Habitat type - beaver ponds	
	Habitat type - glides	
	Habitat type - large cobble/boulder riffles	
	Habitat type - off-channel habitat factor	
	Habitat type - pool tailouts	
	Habitat type - primary pools	
	Habitat type - small cobble/gravel riffles	
2.4 Obstruction	Obstructions to fish migration	
2.5 Riparian and channel integrity	Bed scour	
	Icing	
	Riparian function	
	Wood	
2.6 Sediment type	Embeddedness	
	Fine sediment (intragravel)	
	Turbidity (suspended sediment)	
3 Water Quality		
3.1 Chemistry	Alkalinity	Chemicals (toxic substances) Oxygen Temperature
	Dissolved oxygen	
	Metals - in water column	
	Metals/Pollutants - in sediments/soils	
	Miscellaneous toxic pollutants - water column	
	Nutrient enrichment	
3.2 Temperature variation	Temperature - daily maximum (by month)	
	Temperature - daily minimum (by month)	
	Temperature - spatial variation	

Table 1 continued. Hierarchical organization of Level 2 Environmental Correlates by categories of major stream corridor features.

Environmental Correlates (Level 2)		Related Survival Factors (Level 3)
4 Biological Community		
4.1 Community effects	Fish community richness	Competition with hatchery fish Competition with other fish Food Harassment Pathogens Predation
	Fish pathogens	
	Fish species introductions	
	Harassment	
	Hatchery fish outplants	
	Predation risk	
	Salmonid carcasses	
4.2 Macroinvertebrates	Benthos diversity and production	

Table 2. Rating indexes used for three Level 2 Correlates that address different characteristics of sediment load in a stream system.

Embeddedness	
Rating	Rating definition
0	≤ 10% embedded
1	> 10% and ≤ 25% embedded
2	> 25% and ≤ 50% embedded
3	> 50% and ≤ 90% embedded
4	> 90% embedded
Fine sediment (intragravel)	
Rating	Rating definition
0	≤ 6% fines < 0.85 mm
1	> 6% and ≤ 11% fines < 0.85 mm
2	> 11% and ≤ 18% fines < 0.85 mm
3	> 18% and ≤ 30% fines < 0.85 mm
4	> 30% fines < 0.85 mm
Suspended sediment (from SEV index – after Newcombe and Jensen 1996)	
Rating	Rating definition
0	≤ 4.5 scale of severity (SEV)
1	> 4.5 and ≤ 7.5 scale of severity (SEV)
2	> 7.5 and ≤ 10.5 scale of severity (SEV)
3	> 10.5 and ≤ 12.5 scale of severity (SEV)
4	> 12.5 scale of severity (SEV)

The biological rules translate the Level 2 characterization of the environment into the Level 3 survival factors by life stage (Figure 4), which comprise the components of the biological performance parameters. These factors act as "umbrella attributes", grouping the effects of classes of Level 2 correlates on productivity and capacity. The purpose of grouping effects of classes of attributes in this manner is to allocate mortality by the types of factors that biologists typically refer to in environmental analysis (e.g., limiting factors analysis).

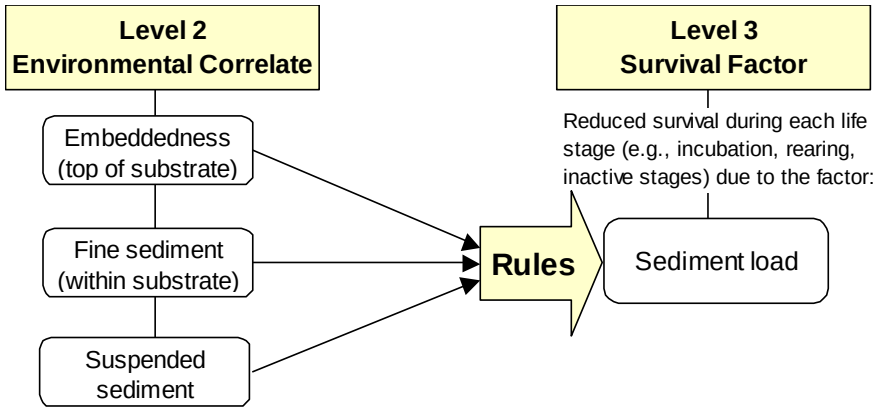

Figure 4. Rules derive (as hypotheses) effects of Level 2 Correlates on species performance by life stage (example shows effects of sediment attributes on life stage productivity).

In most cases, a single rule exists for one life stage-Level 3 Survival Factor combination. However, in some cases more than one rule exists to account for likely differences in biological sensitivity between stream sizes (by channel width) and hydrologic regime (accounting for source of flow, e.g., groundwater vs. rain fed).
See Appendix A-1 Level 3 Survival Response Factor definitions, **Appendix A-2** for species-specific life stage definitions, and **Appendix A-3** for Level 2 Ecological Attributes definitions.

2.1 How the Rules Work: Derivation and Structure

The rules should be seen as hypotheses about how environmental conditions affect biological performance parameters. They produce estimates of productivity and key habitat corresponding to species-specific life stages at a given location within a stream system associated with conditions in a specific month. A location is a single stream reach, delineated by having a relatively uniform set of conditions throughout its length. The rules for productivity and key habitat are structured differently and are treated separately in the following two sections. A third section describes how levels of proof are assigned to the rules.

2.1.1 Rules for Estimating Productivity

The life stage productivity value associated with a specific stream reach is defined as the density independent survival rate expected if the entire life stage occurred under the conditions in that reach.[4]

[4] / Differences in conditions between months are handled within EDT by modeling life history trajectories to capture how groups of fish experience changes in environmental conditions in space and time.

The rules presented here assume that productivity, P, can be partitioned into a set of (16) independent multiplicative survival factors F_i, i.e.

$$P = P_0 \cdot F_1 \cdot F_2 \cdot F_3 \cdots F_{16}$$

where $0 < F_i < 1$ are relative productivity values and P_0 is the maximum productivity for the life stage. We refer to P_0 as the "benchmark survival", described below. Each $F_i < 1$ acts to reduce P from the benchmark productivity due to habitat conditions that are less than optimal corresponding to that F_i in the given reach. When the reach has optimal conditions corresponding to all factors, i.e, $F_i = 1$ for all Level 3 factors, then $P = P_0$. The Level 3 survival factors are defined in Appendix A-4. We then assume that each survival factor F_i can be estimated as a function of the Level 2 correlates for the reach. The functional form used to estimate the F_i may differ among the F_i.

For the sake of simplicity, the functional form that we applied in formulating the present rule set assumes that a Level 3 survival factor will principally be driven by a single dominant, or primary, Level 2 correlate, though other Level 2 correlates can act to modify the overall effect of this attribute. We refer to this rule structure as the Synergistic Form.

In this form for rule structure, we refer to the dominant correlate as the Primary Level 2 correlate for that specific life stage-Level 3 factor. When the Primary Level 2 correlate (p) alone affects the Level 3 survival factor F_i, it is defined as:

$$F_i = 1 - S_{P,i}$$

where the $S_{P,i}$ values for each rating (0 – 4) of the Primary Level 2 are estimated based on published studies, available data or where data is sparse, expert opinion.

In most cases the sensitivity to the Primary Level 2 correlate is affected by one or more Modifying Level 2 correlates. These correlates modify overall sensitivity associated with the Primary Level 2, either increasing it or, in some cases, decreasing it. The functional form used (unless otherwise specified) to capture this modifying effect is:

$$F_i = 1 - \left[\sum_j S_{j,i}{}^{g} \right]^{1/g}$$

where $S_{j,i}$'s are the sensitivities of all contributing Level 2 correlates *j* (including the Primary) operating on factor *i*, and *g* is a "synergy parameter."

Following are examples of how this synergistic effect is incorporated involving sediment.

In all rules, where this synergistic form is used the value of g is 0.4 . This value of g derives from the way the 0 – 4 rating scale for Level 2 attributes were defined. The synergistic form shapes the overall combined effect of multiple Level 2 correlates affecting a single Level 3 factor i consistent with the way in which ratings have been defined for Level 2 correlates. In general, the rating system was devised so that values of 1 or 2 would have little effect on survival, whereas values of between 3 and 4 tend to reflect severe conditions for survival. Use of $g = 0.4$ in the equation retains a minor effect on relative productivity when adding multiple Level 2 modifiers with low ratings, but rapidly increases sensitivity at higher values for modifying attributes. As more data and information become available this function should be tested against observations.

An alternative to the synergistic rule described above would be to assume that Level 2 correlates operate independently of each other. The Independent Form of the rule would assume a simple multiplicative effect:

$$F_i = \prod_j (1 - S_{j,i})$$

None of the rules in the current EDT rule set are structured using this form. We have developed a rule viewer application that allows this structure to be compared to the synergistic form for all productivity rules. It should be recognized, however, that sensitivities ascribed to Level 2 correlates for each factor i in the existing rules database were formulated using the synergistic form—which means that sensitivities of those correlates identified as being "modifiers" are likely set too low to be used without adjustment with the independent form. If a rule structure is modified to follow the Independent Form, then many of these sensitivities may need to be adjusted upwards.

The benchmark survival P_0 for a life stage is the average survival expected for that life stage under optimal habitat quality conditions. It is the expected survival when environmental quality conditions are "as good as they get" in nature for that life stage with a typical duration.

Three examples (Table 3) are presented below to show how rules were formulated and how they function. The logic, approach, and key studies applied are described. Each example looks at how Level 2 correlates are used to derive relative productivity associated with the Level 3 survival factor "sediment load" seen in Figure 4. The examples show how these Level 2 correlates are used to project a total effect on productivity associated with this survival factor. They also illustrate that different levels of confidence or "proof" can be given to the rules depending on how much is known from documented empirical relationships.

<u>Example 1: Incubation life stage – one correlate based on an empirical relationship</u>

This example illustrates the use of a documented relationship between fine sediment within the substrate of riffles and pool-tailouts and survival from egg deposition to fry emergence (STE). Only one Level 2 correlate is used in this rule. Evidence for the effect

Table 3. List of examples to illustrate how rules were formulated and function. Each projects total sensitivity (1- relative productivity) ascribed to the Level 3 survival factor "sediment load."

	Example 1	**Example 2**	**Example 3**
Type of example shown to right	One correlate affecting sensitivity – based on empirical relationship	Multiple correlates affecting sensitivity – based on empirically derived index with added inferences	Multiple correlates affecting sensitivity – inferred from empirical observations and qualitative conclusions
Life stage	Incubation (to emergence)	Resident rearing	Inactive (overwintering)
Primary correlate	Fine sediment (intragravel)	Suspended sediment	Embeddedness
Modifying sediment correlate	none adding sensitivity	none adding sensitivity	Suspended sediment
Other modifying correlate	none adding sensitivity	Temperature (max)	none adding sensitivity

of percent intra-gravel fines (e.g., particles < 1mm in size, most often expressed as <0.85 mm) is well documented (e.g., Chapman and McLeod 1987 and Kondolf 2000). The many studies that have documented effects of sediment on STE typically link the cause of reduced survival to this single aspect of sedimentation.

Kondolf (2000) outlines a procedure to consider two size classes of intragravel sediment in assessing effects on STE, based on analyses by Tapel and Bjornn (1983) and Chapman and McLeod (1987). In areas where excessive fines < 1 mm are present, the major determinant of STE would be based on this size class. The effect in this case occurs due to restriction of oxygenated flow passing incubating eggs with loss of gravel permeability as percent fines increases. In areas where somewhat larger particle sizes are excessive (3-6 mm), such as in the Idaho Batholith, this size is believed to have the dominant effect. In this case, sand size particles can entomb pre-emergent fry. Definitions used to describe the Level 2 correlate for fine sediment provide an option for either using particle sizes <1 mm (as seen in Table 2) or particles between 3-6 mm in size **(see Appendix A-4)**. **Further discussion on how this correlate is to be rated is provided in the separate document "Attributes Ratings Guidelines**." That document discusses consideration that should be given to gravel cleaning by spawners and the reinvasion of fine sediments into redds during the incubation life stage.

We employed the empirical relationship reported by Tagart (1984) for the effects of percent fine sediment (<0.85 mm) on survival to emergence for coho (Figure 5). We assumed the same relationship is applicable to chinook. Using a benchmark survival to emergence of 60% (assumed average survival under optimal conditions), we can convert Tagart's survivals into sensitivity (as 1 minus survival divided by the benchmark) and plot the values against the appropriate Level 2 rating values on the x-axis (Figure 6). The resulting relationship forms the rule for sediment effects on the incubation life stage, except when the hydrologic regime is mainly characterized as groundwater fed.[5] In that case, upwelling associated with groundwater sources appears to largely protect embryos from deleterious effects of high fines (Waters 1995). This explains why salmonids can

[5] Hydrologic regime is a Level 2 correlate. Five regimes are described through the ratings, of which one is predominately groundwater fed (see Appendix A-4).

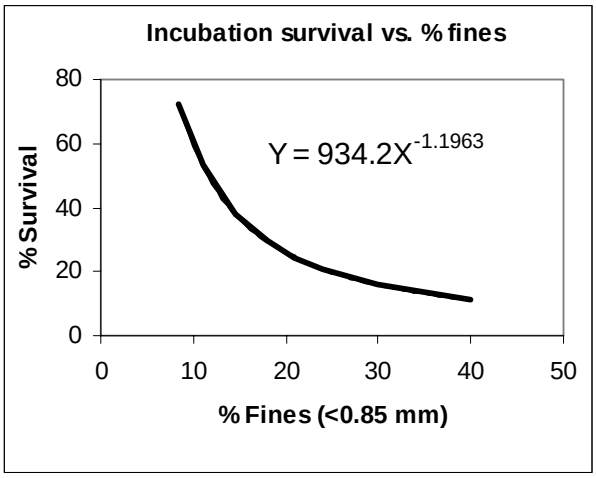

Figure 5. Relationship between percent fines and survival from egg deposition to emergence for coho salmon. Adapted from Tagart (1984).

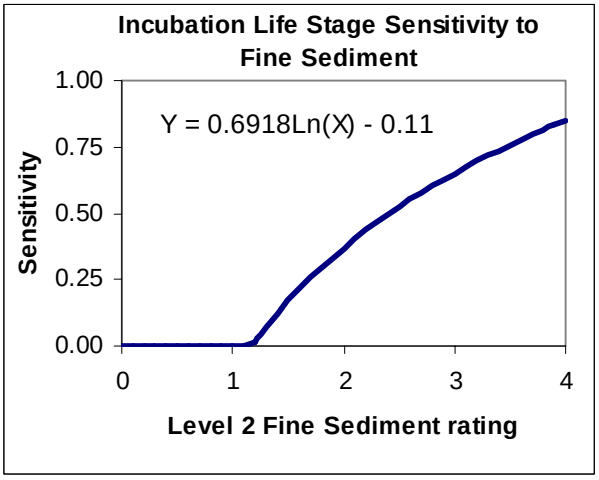

Figure 6. Relationship between ratings for Level 2 Fine Sediment and sensitivity of eggs and alevins, derived by converting the relationship in Figure 5.

have high rates of reproduction in some streams despite excessive deposits of fine sediment (e.g., chum and sockeye salmon are known to spawn heavily in groundwater fed streams, even in areas of excessive fines). We therefore formulated a sensitivity relationship for this hydrologic regime that maintained high survivals even at high levels of fine sediment.

Examples of results obtained by applying the rule described here for all hydrologic regimes except groundwater dominated are provided in Table 4.

Table 4. Example results obtained for the rule incubation-Level 3 Sediment Load for chinook salmon.

Life stage: egg incubation						
Attribute		Example				
		A	B	C	D	E
Fine sediment (intragravel)(Primary)	Rating	0	1	2	3	4
	Sensitivity	0	0	0.370	0.650	0.849
Relative productivity		1.00	1.00	0.63	0.35	0.15
Benchmark survival		0.6	0.6	0.6	0.6	0.6
Absolute survival		0.60	0.60	0.38	0.21	0.09

Example 2: Resident rearing life stages – multiple correlates based on empirically derived index with inferences for synergy

This example involves two correlates acting in synergy to produce a total sensitivity associated with sediment during the active rearing stage. The rule is based on an empirically derived index for sensitivity to suspended sediment, the primary correlate in this case, and an assumed synergistic effect with temperature. This example illustrates how some rules combine a well-documented sensitivity relationship with more qualitative information to derive an overall effect ascribed to a single Level 3 factor.

Effects of suspended sediment (SS), either as turbidity or suspended solids[6], on fish are well documented (summarized in Bash et al. 2001). Suspended sediments can affect fish behavior and physiology and result in stress and reduced survival. Temperature can increase the effect of SS through synergism (Newcombe and Jensen 1996, Bash et al. 2001).

The severity of effect of SS increases as a function of both sediment concentration and exposure time, or dose (Newcombe and Jensen 1996, Bash et al. 2001). Newcombe and Jensen (1996) performed a meta-analysis of data contained in 80 published and documented reports to assess the effects of dose on fish responses, including numerous studies involving salmonids. The analysis yielded empirical equations that relate biological response to duration of exposure and SS, including two that specifically address salmonids. The authors synthesized the results of their scale of severity (SEV) into likely outcomes for fish species (adapted in Table 4). We aligned our rating system of 0-4 to their scale, consistent with our intent to span the general range of effects across our rating scale as described earlier (Table 5).

[6] / The correlate suspended sediment is described either as turbidity or suspended solids, though the latter is preferred. Turbidity is an optical property of water where suspended, including very fine particles such as clays and colloids, and some dissolved materials cause light to be scattered; it is expressed typically in nephelometric turbidity units (NTU). Suspended solids represents the actual measure of mineral and organic particles transported in the water column, either expressed as total suspended solids (TSS) or suspended sediment concentration (SSC)—both as mg/l. Technically, turbidity is not normally considered as SS, but we treat them together since they are usually well correlated.

Table 5. Scale of severity (SEV) index of ill effects associated with excess suspended sediment (adapted from Newcombe and Jensen 1996) and corresponding Level 2 Suspended Sediment ratings used in rule formulation.

SEV	Description of effect	Level 2 SS rating
	Nil effect	0
0	No behavioral effects	
	Behavioral effects	
1	Alarm reaction	
2	Abandonment of cover	
3	Avoidance response	
	Sublethal effects	
4	Short-term reduction in feeding rates; short term reduction in feeding success	
5	Minor physiological stress; increase in rate of coughing;	1
6	Moderate physiological stress	
7	Impaired homing	
8	Indications of major physiological stress; long-term reduction in feeding rate; long-term reduction in feeding success; poor condition	2
	Lethal and paralethal effects	
9	Reduced growth rate; reduced fish density	
10	0-20% mortality; increased predation	
11	>20 – 40% mortality	3
12	>40 – 60% mortality	
13	>60 – 80% mortality	4
14	>80 – 100% mortality	

We interpret Table 5 as seen in Figure 7 -- giving a relationship between life stage survival and SEV (based on discussion in Newcombe and Jensen, we assume these results apply to actively rearing fish, as well as adult prespawners). Figure 7 is then easily converted to a relationship between our rating scale of 0-4 and life stage sensitivity (Figure 8).

The SEV index is easily computed by expressing SS in mg/l (which can be estimated from turbidity NTUs) and making a reasoned assumption about the percent of time during the worst case month (on average) when that concentration is attained. Further discussion on how this correlate is to be rated is provided in the separate document "Attributes Ratings Guidelines."

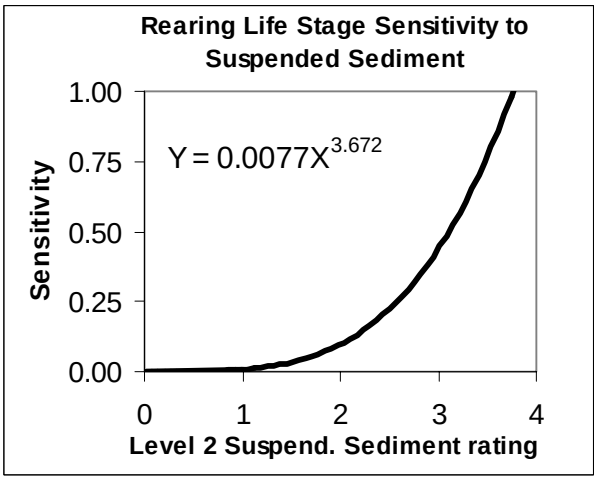

Figure 7. Relationship between scale of severity (SEV) index for suspended sediment (SS) and percent survival in rearing and prespawning life stages for salmonids – interpreted from Newcombe and Jensen (1996).

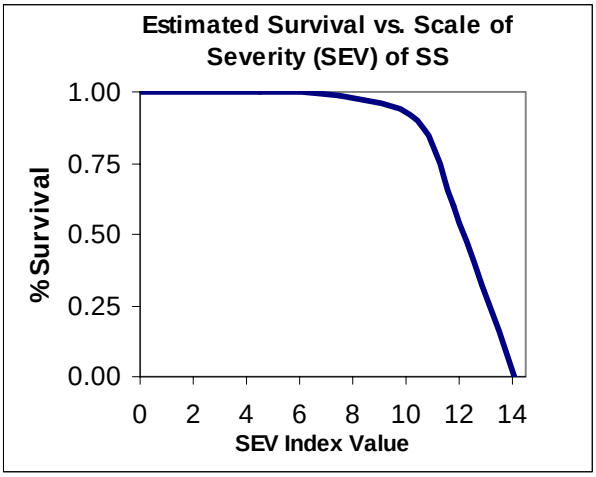

Figure 8. Relationship between ratings for Level 2 Suspended Sediment and sensitivity of salmonids during active rearing stages derived by converting the relationship in Figure 7.

Although it is readily accepted that higher temperatures act through synergism to increase the effect of SS, the extent of the effect has not yet been quantified in a manner to be included directly in the SEV index (Newcombe and Jensen 1996). The authors of the SEV state that the effect probably has to do with temperature-related patterns of oxygen saturation, respiration rate, and metabolic rate of fishes. From our review, we conclude that a noticeable effect of synergy between SS and temperature is needed in the rule to recognize this effect. We therefore assumed what is likely a conservative synergistic effect, setting the sensitivity to temperature (maximum) in the rule to add approximately 20-25% greater effect with intermediate temperature ratings when occur with intermediate SS ratings.

An additional note on the effect of sediment during the active rearing stage is warranted. Bjornn and Reiser (1991) summarize findings of several studies that suggest that embeddedness may further increase the effect of overall sedimentation during active rearing stages. Bjornn and Reiser conclude however that the effect likely occurs largely through reduced benthos as food for chinook. We concur with this interpretation—we address the effect of reduced benthos through the Level 3 factor food and not through sediment load.

An examples of results obtained by applying the rule described here are provided here.

Table 6. Example results obtained for the rule 0-age resident rearing-Level 3 Sediment Load for chinook salmon

Life stage: 0-age resident rearing						
Attribute		Example				
		A	B	C	D	E
Suspended sediment (Primary)	Rating	2	2	3	3	3
	Sensitivity	0.098	0.098	0.436	0.436	0.436
Temperature (max)(Modifier)	Rating	0	2	0	2	3
	Sensitivity	0	0.001	0	0.001	0.005
Relative productivity		0.90	0.84	0.56	0.42	0.29
Benchmark survival		0.7	0.7	0.7	0.7	0.7
Absolute survival		0.63	0.59	0.40	0.29	0.20

<u>Example 3: Inactive life stage – multiple correlates based on a weight of evidence approach, including synergy</u>

As in the previous case, this example involves two correlates, assumed to act in synergy to produce a total sensitivity associated with sediment during the inactive rearing stage. The rule is based on a weight of evidence from several studies on the impact of substrate embeddedness on overwintering juveniles conducted over the past three decades. In addition, the rule incorporates a synergistic effect for suspended sediment, here acting as a modifying correlate to embeddedness.

Embeddedness describes the extent that interstitial spaces between cobble and gravel on the substrate surface is filled with fine particles. Some species of salmonids, e.g., chinook, use the voids between cobbles as hiding cover during the inactive (overwintering) life stage. It is well documented that the capability of the substrate to hold juvenile salmonids during winter diminishes as the substrate becomes more embedded (Bjornn and Reiser 1991), implying that overall habitat quality during this life stage declines with sedimentation. Further, the overall sensitivity to fine sediment during this stage can include effects of suspended sediment, as described above for the active rearing stages. Here, however, fish in the inactive stage are much less sensitive to suspended sediment (Noggle 1978), apparently because of reduced respiratory and

metabolic requirements. We therefore allowed for some added effect of suspended sediment and assumed that it would operate to increase sensitivity identified with embeddedness in this case.

Efforts to quantify effects of embeddedness on overwintering juvenile chinook are based in large part on studies by Bjornn et al. (1977) and Hillman et al. (1987). Both studies reported that juvenile densities were reduced by more than half when cobble substrate became highly embedded. Juveniles are known to emigrate at the onset of winter from areas of high embeddedness and to keep moving until suitable substrate is found (Bjornn 1978). We are not aware of any studies in which mortality was specifically assessed in relation to embeddedness, though it is believed to increase under such conditions (Waters 1995). Presumably, some fish emigrate because survival of fish remaining in embedded substrates is lower than for migrants that successfully find better habitat. Moreover, if emigrants do not find suitable substrates (as must sometimes occur because the extent of sedimentation has increased over pristine conditions), their penalty might be an even greater reduction in survival than those that do not migrate from poor quality habitat. Lacking a quantitative relationship to apply, we drew on Chapman and McLeod's (1987) interpretation of the Bjornn et al. (1977) and Hillman et al. (1987) studies. They concluded that a reduction in winter habitat must occur at embeddedness levels somewhere between 0% and 66% and that at that level or higher that such areas would be made unusable by overwintering fish. They also stated: "We have no doubt that functional relationships exist between embeddedness and winter holding capacity of the substrate for salmonids, and that those relationships differ by fish size and perhaps by species."
We conclude from the foregoing that it is reasonable to hypothesize a functional relationship between the survival of fish that attempt to overwinter in embedded stream reaches and the extent that the substrate is embedded there. We hypothesize that the relationship between sensitivity and embeddedness would show little effect up to about 66% embeddedness, then exhibit a very rapid increase in sensitivity above that level (Figure 9).

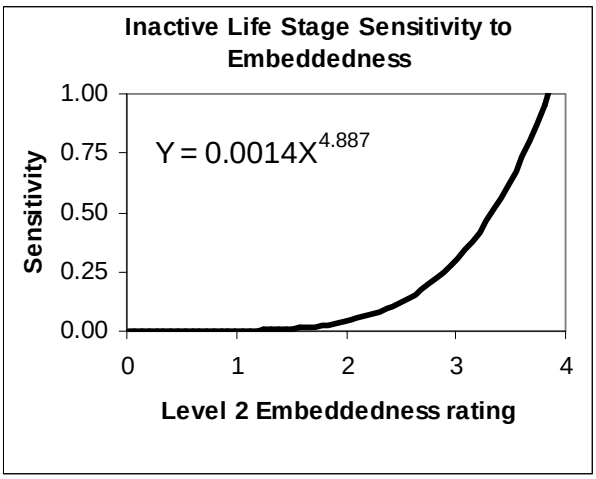

Figure 9. Relationship between ratings for Level 2 Embeddedness and sensitivity for juvenile chinook during the inactive (overwintering) life stage—assumed based on general conclusions in Chapman and McLeod (1987).

Additional mortality due to sedimentation could also occur if pulses of suspended sediment (SS) are sufficiently high. The tolerance of juvenile salmonids to SS during winter is known to be much higher than during periods of active rearing, likely due to a reduced state of activity. Still, some added effect associated with high SS doses is expected. We treat this potential effect as operating in a synergistic manner with embeddedness. If embeddedness is low, then the effect that might be ascribed to high SS doses should be much lower than if embeddedness is high, when fish should be more exposed to SS. We consider exposure here in the sense that fish would be more likely to have to enter the water column when embeddedness is high, instead of remaining in a resting state within the substrate at low embeddedness. Hence a higher state of activity should make them more vulnerable to SS.

Examples of results obtained by applying the rule described here are provided in Table 7.

Table 7. Example results obtained for the rule inactive (overwintering)-Level 3 Sediment Load for chinook salmon.

Life stage: Inactive (overwintering)						
Attribute		Example				
		A	B	C	D	E
Embeddedness (Primary)	Rating	2	2	3	3	3
	Sensitivity	0.041	0.041	0.299	0.299	0.299
Suspended sediment (Modifier)	Rating	0	2	0	2	3
	Sensitivity	0	0.008	0	0.008	0.128
Relative productivity		0.96	0.86	0.70	0.44	0
Benchmark survival		0.7	0.7	0.7	0.7	0.7
Absolute survival		0.67	0.61	0.49	0.31	0

2.1.2 Rules for Estimating Key Habitat

The rules for deriving the Level 3 survival factor for habitat quantity produce estimates of the percent of the wetted channel surface area comprised of what is called Key Habitat for the species of interest. Key Habitat is defined as the primary habitat type(s) utilized by a species during a particular life stage. Preference for habitat types changes with life stages. Some life stages, like egg incubation, occur almost entirely within three habitat types (i.e., pool-tailouts, glides and riffles), while other life stages, like actively migrating fish, use all habitat types. Level 2 correlates for habitat types are those in Table 1 beginning with "Habitat Type."

The use of habitat types by individual life stages is not necessarily "all or nothing", however. For example, resident rearing by 0-age juvenile chinook does not occur equally in those habitat types that are utilized, some types that show use appear to be more preferred than others, while other types show almost no use.

The rules were formulated by assigning weights to each habitat type to represent relative levels of preference based on patterns reported in literature and consultation with knowledgeable biologists.

Percent Key Habitat (*%KeyHab*) for any life stage was computed to be the sum of the weighted percentages of habitat types *i* within a geographic unit, as follows

$$\%KeyHab = \sum \%HabType_i * Weight_i$$

where $\%HabType_i$ is the percent of wetted channel surface area comprised of habitat type *i* and $Weight_i$ is the preference weight for habitat type *i* in the appropriate life stage.

The format for the presentation of rules for the Level 3 Key Habitat attribute is shown in Figure 10.

2.1.3 Level of Proof

Four levels of proof were assigned to the use of each correlate within each rule to define the basis of the relationship employed (Table 8).

Level 3 -- Key Habitat
Species: Chinook Life Stage:

Definition: The relative quantity (%) of the primary habitat type(s) utilized by the focus species during a life stage; quantity is expressed as percent of wetted surface area of the stream channel. Environmental quality attributes characterize the quality of this habitat for the focus species.

Rule: The quantity of Key Habitat in a stream reach is computed from reach channel length, channel width, and percent of Key Habitat within the reach. Percent Key Habitat is estimated from habitat type composition based on a weighted sum of seven Level 2 Environmental Attributes (see table below) that quantify stream habitat types.

Contributing Level 2 attributes:

Level 2 attribute	Abbrev.	Weight	Rationale	Level of Proof
Habitat type - backwater pools	HbBckPls	0.00	Eggs placed by spawners; weighting same as for Spawning. Chinook spawning does not occur in backwater pools.	1
Habitat type - beaver ponds	HbBvrPnds	0.00	Eggs placed by spawners; weighting same as for Spawning. Chinook spawning does not occur in beaver ponds.	1
Habitat type - large cobble/boulder riffles	HbLrgCbl	0.00	Eggs placed by spawners; weighting same as for Spawning. Substrate size typically too large for chinook spawning in large cobble/boulder riffles.	2
Habitat type - primary pools	HbPls	0.00	Eggs placed by spawners; weighting same as for Spawning. Chinook spawning does not typically occur in pools.	2
Habitat type - small cobble/gravel riffles	HbSmlCbl	0.60	Eggs placed by spawners; weighting same as for Spawning. Chinook spawn heavily on riffles with substrate sizes suitable for nest building.	1
Habitat type - glides	HbGlide	0.40	Chinook spawn in swifter areas of glides, similar to pool-tailouts in characteristics.	1
Habitat type - pool tailouts	HbPlTails	0.80	Chinook spawning densities are typically greatest on pool-tailouts.	1

Examples:	Example 1			Example 2			Example 3		
Level 2 attribute	Percent of reach	Weight	Weighted percent	Percent of reach	Weight	Weighted percent	Percent of reach	Weight	Weighted percent
Habitat type - backwater pools	10	0.00	0.0	5	0.00	0.0	0	0.00	0.0
Habitat type - beaver ponds	10	0.00	0.0	0	0.00	0.0	0	0.00	0.0
Habitat type - large cobble/boulder riffles	5	0.00	0.0	20	0.00	0.0	50	0.00	0.0
Habitat type - primary pools	40	0.00	0.0	32	0.00	0.0	20	0.00	0.0
Habitat type - small cobble/gravel riffles	15	0.60	9.0	35	0.60	21.0	25	0.60	15.0
Habitat type - glides	10	0.40	4.0	4	0.40	1.6	2.5	0.40	1.0
Habitat type - pool tailouts	10	0.80	8.0	4	0.80	3.2	2.5	0.80	2.0
Sum	100		21.0	100		25.8	100		18.0

Figure 10. Format for rule presentation for the Level 3 survival factor Key Habitat. An example rule for the incubation life stage is shown.

Table 8. Levels of proof assigned to the use of Level 2 correlates in rules.

Level of proof	Evidence
1	Thoroughly established, generally accepted, good peer-reviewed empirical evidence in its favor
2	Strong weight of evidence in support but not fully conclusive
3	Theoretical support with some evidence from experiments or observations
4	Speculative, little empirical support

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APPENDIX C

Reach Data for Clearwater River

Current vs. Historic Potential

EDT WATERSHED ASSESSMENT

Clearwater River
for
Coho

26-Jun-03

Index to Stream Reaches

Clearwater River - Coho

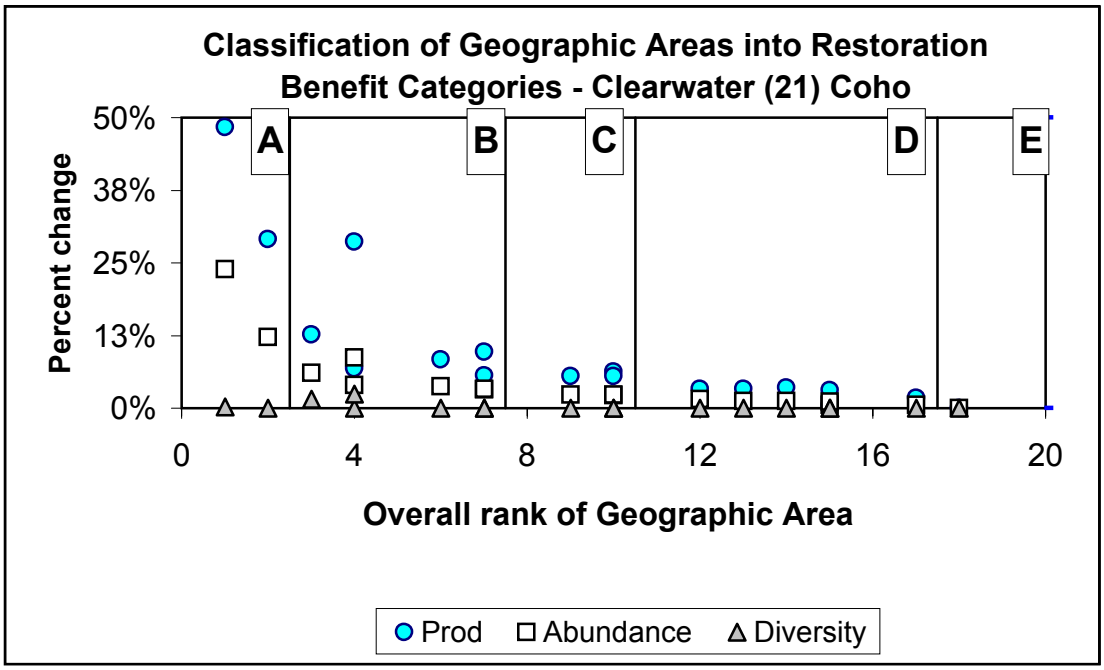
Reach code	No.	Stream	Geographic area	Reach location/description	Length (meters)
Queets-1	1	0	Queets River	Mouth of Queets River to Fisher Creek	8,728
Queets-2	2	0	Queets River	Fisher Ck mouth to Clearwater Riv	2,307
Queets-0	3	0	Queets River	Estuary Reach	2,896
Clearwater-01	4	0	Lower Clearwater mainstem	Mouth to Mule Pasture Pond	880
Clearwater-02A	5	0	Lower Clearwater mainstem	Mule Pasture Pond to outlet of Dasher Pond (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO	1,207
Clearwater-02B	6	0	Lower Clearwater mainstem	Dasher Pond to mouth of Hurst Ck.(NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)	1,359
Clearwater-03A	7	0	Lower Clearwater mainstem	Hurst Creek mouth to Tiermeyer Pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO	161
Clearwater-03B	8	0	Lower Clearwater mainstem	Tiemeyer Pond outlet to Morrison Pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO	917
Clearwater-04A	9	0	Lower Clearwater mainstem	Morrison Pond outlet to Dogleg pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO	1,143
Clearwater-04B	10	0	Lower Clearwater mainstem	Dogleg Pond outlet to Airport pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO	1,143
Clearwater-05	11	0	Lower Clearwater mainstem	Airport Pond outlet to Wildcat Ck mouth	1,791
Clearwater-06	12	0	Lower Clearwater mainstem	Wildcat Ck. Mouth to Hunt Ck. Mouth; includes Preacher Rapids	4,028
Clearwater-07	13	0	Lower Clearwater mainstem	Hunt Ck. Mouth to Cougar Ck. Mouth	1,750
Clearwater-08	14	0	Lower Clearwater mainstem	Cougar Ck. Mouth to Elkhorn Ck. Mouth	975
Clearwater-09A	15	0	Lower Clearwater mainstem	Elkhorn Ck. Mouth to Paradise Pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO	314
Clearwater-09B	16	0	Lower Clearwater mainstem	Paradise Pond outlet to Swamp Pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO	314
Clearwater-09C	17	0	Lower Clearwater mainstem	Swamp Pond outlet to Mink Ck. Mouth (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO	314

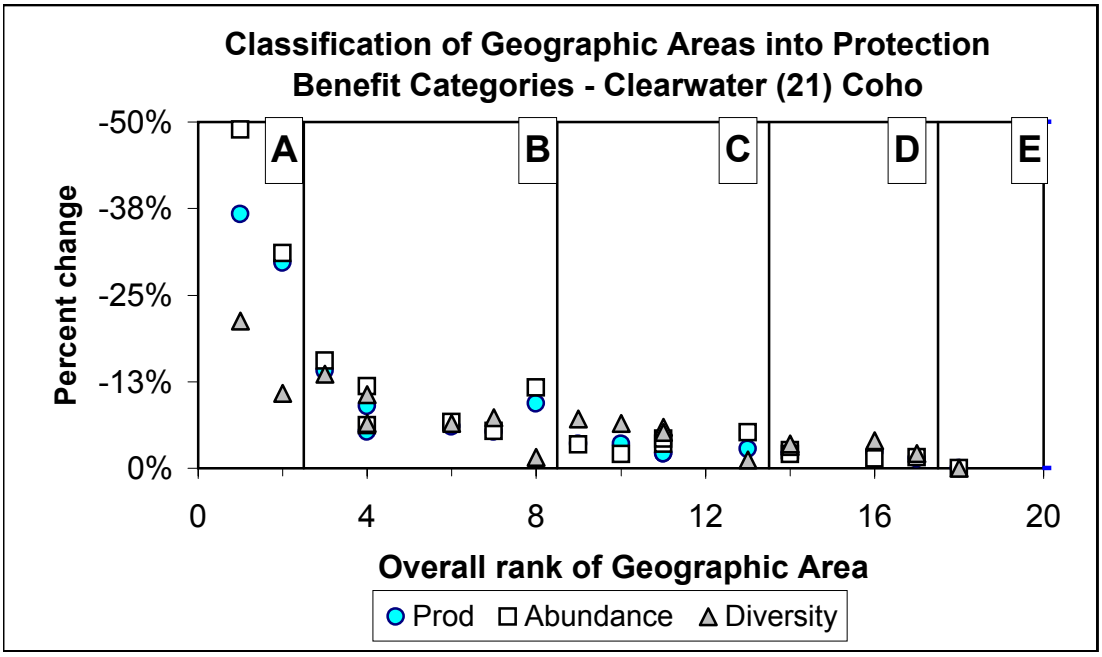
Reach code	No.	Stream	Geographic area	Reach location/description	Length (meters)
Clearwater-10	18	0	Lower Clearwater mainstem	Mink Ck. Mouth to Shale Ck. Mouth	1,554
Clearwater-11	19	0	Lower Clearwater mainstem	Shale Ck mouth to Miller Ck mouth	1,234
Clearwater-12A	20	0	Lower Clearwater mainstem	Miller Ck mouth to Pond 1 outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)	1,030
Clearwater-12B	21	0	Lower Clearwater mainstem	Pond 1 outlet to Pond 2 outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)	16
Clearwater-12C	22	0	Lower Clearwater mainstem	Pond 2 outlet to Christmas Ck (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)	1,575
Clearwater-13	23	0	Lower Clearwater mainstem	Christmas Ck mouth to Peterson Ck mouth	2,945
Clearwater-14A	24	0	Lower Clearwater mainstem	Peterson Ck mouth to Coppermine Bottom Pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH	2,544
Clearwater-14B	25	0	Lower Clearwater mainstem	Coppermine Bottom Pond outlet to Deception Ck mouth (NOTE: LESTELLE'S ESTIMATE ON REACH	1,281
Clearwater-15	26	0	Lower Clearwater mainstem	Deception Ck mouth to Snahapish Riv mouth	1,128
Clearwater-16	27	0	Mid Clearwater mainstem	Snahapish Riv mouth to Bull ck mouth	1,692
Clearwater-17	28	0	Mid Clearwater mainstem	Bull Ck mouth to Manor Ck mouth	1,874
Clearwater-18	29	0	Mid Clearwater mainstem	Manor Ck mouth to Stequaleho Ck mouth	4,236
Clearwater-19	30	0	Mid Clearwater mainstem	Stequaleho Ck mouth to Solleks Riv mouth	2,317
Clearwater-20A	31	0	Upper Clearwater mainstem	Solleks Riv mouth to Nancy Cr (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)	1,086
Clearwater-20B	32	0	Upper Clearwater mainstem	Nancy Cr mouth to Itswoot mouth (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)	4,164
Clearwater-21	33	0	Upper Clearwater mainstem	Itswoot Ck mouth to Kunamakst Ck mouth	701
Clearwater-22	34	0	Upper Clearwater mainstem	Kunamakst Ck mouth to Wilson Ck (#0120) mouth	3,413
Clearwater-23	35	0	Upper Clearwater mainstem	Wilson Ck mouth (#0120) to #0122 trib	1,112
Clearwater-24	36	0	Upper Clearwater mainstem	Trib #0122 mouth to Ding-a-ling Ck	789

Reach code	No.	Stream	Geographic area	Reach location/description	Length (meters)
Clearwater-25	37	0	Upper Clearwater mainstem	Ding-a-ling Ck mouth to Susie Ck mouth	1,463
Hurst-1	38	0	Hurst Creek	Hurst ck mouth to Boulder ck mouth	1,245
Hurst-2	39	0	Hurst Creek	Boulder ck mouth to unnamed RB Trib 0027	1,591
Hurst-3	40	0	Hurst Creek	Unnamed RB Trib mouth to Trib 0028	1,689
Hurst-4	41	0	Hurst Creek	Unnamed Trib0028 to coho limit (mouth of Trib0029)	1,245
Boulder-1	42	0	Hurst Creek	Boulder ck mouth to road crossing in middle of section 16	3,139
Hurst-unnamed RB trib # 0025.5	43	0	Hurst Creek	Hurst-2 end to fork at top of section 8	1,844
Wildcat-1	44	0	Misc Lower Clearwater Tribs	Mouth to unnamed trib 0030	1,052
Hunt-1	45	0	Misc Lower Clearwater Tribs	Hunt Ck mouth to Waring Ck mouth	152
Hunt-2	46	0	Misc Lower Clearwater Tribs	Waring ck mouth to coho limit (fork)	3,142
Waring-1	47	0	Misc Lower Clearwater Tribs	Waring ck mouth to road crossing	579
Cougar-1	48	0	Misc Lower Clearwater Tribs	Cougar Ck mouth to Cougar Creek 1/4 mile	536
Elkhorn-1	49	0	Misc Lower Clearwater Tribs	Elkhorn Ck mouth to road crossing @ mainline gravel pit	1,017
Mink-1	50	0	Misc Lower Clearwater Tribs	Mink Ck mouth to Trib0039 mouth	1,093
Mink unnamed LB trib # 0039	51	0	Misc Lower Clearwater Tribs	Trib0039 mouth to fish limit	1,579
Shale-1	52	0	Shale Creek	Shale Ck mouth to Iska Ck (0042)	1,127
Shale-2	53	0	Shale Creek	Iska Ck mouth to Unnamed RB Trib0045	3,748
Shale-3	54	0	Shale Creek	Unnamed RB Trib0045 mouth to unnamed LB Trib0047 mouth	2,499
Shale-4	55	0	Shale Creek	Unnamed LB Trib0047 mouth to coho limit	975

Reach code	No.	Stream	Geographic area	Reach location/description	Length (meters)
Iska-1	56	0	Misc Upper Clearwater Tribs	Iska Ck. mouth to coho limit	884
Shale-unnamed LB trib # 0047	57	0	Shale Creek	Unnamed Trib0047 mouth to coho limit	1,067
Miller-1	58	0	Miller Creek	Miller Ck mouth to East Fork Miller Confluence	701
Miller-2	59	0	Miller Creek	Miller East/West Fork confluence mouth to unnamed RB Trib # 0057	3,657
Miller-3	60	0	Miller Creek	Unnamed Miller RB trib0057 mouth to Trib0062 mouth	5,883
Miller-4	61	0	Miller Creek	Unnamed Trib # 0062 to coho limit;	4,199
MillerEFk-1	62	0	Miller Creek	East Fork Miller mouth to Gaf creek	5,050
Gaf-1	63	0	Miller Creek	Trib # 0053 mouth to coho limit, road crossing @ Sec 10, a.k.a. Gaf Ck	823
MillerEFk-2	64	0	Miller Creek	Gaf Ck mouth to coho limit	2,286
Christmas-01A	65	0	Christmas Creek	Christmas Ck mouth to Christmas Pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO	161
Christmas-01B	66	0	Christmas Creek	Christmas Pond outlet to mainline crossing (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO	761
Christmas-02	67	0	Christmas Creek	Mainline crossing to Trib0066 (Samuelson's Trib)	9,538
Christmas-03	68	0	Christmas Creek	Trib0066 (Samuelson's trib) to coho limit	1,889
Samuelsons Trib	69	0	Christmas Creek	Christmas Ck to coho limit	1,931
Peterson-1	70	0	Misc Lower Clearwater Tribs	Peterson Ck. mouth to coho limit; section line road crossing	1,691
Deception-1	71	0	Deception Creek	Deception Ck mouth to Prairie Creek	396
Deception-2	72	0	Deception Creek	Prairie Ck mouth to section 29/30 line; coho limit	1,737
Deception-4	73	0	Deception Creek	Trib # 0075 mouth to fish limit	1,219
Prairie-1	74	0	Deception Creek	Prairie Ck mouth to coho dist	402

Reach code	No.	Stream	Geographic area	Reach location/description	Length (meters)
Snahapish-1	75	0	Lower Snahapish River	Snahapish Riv mouth to mainline crossing	2,378
Snahapish-2	76	0	Upper Snahapish River	Mainline crossing to West Fork Snahapish	8,903
Snahapish-3	77	0	Upper Snahapish River	West Fk Snahapish to Octopus Creek mouth	9,139
Snahapish-4	78	0	Upper Snahapish River	Ocotpus Ck. to coho limit	2,574
W.F. Snahapish-1	79	0	Snahapish Tribs	West Fork Snahapish mouth to Trib0080; coho limit	2,397
W.F. Snahapish-2	80	0	Snahapish Tribs	Unnamed Trib0079 mouth to fish limit	1,874
Octopus-1	81	0	Snahapish Tribs	Octopus Ck mouth to coho limit	914
Bull-1	82	0	Bull Creek	Bull Ck mouth to mainline roadcrossing	901
Bull-2	83	0	Bull Creek	Mainline to coho limit	2,724
Stequaleho-1	84	0	Stequaleho Creek	Stequaleho Ck mouth to the Falls @ RM2	3,471
Solleks-1	85	0	Solleks River	Solleks River mouth to Kloochman Creek mouth	8,129
Solleks-2	86	0	Solleks River	Kloochman Ck mouth to coho limit (Grouse Ck mouth)	3,195
Grouse-1	87	0	Solleks River	Grouse Ck to Grouse Ck fish limit	728
Kloochman-1	88	0	Misc Upper Clearwater Tribs	Kloochman mouth to Kloochman coho limit	2,810
Itswoot-1	89	0	Misc Upper Clearwater Tribs	Itswoot Ck mouth to coho limit	483
Kunamaskt-1	90	0	Misc Upper Clearwater Tribs	Kunamaskt Ck mouth to mainline/Trib0118;	1,799
Susie-1	91	0	Misc Upper Clearwater Tribs	Susie Ck mouth to coho limit	581

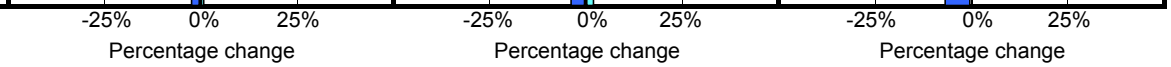

Classification of Geographic Areas into Restoration Benefit Categories - Clearwater (21) Coho
Percent change
50%
38%
25%
13%
0%
A
B
C
D
E
0
4
8
12
16
20
Overall rank of Geographic Area
Prod
Abundance
Diversity


Classification of Geographic Areas into Protection Benefit Categories - Clearwater (21) Coho
Percent change
-50%
-38%
-25%
-13%
0%
A
B
C
D
E
0
4
8
12
16
20
Overall rank of Geographic Area
Prod
Abundance
Diversity

Clearwater (21) Coho

Relative Importance Of Geographic Areas For Protection and Restoration Measures

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category/rank		Category/rank		Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
Queets River	B	8	D	15						
Lower Clearwater mainstem	A	1	A	1						
Mid Clearwater mainstem	B	4	B	3						
Upper Clearwater mainstem	C	9	C	10						
Off-channel Ponds	E	18	E	18						
Misc Lower Clearwater Tribs	B	4	C	10						
Hurst Creek	B	7	B	6						
Shale Creek	B	6	B	7						
Miller Creek	B	3	A	2						
Christmas Creek	C	11	B	7						
Deception Creek	D	16	D	14						
Lower Snahapish River	C	13	C	9						
Upper Snahapish River	A	2	B	4						
Snahapish Tribs	D	14	D	12						
Bull Creek	D	14	D	13						
Stequaleho Creek	D	17	D	15						
Solleks River	C	11	B	4						
Misc Upper Clearwater Tribs	C	10	D	17						



Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Queets River			**Stream:**	
Reach:	Mouth of Queets River to Fisher Creek			**Reach Length (mi):**	5.42
				Reach Code:	Queets-1
Restoration Benefit Category:1/	D	**Productivity Rank:1/**	17	**Potential % change in productivity:2/**	0.4%
Overall Restoration Potential Rank:1/	15	**Average Abundance (Neq) Rank:1/**	17	**Potential % change in Neq:2/**	0.5%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	4	**loss in productivity with degradation:2/**	-9.4%
Overall Preservation Rank:1/	8	**Average Abundance (Neq) Rank:1/**	5	**% loss in Neq with degradation:2/**	-11.7%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	16	**% loss in diversity with degradation:2/**	-1.6%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	0.3%	-1.4%	6																
0-age active rearing	Mar-Oct	0.3%	-5.0%	4																
0-age migrant	Oct-Nov	0.8%	-0.6%	5																
0-age inactive	Oct-Mar	0.8%	-4.7%	2					●		●									
1-age active rearing	Mar-May	0.8%	-2.7%	3																
1-age migrant	Mar-Jun	100.0%	0.0%								●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	100.0%	-0.1%	1								●								
Prespawning holding																				
All Stages Combined		100.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	●	○
Moderate	●	○
High	●	○
Extreme	●	○

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Queets River			**Stream:**	
Reach:	Fisher Ck mouth to Clearwater Riv			**Reach Length (mi):**	1.43
				Reach Code:	Queets-2
Restoration Benefit Category:1/	D	**Productivity Rank:1/**	17	**Potential % change in productivity:2/**	0.4%
Overall Restoration Potential Rank:1/	15	**Average Abundance (Neq) Rank:1/**	17	**Potential % change in Neq:2/**	0.5%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	4	**loss in productivity with degradation:2/**	-9.4%
Overall Preservation Rank:1/	8	**Average Abundance (Neq) Rank:1/**	5	**% loss in Neq with degradation:2/**	-11.7%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	16	**% loss in diversity with degradation:2/**	-1.6%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	0.7%	-1.0%	5																
0-age active rearing	Mar-Oct	0.3%	-4.0%	4																
0-age migrant	Oct-Nov	1.8%	0.0%																	
0-age inactive	Oct-Mar	1.3%	-3.7%	1	●				●	●	●									
1-age active rearing	Mar-May	1.3%	-1.7%	3																
1-age migrant	Mar-Jun	99.2%	0.0%																	
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	100.0%	0.0%	2								●								
Prespawning holding																				
All Stages Combined		100.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	●	○
Moderate	●	○
High	●	○
Extreme	●	○

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Queets River	**Stream:**	
Reach:	Estuary Reach	**Reach Length (mi):**	1.80
		Reach Code:	Queets-0

Restoration Benefit Category:1/	D	**Productivity Rank:1/**	17	**Potential % change in productivity:2/**	0.4%
Overall Restoration Potential Rank:1/	15	**Average Abundance (Neq) Rank:1/**	17	**Potential % change in Neq:2/**	0.5%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	4	**loss in productivity with degradation:2/**	-9.4%
Overall Preservation Rank:1/	8	**Average Abundance (Neq) Rank:1/**	5	**% loss in Neq with degradation:2/**	-11.7%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	16	**% loss in diversity with degradation:2/**	-1.6%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel landscape	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization																				
0-age active rearing																				
0-age migrant																				
0-age inactive																				
1-age active rearing																				
1-age migrant	Mar-Jun	100.0%	0.0%																	
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	100.0%	0.0%																	
Prespawning holding																				
All Stages Combined		100.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem			**Stream:**	
Reach:	Mouth to Mule Pasture Pond			**Reach Length (mi):**	0.55
				Reach Code:	Clearwater-01
Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-1.8%	7																
Egg incubation	Oct-May	1.0%	-40.6%	1	●												●			
Fry colonization	Mar-May	1.3%	-4.7%	2	•				•	•	•									
0-age active rearing	Mar-Oct	0.7%	-7.8%	4						•	•									
0-age migrant	Oct-Nov	2.0%	-0.3%	9																
0-age inactive	Oct-Mar	0.5%	-10.5%	3	•						•									
1-age active rearing	Mar-May	0.5%	-3.6%	6																
1-age migrant	Mar-Jun	97.8%	0.0%	5							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	100.0%	0.0%	10																
Prespawning holding	Oct-Dec	1.0%	-0.9%	8																
All Stages Combined		100.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem	**Stream:**	
Reach:	Mule Pasture Pond to outlet of Dasher Pond (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)	**Reach Length (mi):**	0.75
		Reach Code:	Clearwater-02A

Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	0.3%	-1.0%	6																
0-age active rearing																				
0-age migrant	Oct-Nov	2.5%	-0.1%	5																
0-age inactive	Oct-Mar	1.2%	-10.5%	1	●				●	●	●									
1-age active rearing	Mar-May	1.2%	-3.8%	2					●		●									
1-age migrant	Mar-Jun	97.3%	0.0%	3							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	99.0%	0.0%	4																
Prespawning holding																				
All Stages Combined		99.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem			**Stream:**	
Reach:	Dasher Pond to mouth of Hurst Ck.(NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)			**Reach Length (mi):**	0.84
				Reach Code:	Clearwater-02B
Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	1.0%	-0.9%	6																
0-age active rearing	Mar-Oct	0.7%	-7.5%	2							●									
0-age migrant	Oct-Nov	3.7%	-0.3%	5																
0-age inactive	Oct-Mar	1.2%	-9.9%	1	●				●	●	●									
1-age active rearing	Mar-May	1.2%	-3.9%	3					●		●									
1-age migrant	Mar-Jun	96.1%	0.0%	4							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	99.0%	0.0%	7																
Prespawning holding																				
All Stages Combined		99.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem			**Stream:**	
Reach:	Hurst Creek mouth to Tiermeyer Pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)			**Reach Length (mi):**	0.10
				Reach Code:	Clearwater-03A
Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	0.2%	-3.4%	####																
0-age active rearing																				
0-age migrant	Oct-Nov	1.8%	0.0%	6																
0-age inactive	Oct-Mar	0.2%	-11.7%	1							●									
1-age active rearing	Mar-May	0.2%	-2.5%	4																
1-age migrant	Mar-Jun	90.5%	0.0%	2																
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	92.0%	0.0%	5																
Prespawning holding																				
All Stages Combined		92.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem	**Stream:**	
Reach:	Tiemeyer Pond outlet to Morrison Pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)	**Reach Length (mi):**	0.57
		Reach Code:	Clearwater-03B

Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	0.3%	-0.4%	8																
0-age active rearing	Mar-Oct	0.3%	-8.1%	2							●									
0-age migrant	Oct-Nov	2.0%	-0.1%	6																
0-age inactive	Oct-Mar	0.2%	-9.5%	3																
1-age active rearing	Mar-May	0.2%	-4.4%	4																
1-age migrant	Mar-Jun	90.3%	0.0%	1							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	92.0%	0.0%	5																
Prespawning holding																				
All Stages Combined		92.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem			**Stream:**	
Reach:	Morrison Pond outlet to Dogleg pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)			**Reach Length (mi):**	0.71
				Reach Code:	Clearwater-04A
Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	0.2%	-0.6%	6																
0-age active rearing																				
0-age migrant	Oct-Nov	2.5%	-0.2%	5																
0-age inactive	Oct-Mar	0.8%	-9.3%	1	●				●		●									
1-age active rearing	Mar-May	0.8%	-5.8%	2					●		●									
1-age migrant	Mar-Jun	90.1%	0.0%	3							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	92.0%	0.0%	4																
Prespawning holding																				
All Stages Combined		92.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem			**Stream:**	
Reach:	Dogleg Pond outlet to Airport pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)			**Reach Length (mi):**	0.71
				Reach Code:	Clearwater-04B
Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	0.5%	-0.6%	6																
0-age active rearing	Mar-Oct	0.3%	-16.2%	2														●		
0-age migrant	Oct-Nov	3.5%	-0.1%	5																
0-age inactive	Oct-Mar	1.0%	-8.3%	1	●				●	●	●									
1-age active rearing	Mar-May	1.0%	-3.7%	3					●		●									
1-age migrant	Mar-Jun	89.3%	0.0%								●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	92.0%	0.0%	4																
Prespawning holding																				
All Stages Combined		92.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem			**Stream:**	
Reach:	Airport Pond outlet to Wildcat Ck mouth			**Reach Length (mi):**	1.11
				Reach Code:	Clearwater-05
Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-2.0%	8																
Egg incubation	Oct-May	1.0%	-50.9%	1	●												●			
Fry colonization	Mar-May	1.8%	-5.5%	5	•				•	•	•									
0-age active rearing	Mar-Oct	1.3%	-23.3%	3	•		•			•	●				•	•		●		
0-age migrant	Oct-Nov	5.4%	-0.9%	7							•						•			
0-age inactive	Oct-Mar	2.2%	-18.6%	2	●				•	•	●									
1-age active rearing	Mar-May	2.2%	-6.8%	4	•		•		•	•	•									
1-age migrant	Mar-Jun	88.3%	-0.1%	6							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	92.0%	0.0%	9																
Prespawning holding	Oct-Dec	1.0%	-0.9%	10																
All Stages Combined		92.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem			**Stream:**	
Reach:	Wildcat Ck. Mouth to Hunt Ck. Mouth; includes Preacher Rapids			**Reach Length (mi):**	2.50
				Reach Code:	Clearwater-06
Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	2.0%	-1.8%	8							•						•			
Egg incubation	Oct-May	2.0%	-57.6%	1	●												●			
Fry colonization	Mar-May	4.7%	-6.4%	5	•				•	•	●									
0-age active rearing	Mar-Oct	3.7%	-19.9%	3	•		•			•	●				•	•		●		
0-age migrant	Oct-Nov	9.0%	-1.2%	7							•						•			
0-age inactive	Oct-Mar	5.2%	-15.4%	2	●				●	•	●									
1-age active rearing	Mar-May	5.2%	-6.2%	4	•		•		•	•	●									
1-age migrant	Mar-Jun	85.3%	-0.1%	6							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	89.9%	0.0%	9													•			
Prespawning holding	Oct-Dec	2.0%	-1.1%	10													•			
All Stages Combined		89.9%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem			**Stream:**	
Reach:	Hunt Ck. Mouth to Cougar Ck. Mouth			**Reach Length (mi):**	1.09
				Reach Code:	Clearwater-07
Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-2.3%	8							•						•			
Egg incubation	Oct-May	1.0%	-54.9%	1	●												●			
Fry colonization	Mar-May	2.3%	-5.9%	4	•				•	•	•									
0-age active rearing	Mar-Oct	1.8%	-10.5%	3	•		•			•	●				•	•				
0-age migrant	Oct-Nov	6.2%	-0.8%	7							•						•			
0-age inactive	Oct-Mar	2.0%	-14.7%	2	•				•	•	●									
1-age active rearing	Mar-May	2.0%	-6.7%	5	•				•	•	•									
1-age migrant	Mar-Jun	79.2%	-0.1%	6							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	83.9%	0.0%	9																
Prespawning holding	Oct-Dec	1.0%	-0.9%	10																
All Stages Combined		83.9%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem			**Stream:**	
Reach:	Cougar Ck. Mouth to Elkhorn Ck. Mouth			**Reach Length (mi):**	0.61
				Reach Code:	Clearwater-08
Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-2.2%	8							•						•			
Egg incubation	Oct-May	1.0%	-56.7%	1	●												●			
Fry colonization	Mar-May	2.2%	-4.3%	5	•				•	•	•									
0-age active rearing	Mar-Oct	1.2%	-10.1%	4			•			•	•				•	•				
0-age migrant	Oct-Nov	6.2%	-0.4%	7							•						•			
0-age inactive	Oct-Mar	2.2%	-15.5%	2	•				•	•	●									
1-age active rearing	Mar-May	2.2%	-6.9%	3	•		•		•	•	•									
1-age migrant	Mar-Jun	77.1%	0.0%	6							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	81.9%	0.0%	11																
Prespawning holding	Oct-Dec	1.0%	-0.9%	9																
All Stages Combined		81.9%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem			**Stream:**	
Reach:	Elkhorn Ck. Mouth to Paradise Pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)			**Reach Length (mi):**	0.19
				Reach Code:	Clearwater-09A
Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	1.0%	-0.6%	6																
0-age active rearing	Mar-Oct	0.2%	-10.3%	3							●									
0-age migrant	Oct-Nov	5.5%	-0.2%	5																
0-age inactive	Oct-Mar	0.5%	-16.4%	1	●				●		●									
1-age active rearing	Mar-May	0.5%	-7.2%	2					●		●									
1-age migrant	Mar-Jun	74.4%	0.0%	4							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	79.9%	0.0%	8																
Prespawning holding																				
All Stages Combined		79.9%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem			**Stream:**	
Reach:	Paradise Pond outlet to Swamp Pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)			**Reach Length (mi):**	0.19
				Reach Code:	Clearwater-09B
Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	1.5%	-0.8%	4																
0-age active rearing	Mar-Oct	0.5%	-10.6%	2							●									
0-age migrant	Oct-Nov	5.5%	-0.1%	6																
0-age inactive	Oct-Mar	0.5%	-16.0%	1	●				●		●									
1-age active rearing	Mar-May	0.5%	-7.3%	3					●		●									
1-age migrant	Mar-Jun	73.9%	0.0%	5							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	79.9%	0.0%	7																
Prespawning holding																				
All Stages Combined		79.9%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem	**Stream:**	
Reach:	Swamp Pond outlet to Mink Ck. Mouth (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)	**Reach Length (mi):**	0.19
		Reach Code:	Clearwater-09C

Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	1.5%	-0.8%	1																
0-age active rearing																				
0-age migrant	Oct-Nov	5.0%	-0.1%	3																
0-age inactive																				
1-age active rearing																				
1-age migrant	Mar-Jun	73.4%	0.0%	2							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	79.9%	0.0%	4																
Prespawning holding																				
All Stages Combined		79.9%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem			**Stream:**	
Reach:	Mink Ck. Mouth to Shale Ck. Mouth			**Reach Length (mi):**	0.97
				Reach Code:	Clearwater-10
Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-2.1%	8							•						•			
Egg incubation	Oct-May	1.0%	-54.5%	1	●												●			
Fry colonization	Mar-May	3.2%	-4.1%	4	•				•	•	•									
0-age active rearing	Mar-Oct	2.2%	-9.9%	3	•		•		•	•	●				•	•				
0-age migrant	Oct-Nov	6.7%	-0.6%	7							•						•			
0-age inactive	Oct-Mar	1.8%	-12.1%	2	•				•	•	●									
1-age active rearing	Mar-May	1.8%	-4.9%	5	•				•	•	•									
1-age migrant	Mar-Jun	72.5%	-0.1%	6							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	77.9%	0.0%	9																
Prespawning holding	Oct-Dec	1.0%	-0.9%	10																
All Stages Combined		77.9%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem			**Stream:**	
Reach:	Shale Ck mouth to Miller Ck mouth			**Reach Length (mi):**	0.77
				Reach Code:	Clearwater-11
Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-1.7%	8							•									
Egg incubation	Oct-May	1.0%	-55.1%	1	●												●			
Fry colonization	Mar-May	2.8%	-4.2%	4	•				•	•	•									
0-age active rearing	Mar-Oct	1.5%	-13.9%	2	•		•		•	•	●				•	•		•		
0-age migrant	Oct-Nov	4.5%	-0.6%	7							•						•			
0-age inactive	Oct-Mar	1.5%	-11.5%	3	•				•	•	●									
1-age active rearing	Mar-May	1.5%	-4.6%	5	•				•	•	•									
1-age migrant	Mar-Jun	65.8%	-0.1%	6							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	69.8%	0.0%	10																
Prespawning holding	Oct-Dec	1.0%	-1.0%	9													•			
All Stages Combined		69.8%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	●	○
Extreme	●	○

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem			**Stream:**	
Reach:	Miller Ck mouth to Pond 1 outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)			**Reach Length (mi):**	0.64
				Reach Code:	Clearwater-12A
Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	0.7%	-0.9%	6																
0-age active rearing	Mar-Oct	0.2%	-12.6%	3							●							●		
0-age migrant	Oct-Nov	2.5%	-0.3%	5																
0-age inactive	Oct-Mar	0.5%	-8.9%	1	●				●		●									
1-age active rearing	Mar-May	0.5%	-5.5%	2					●		●									
1-age migrant	Mar-Jun	53.4%	0.0%	4							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	55.8%	0.0%	7																
Prespawning holding																				
All Stages Combined		55.8%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem	**Stream:**	
Reach:	Pond 1 outlet to Pond 2 outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)	**Reach Length (mi):**	0.01
		Reach Code:	Clearwater-12B

Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	0.7%	-0.1%	3																
0-age active rearing																				
0-age migrant	Oct-Nov	2.2%	0.0%	4																
0-age inactive																				
1-age active rearing																				
1-age migrant	Mar-Jun	52.9%	0.0%	1																
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	55.8%	0.0%	2																
Prespawning holding																				
All Stages Combined		55.8%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem	**Stream:**	
Reach:	Pond 2 outlet to Christmas Ck (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)	**Reach Length (mi):**	0.98
		Reach Code:	Clearwater-12C

Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	1.5%	-1.1%	6																
0-age active rearing	Mar-Oct	0.8%	-11.7%	2			●		●	●	●				●	●		●		
0-age migrant	Oct-Nov	3.4%	-0.7%	5							●						●			
0-age inactive	Oct-Mar	1.2%	-9.6%	1	●				●	●	●									
1-age active rearing	Mar-May	1.2%	-4.9%	3	●				●	●	●									
1-age migrant	Mar-Jun	52.9%	-0.1%	4							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	55.8%	0.0%	7																
Prespawning holding																				
All Stages Combined		55.8%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem			**Stream:**	
Reach:	Christmas Ck mouth to Peterson Ck mouth			**Reach Length (mi):**	1.83
				Reach Code:	Clearwater-13
Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.8%	-2.1%	7							•						•			
Egg incubation	Oct-May	1.8%	-53.1%	1	●												●			
Fry colonization	Mar-May	2.8%	-4.0%	4	•				•	•	•									
0-age active rearing	Mar-Oct	1.5%	-11.7%	2			•		•	•	•				•	•		●		
0-age migrant	Oct-Nov	2.8%	-1.0%	8							•						•			
0-age inactive	Oct-Mar	1.3%	-9.3%	3	•				•	•	●									
1-age active rearing	Mar-May	1.3%	-4.1%	5	•				•	•	•									
1-age migrant	Mar-Jun	47.2%	-0.1%	6							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	50.1%	0.0%	10													•			
Prespawning holding	Oct-Dec	1.8%	-0.9%	9													•			
All Stages Combined		50.1%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	●	○
Extreme	●	○

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem	**Stream:**	
Reach:	Peterson Ck mouth to Coppermine Bottom Pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)	**Reach Length (mi):**	1.58
		Reach Code:	Clearwater-14A

Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	1.5%	-1.6%	5	●				●		●									
0-age active rearing	Mar-Oct	0.8%	-12.1%	2			●		●	●	●				●	●		●		
0-age migrant	Oct-Nov	2.5%	-0.8%	6							●						●			
0-age inactive	Oct-Mar	1.3%	-9.6%	1	●				●	●	⬤									
1-age active rearing	Mar-May	1.3%	-4.7%	3	●				●	●	●									
1-age migrant	Mar-Jun	45.4%	-0.1%	4							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	47.2%	0.0%	7													●			
Prespawning holding																				
All Stages Combined		47.2%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	●	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem	**Stream:**	
Reach:	Coppermine Bottom Pond outlet to Deception Ck mouth (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)	**Reach Length (mi):**	0.80
		Reach Code:	Clearwater-14B

Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	2.3%	-1.8%	4	●				●	●	●									
0-age active rearing	Mar-Oct	0.8%	-12.1%	2			●		●	●	●				●	●		●		
0-age migrant	Oct-Nov	2.8%	-0.6%	6							●						●			
0-age inactive	Oct-Mar	1.2%	-9.5%	1	●				●	●	●									
1-age active rearing	Mar-May	1.2%	-4.4%	3	●				●	●	●									
1-age migrant	Mar-Jun	44.1%	-0.1%	5							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	47.2%	0.0%	7																
Prespawning holding																				
All Stages Combined		47.2%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	●	○
Moderate	●	○
High	●	○
Extreme	●	○

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Clearwater mainstem			**Stream:**	
Reach:	Deception Ck mouth to Snahapish Riv mouth			**Reach Length (mi):**	0.70
				Reach Code:	Clearwater-15
Restoration Benefit Category:1/	A	**Productivity Rank:1/**	1	**Potential % change in productivity:2/**	48.3%
Overall Restoration Potential Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**Potential % change in Neq:2/**	23.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**Potential % change in diversity:2/**	0.2%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	1	**loss in productivity with degradation:2/**	-36.6%
Overall Preservation Rank:1/	1	**Average Abundance (Neq) Rank:1/**	1	**% loss in Neq with degradation:2/**	-48.9%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**% loss in diversity with degradation:2/**	-21.2%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-1.9%	8							•						•			
Egg incubation	Oct-May	1.0%	-51.9%	1	●												●			
Fry colonization	Mar-May	1.8%	-3.9%	4	•				•	•	•						•			
0-age active rearing	Mar-Oct	1.2%	-11.9%	3			•		•	•	•				•	•		●		
0-age migrant	Oct-Nov	3.7%	-0.8%	6							•						•			
0-age inactive	Oct-Mar	1.8%	-9.1%	2	●				•	•	●									
1-age active rearing	Mar-May	1.8%	-3.8%	5	•		•		•	•	•									
1-age migrant	Mar-Jun	40.7%	-0.1%	7							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	43.2%	0.0%	10																
Prespawning holding	Oct-Dec	1.0%	-0.9%	9													•			
All Stages Combined		43.2%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	●	○
Extreme	●	○

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Mid Clearwater mainstem			**Stream:**	
Reach:	Snahapish Riv mouth to Bull ck mouth			**Reach Length (mi):**	1.05
				Reach Code:	Clearwater-16
Restoration Benefit Category:1/	B	**Productivity Rank:1/**	4	**Potential % change in productivity:2/**	12.7%
Overall Restoration Potential Rank:1/	3	**Average Abundance (Neq) Rank:1/**	4	**Potential % change in Neq:2/**	6.1%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	4	**Potential % change in diversity:2/**	1.6%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	7	**loss in productivity with degradation:2/**	-5.3%
Overall Preservation Rank:1/	4	**Average Abundance (Neq) Rank:1/**	4	**% loss in Neq with degradation:2/**	-11.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	7	**% loss in diversity with degradation:2/**	-6.4%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-1.5%	8							•						•			
Egg incubation	Oct-May	1.0%	-73.0%	1	●												●			
Fry colonization	Mar-May	2.0%	-3.7%	5	•				•	•	•									
0-age active rearing	Mar-Oct	1.3%	-11.9%	3	•		•		•	•	●				•	•		●		
0-age migrant	Oct-Nov	3.9%	-0.9%	6							•						•			
0-age inactive	Oct-Mar	2.0%	-9.4%	2	●				●	•	●									
1-age active rearing	Mar-May	2.0%	-3.9%	4	•		•		•	•	•									
1-age migrant	Mar-Jun	25.8%	-0.1%	7							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	28.1%	0.0%	10																
Prespawning holding	Oct-Dec	1.0%	-1.3%	9													•			
All Stages Combined		28.1%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	●	○
Extreme	●	○

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Mid Clearwater mainstem			**Stream:**	
Reach:	Bull Ck mouth to Manor Ck mouth			**Reach Length (mi):**	1.16
				Reach Code:	Clearwater-17
Restoration Benefit Category:1/	B	**Productivity Rank:1/**	4	**Potential % change in productivity:2/**	12.7%
Overall Restoration Potential Rank:1/	3	**Average Abundance (Neq) Rank:1/**	4	**Potential % change in Neq:2/**	6.1%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	4	**Potential % change in diversity:2/**	1.6%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	7	**loss in productivity with degradation:2/**	-5.3%
Overall Preservation Rank:1/	4	**Average Abundance (Neq) Rank:1/**	4	**% loss in Neq with degradation:2/**	-11.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	7	**% loss in diversity with degradation:2/**	-6.4%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-1.9%	7							•						•			
Egg incubation	Oct-May	1.0%	-73.0%	1	●												●			
Fry colonization	Mar-May	1.7%	-4.0%	6	•				•	•	•									
0-age active rearing	Mar-Oct	1.2%	-11.9%	3	•		•		•	•	●				•	•		●		
0-age migrant	Oct-Nov	4.0%	-0.4%	8							•						•			
0-age inactive	Oct-Mar	2.0%	-8.4%	2	●				●	•	●									
1-age active rearing	Mar-May	2.0%	-3.9%	4	•		•		•	•	•									
1-age migrant	Mar-Jun	22.3%	-0.1%	6							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	24.1%	0.0%	12																
Prespawning holding	Oct-Dec	1.0%	-0.9%	9													•			
All Stages Combined		24.1%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	●	○
Extreme	●	○

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Mid Clearwater mainstem			**Stream:**	
Reach:	Manor Ck mouth to Stequaleho Ck mouth			**Reach Length (mi):**	2.63
				Reach Code:	Clearwater-18
Restoration Benefit Category:1/	B	**Productivity Rank:1/**	4	**Potential % change in productivity:2/**	12.7%
Overall Restoration Potential Rank:1/	3	**Average Abundance (Neq) Rank:1/**	4	**Potential % change in Neq:2/**	6.1%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	4	**Potential % change in diversity:2/**	1.6%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	7	**loss in productivity with degradation:2/**	-5.3%
Overall Preservation Rank:1/	4	**Average Abundance (Neq) Rank:1/**	4	**% loss in Neq with degradation:2/**	-11.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	7	**% loss in diversity with degradation:2/**	-6.4%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	2.0%	-2.0%	8							•						•			
Egg incubation	Oct-May	2.0%	-82.4%	1	●												●			
Fry colonization	Mar-May	3.4%	-4.5%	5	●				●	●	●						•			
0-age active rearing	Mar-Oct	2.8%	-12.3%	3	•		•		●	●	●				•	●		●		
0-age migrant	Oct-Nov	6.4%	-0.7%	7							●						●			
0-age inactive	Oct-Mar	4.0%	-9.5%	2	●				●	●	●									
1-age active rearing	Mar-May	4.0%	-4.3%	4	●		•		●	•	●									
1-age migrant	Mar-Jun	20.3%	-0.2%	6							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	23.1%	0.0%	10													•			
Prespawning holding	Oct-Dec	2.0%	-0.9%	9													•			
All Stages Combined		23.1%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	●	○
Extreme	●	○

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Mid Clearwater mainstem			**Stream:**	
Reach:	Stequaleho Ck mouth to Solleks Riv mouth			**Reach Length (mi):**	1.44
				Reach Code:	Clearwater-19
Restoration Benefit Category:1/	B	**Productivity Rank:1/**	4	**Potential % change in productivity:2/**	12.7%
Overall Restoration Potential Rank:1/	3	**Average Abundance (Neq) Rank:1/**	4	**Potential % change in Neq:2/**	6.1%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	4	**Potential % change in diversity:2/**	1.6%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	7	**loss in productivity with degradation:2/**	-5.3%
Overall Preservation Rank:1/	4	**Average Abundance (Neq) Rank:1/**	4	**% loss in Neq with degradation:2/**	-11.8%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	7	**% loss in diversity with degradation:2/**	-6.4%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-1.1%	6							●						●			
Egg incubation	Oct-May	1.0%	-93.2%	1	⬤												⬤			
Fry colonization	Mar-May	1.0%	-7.0%	4	⬤				⬤	⬤	⬤						●			
0-age active rearing	Mar-Oct	1.0%	-15.3%	2	●		●		⬤	⬤	⬤				●	●		⬤		
0-age migrant	Oct-Nov	1.2%	-1.0%	7							●									
0-age inactive	Oct-Mar	1.0%	-13.0%	3	⬤				⬤	⬤	⬤									
1-age active rearing	Mar-May	1.0%	-5.0%	5	●		●		⬤	●	⬤									
1-age migrant	Mar-Jun	1.0%	-0.2%	9							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%	11																
Prespawning holding	Oct-Dec	1.0%	-0.3%	8					●								●			
All Stages Combined		1.2%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	●	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Upper Clearwater mainstem	**Stream:**	
Reach:	Solleks Riv mouth to Nancy Cr (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)	**Reach Length (mi):**	0.68
		Reach Code:	Clearwater-20A

Restoration Benefit Category:1/	C	**Productivity Rank:1/**	8	**Potential % change in productivity:2/**	6.2%
Overall Restoration Potential Rank:1/	10	**Average Abundance (Neq) Rank:1/**	11	**Potential % change in Neq:2/**	2.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	9	**loss in productivity with degradation:2/**	-3.5%
Overall Preservation Rank:1/	9	**Average Abundance (Neq) Rank:1/**	12	**% loss in Neq with degradation:2/**	-3.4%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**% loss in diversity with degradation:2/**	-7.1%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	0.8%	-1.3%	4	•				•	•	•									
0-age active rearing	Mar-Oct	0.2%	-17.7%	1	•		•		•	•	●				•	•		•		
0-age migrant	Oct-Nov	1.3%	-0.2%	6							•									
0-age inactive	Oct-Mar	0.2%	-15.6%	2	•				•	•	●									
1-age active rearing	Mar-May	0.2%	-6.8%	3	•				•	•	•									
1-age migrant	Mar-Jun	7.2%	-0.1%	5							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	9.0%	0.0%	7																
Prespawning holding																				
All Stages Combined		9.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Upper Clearwater mainstem			**Stream:**	
Reach:	Nancy Cr mouth to Itswoot mouth (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)			**Reach Length (mi):**	2.59
				Reach Code:	Clearwater-20B
Restoration Benefit Category:1/	C	**Productivity Rank:1/**	8	**Potential % change in productivity:2/**	6.2%
Overall Restoration Potential Rank:1/	10	**Average Abundance (Neq) Rank:1/**	11	**Potential % change in Neq:2/**	2.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	9	**loss in productivity with degradation:2/**	-3.5%
Overall Preservation Rank:1/	9	**Average Abundance (Neq) Rank:1/**	12	**% loss in Neq with degradation:2/**	-3.4%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**% loss in diversity with degradation:2/**	-7.1%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	1.8%	-5.3%	4	●				●	●	●						•			
0-age active rearing	Mar-Oct	1.0%	-17.1%	2	•		●		●	●	●				•	•		●		
0-age migrant	Oct-Nov	3.2%	-0.6%	5							●									
0-age inactive	Oct-Mar	2.0%	-16.4%	1	●				●	●	⬤									
1-age active rearing	Mar-May	2.0%	-6.3%	3	●		•		●	●	●									
1-age migrant	Mar-Jun	7.0%	-0.2%	6							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	9.0%	0.0%	7																
Prespawning holding																				
All Stages Combined		9.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Upper Clearwater mainstem			**Stream:**	
Reach:	Itswoot Ck mouth to Kunamakst Ck mouth			**Reach Length (mi):**	0.44
				Reach Code:	Clearwater-21
Restoration Benefit Category:1/	C	**Productivity Rank:1/**	8	**Potential % change in productivity:2/**	6.2%
Overall Restoration Potential Rank:1/	10	**Average Abundance (Neq) Rank:1/**	11	**Potential % change in Neq:2/**	2.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	9	**loss in productivity with degradation:2/**	-3.5%
Overall Preservation Rank:1/	9	**Average Abundance (Neq) Rank:1/**	12	**% loss in Neq with degradation:2/**	-3.4%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**% loss in diversity with degradation:2/**	-7.1%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-1.0%	6							•						•			
Egg incubation	Oct-May	1.0%	-48.4%	1	●												●			
Fry colonization	Mar-May	2.2%	-2.1%	3	●				●	●	●									
0-age active rearing	Mar-Oct	0.7%	-14.6%	2	•		•		●	●	●				•	•		●		
0-age migrant	Oct-Nov	2.0%	-0.3%	7							•									
0-age inactive	Oct-Mar	0.3%	-12.4%	4	●				•	•	●									
1-age active rearing	Mar-May	0.3%	-5.5%	5	•		•		•	•	•									
1-age migrant	Mar-Jun	4.9%	0.0%	8							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	8.0%	0.0%	10																
Prespawning holding	Oct-Dec	1.0%	-0.2%	9													•			
All Stages Combined		8.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	●	○
Extreme	●	○

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Upper Clearwater mainstem			**Stream:**	
Reach:	Kunamakst Ck mouth to Wilson Ck (#0120) mouth			**Reach Length (mi):**	2.12
				Reach Code:	Clearwater-22
Restoration Benefit Category:1/	C	**Productivity Rank:1/**	8	**Potential % change in productivity:2/**	6.2%
Overall Restoration Potential Rank:1/	10	**Average Abundance (Neq) Rank:1/**	11	**Potential % change in Neq:2/**	2.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	9	**loss in productivity with degradation:2/**	-3.5%
Overall Preservation Rank:1/	9	**Average Abundance (Neq) Rank:1/**	12	**% loss in Neq with degradation:2/**	-3.4%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**% loss in diversity with degradation:2/**	-7.1%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	2.0%	-1.1%	7							●						●			
Egg incubation	Oct-May	2.0%	-46.7%	1	⬤												⬤			
Fry colonization	Mar-May	3.0%	-4.4%	4	●				●	●	●									
0-age active rearing	Mar-Oct	1.8%	-14.6%	2	●		●		⬤	●	⬤				●	●		●		
0-age migrant	Oct-Nov	2.8%	-0.8%	6							●									
0-age inactive	Oct-Mar	2.2%	-11.9%	3	⬤				●	●	⬤									
1-age active rearing	Mar-May	2.2%	-5.1%	5	●		●		●	●	●									
1-age migrant	Mar-Jun	4.2%	-0.2%	8							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	6.0%	0.0%	10																
Prespawning holding	Oct-Dec	2.0%	-0.1%	9					•								•			
All Stages Combined		6.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Upper Clearwater mainstem			**Stream:**	
Reach:	Wilson Ck mouth (#0120) to #0122 trib			**Reach Length (mi):**	0.69
				Reach Code:	Clearwater-23
Restoration Benefit Category:1/	C	**Productivity Rank:1/**	8	**Potential % change in productivity:2/**	6.2%
Overall Restoration Potential Rank:1/	10	**Average Abundance (Neq) Rank:1/**	11	**Potential % change in Neq:2/**	2.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	9	**loss in productivity with degradation:2/**	-3.5%
Overall Preservation Rank:1/	9	**Average Abundance (Neq) Rank:1/**	12	**% loss in Neq with degradation:2/**	-3.4%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**% loss in diversity with degradation:2/**	-7.1%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-0.8%	7							●						•			
Egg incubation	Oct-May	1.0%	-51.0%	1	⬤												⬤			
Fry colonization	Mar-May	2.2%	-4.4%	4	●				●	●	●									
0-age active rearing	Mar-Oct	1.2%	-14.4%	2	•		●		⬤	●	⬤				●	●		●		
0-age migrant	Oct-Nov	2.0%	-0.6%	6							●									
0-age inactive	Oct-Mar	1.0%	-12.5%	3	●				●	●	⬤									
1-age active rearing	Mar-May	1.0%	-5.4%	5	●		●		●	●	●									
1-age migrant	Mar-Jun	2.0%	-0.1%	9							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	4.0%	0.0%	10																
Prespawning holding	Oct-Dec	1.0%	-0.2%	8					•								•			
All Stages Combined		4.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Upper Clearwater mainstem			**Stream:**	
Reach:	Trib #0122 mouth to Ding-a-ling Ck			**Reach Length (mi):**	0.49
				Reach Code:	Clearwater-24
Restoration Benefit Category:1/	C	**Productivity Rank:1/**	8	**Potential % change in productivity:2/**	6.2%
Overall Restoration Potential Rank:1/	10	**Average Abundance (Neq) Rank:1/**	11	**Potential % change in Neq:2/**	2.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	9	**loss in productivity with degradation:2/**	-3.5%
Overall Preservation Rank:1/	9	**Average Abundance (Neq) Rank:1/**	12	**% loss in Neq with degradation:2/**	-3.4%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**% loss in diversity with degradation:2/**	-7.1%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-0.9%	6							●						●			
Egg incubation	Oct-May	1.0%	-48.8%	1	⬤												⬤			
Fry colonization	Mar-May	2.3%	-2.5%	4	●				●	●	●									
0-age active rearing	Mar-Oct	1.2%	-14.6%	2	●		●		⬤	●	⬤				●	●		●		
0-age migrant	Oct-Nov	1.5%	-0.3%	7							●									
0-age inactive	Oct-Mar	0.7%	-12.6%	3	●				●	●	⬤									
1-age active rearing	Mar-May	0.7%	-5.5%	5	●		•		●	●	●									
1-age migrant	Mar-Jun	1.0%	-0.1%	9							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	3.0%	0.0%	10																
Prespawning holding	Oct-Dec	1.0%	-0.2%	8					•								•			
All Stages Combined		3.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Upper Clearwater mainstem			**Stream:**	
Reach:	Ding-a-ling Ck mouth to Susie Ck mouth			**Reach Length (mi):**	0.91
				Reach Code:	Clearwater-25
Restoration Benefit Category:1/	C	**Productivity Rank:1/**	8	**Potential % change in productivity:2/**	6.2%
Overall Restoration Potential Rank:1/	10	**Average Abundance (Neq) Rank:1/**	11	**Potential % change in Neq:2/**	2.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	9	**loss in productivity with degradation:2/**	-3.5%
Overall Preservation Rank:1/	9	**Average Abundance (Neq) Rank:1/**	12	**% loss in Neq with degradation:2/**	-3.4%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**% loss in diversity with degradation:2/**	-7.1%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-1.1%	5							●						●			
Egg incubation	Oct-May	1.0%	-18.7%	1	⬤												⬤			
Fry colonization	Mar-May	1.7%	-4.2%	2	●				●	⬤	⬤									
0-age active rearing	Mar-Oct	0.3%	-15.0%	3	•		●		●	●	●				•	●		●		
0-age migrant	Oct-Nov	0.5%	-0.9%	7							●									
0-age inactive	Oct-Mar	0.2%	-9.5%	4	●				●	●	●									
1-age active rearing	Mar-May	0.2%	-2.9%	6	•		•		•	•	•									
1-age migrant	Mar-Jun	0.3%	-0.2%	9							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	2.0%	0.0%	10																
Prespawning holding	Oct-Dec	1.0%	-0.2%	8					•								•			
All Stages Combined		2.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Hurst Creek			**Stream:**	
Reach:	Hurst ck mouth to Boulder ck mouth			**Reach Length (mi):**	0.77
				Reach Code:	Hurst-1
Restoration Benefit Category:1/	B	**Productivity Rank:1/**	6	**Potential % change in productivity:2/**	8.4%
Overall Restoration Potential Rank:1/	6	**Average Abundance (Neq) Rank:1/**	6	**Potential % change in Neq:2/**	3.7%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	7	**loss in productivity with degradation:2/**	-5.3%
Overall Preservation Rank:1/	7	**Average Abundance (Neq) Rank:1/**	8	**% loss in Neq with degradation:2/**	-5.4%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**% loss in diversity with degradation:2/**	-7.3%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-1.4%	6							•						●			
Egg incubation	Oct-May	1.0%	-41.9%	1	⬤												⬤			
Fry colonization	Mar-May	1.7%	-2.9%	3	●				●	●	●						•			•
0-age active rearing	Mar-Oct	0.5%	-5.1%	5	•		•		•	●	●				•	•				
0-age migrant	Oct-Nov	2.2%	-0.5%	7							•						●			
0-age inactive	Oct-Mar	0.8%	-6.6%	2	●				●	●	●									
1-age active rearing	Mar-May	0.8%	-3.2%	4	•		•		●	•	•									
1-age migrant	Mar-Jun	4.5%	0.0%								•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	7.0%	0.0%	9													•			
Prespawning holding	Oct-Dec	1.0%	-0.8%	8													•			
All Stages Combined		7.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Hurst Creek	**Stream:**	
Reach:	Boulder ck mouth to unnamed RB Trib 0027	**Reach Length (mi):**	0.99
		Reach Code:	Hurst-2

Restoration Benefit Category:1/	B	**Productivity Rank:1/**	6	**Potential % change in productivity:2/**	8.4%
Overall Restoration Potential Rank:1/	6	**Average Abundance (Neq) Rank:1/**	6	**Potential % change in Neq:2/**	3.7%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	7	**loss in productivity with degradation:2/**	-5.3%
Overall Preservation Rank:1/	7	**Average Abundance (Neq) Rank:1/**	8	**% loss in Neq with degradation:2/**	-5.4%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**% loss in diversity with degradation:2/**	-7.3%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-1.7%	6							•						●			○
Egg incubation	Oct-May	1.0%	-52.2%	1	⬤												⬤			○
Fry colonization	Mar-May	1.5%	-3.7%	5	●				●	●	●						•			•
0-age active rearing	Mar-Oct	1.0%	-7.0%	2	•		●		●	●	●				•	●				•
0-age migrant	Oct-Nov	1.8%	-0.4%	9							•						●			
0-age inactive	Oct-Mar	0.8%	-7.6%	3	●				●	●	●									•
1-age active rearing	Mar-May	0.8%	-3.2%	5	●		•		●	●	•									•
1-age migrant	Mar-Jun	2.8%	0.0%								•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	4.0%	0.0%	10													•			
Prespawning holding	Oct-Dec	1.0%	-1.2%	7					•		●						●			•
All Stages Combined		4.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Hurst Creek			**Stream:**	
Reach:	Unnamed RB Trib mouth to Trib 0028			**Reach Length (mi):**	1.05
				Reach Code:	Hurst-3
Restoration Benefit Category:1/	B	**Productivity Rank:1/**	6	**Potential % change in productivity:2/**	8.4%
Overall Restoration Potential Rank:1/	6	**Average Abundance (Neq) Rank:1/**	6	**Potential % change in Neq:2/**	3.7%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	7	**loss in productivity with degradation:2/**	-5.3%
Overall Preservation Rank:1/	7	**Average Abundance (Neq) Rank:1/**	8	**% loss in Neq with degradation:2/**	-5.4%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**% loss in diversity with degradation:2/**	-7.3%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-1.5%	7							●						●			○
Egg incubation	Oct-May	1.0%	-56.0%	1	⬤												⬤			○
Fry colonization	Mar-May	1.5%	-4.9%	4	●				●	●	●						•			●
0-age active rearing	Mar-Oct	1.5%	-10.8%	2	●		●		⬤	⬤	⬤				●	●	•	⬤		●
0-age migrant	Oct-Nov	1.5%	-0.8%	8							●						●			
0-age inactive	Oct-Mar	0.7%	-8.5%	4	⬤				●	●	●									●
1-age active rearing	Mar-May	0.7%	-4.2%	5	●		•		●	●	●									●
1-age migrant	Mar-Jun	1.3%	-0.1%	9							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	2.0%	0.0%	10													•			
Prespawning holding	Oct-Dec	1.0%	-2.4%	6					•		●						●			●
All Stages Combined		2.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Hurst Creek	**Stream:**	
Reach:	Unnamed Trib0028 to coho limit (mouth of Trib0029)	**Reach Length (mi):**	0.77
		Reach Code:	Hurst-4

Restoration Benefit Category:1/	B	**Productivity Rank:1/**	6	**Potential % change in productivity:2/**	8.4%
Overall Restoration Potential Rank:1/	6	**Average Abundance (Neq) Rank:1/**	6	**Potential % change in Neq:2/**	3.7%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	7	**loss in productivity with degradation:2/**	-5.3%
Overall Preservation Rank:1/	7	**Average Abundance (Neq) Rank:1/**	8	**% loss in Neq with degradation:2/**	-5.4%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**% loss in diversity with degradation:2/**	-7.3%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-2.0%	6							●						●			○
Egg incubation	Oct-May	1.0%	-49.4%	1	⬤												⬤			○
Fry colonization	Mar-May	1.0%	-7.0%	3	⬤				⬤	⬤	●						●			⬤
0-age active rearing	Mar-Oct	0.7%	-11.3%	2	●		●		⬤	⬤	⬤				●	●	•	⬤		⬤
0-age migrant	Oct-Nov	0.7%	-0.9%	8							●						●			
0-age inactive	Oct-Mar	0.7%	-8.7%	4	⬤				⬤	●	⬤									⬤
1-age active rearing	Mar-May	0.7%	-5.3%	5	●		●		⬤	●	●									⬤
1-age migrant	Mar-Jun	0.7%	0.0%	10							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%	9													•			
Prespawning holding	Oct-Dec	1.0%	-1.9%	7					●		●						●			⬤
All Stages Combined		1.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	○
Extreme	⬤	⬤

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Hurst Creek			**Stream:**	
Reach:	Boulder ck mouth to road crossing in middle of section 16			**Reach Length (mi):**	1.95
				Reach Code:	Boulder-1
Restoration Benefit Category:1/	B	**Productivity Rank:1/**	6	**Potential % change in productivity:2/**	8.4%
Overall Restoration Potential Rank:1/	6	**Average Abundance (Neq) Rank:1/**	6	**Potential % change in Neq:2/**	3.7%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	7	**loss in productivity with degradation:2/**	-5.3%
Overall Preservation Rank:1/	7	**Average Abundance (Neq) Rank:1/**	8	**% loss in Neq with degradation:2/**	-5.4%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**% loss in diversity with degradation:2/**	-7.3%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	2.0%	-2.0%	5							●						●			
Egg incubation	Oct-May	2.0%	-9.5%	1	⬤															
Fry colonization	Mar-May	2.0%	-3.4%	3	●				⬤	●	●									⬤
0-age active rearing	Mar-Oct	1.5%	-7.9%	2	●				⬤	⬤	⬤				●	●	•	⬤		●
0-age migrant	Oct-Nov	1.5%	-1.3%	7							●						●			
0-age inactive	Oct-Mar	0.8%	-6.1%	4	●				●	●	●									●
1-age active rearing	Mar-May	0.8%	-3.4%	6	●				●	●	●									●
1-age migrant	Mar-Jun	0.8%	-0.1%	9							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	2.0%	0.0%	10													•			
Prespawning holding	Oct-Dec	2.0%	-0.9%	8													●			●
All Stages Combined		2.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Hurst Creek			**Stream:**	
Reach:	Hurst-2 end to fork at top of section 8			**Reach Length (mi):**	1.15
				Reach Code:	Hurst-unnamed RB trib # 0025.5
Restoration Benefit Category:1/	B	**Productivity Rank:1/**	6	**Potential % change in productivity:2/**	8.4%
Overall Restoration Potential Rank:1/	6	**Average Abundance (Neq) Rank:1/**	6	**Potential % change in Neq:2/**	3.7%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	7	**loss in productivity with degradation:2/**	-5.3%
Overall Preservation Rank:1/	7	**Average Abundance (Neq) Rank:1/**	8	**% loss in Neq with degradation:2/**	-5.4%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	5	**% loss in diversity with degradation:2/**	-7.3%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-1.9%	6							●						●			○
Egg incubation	Oct-May	1.0%	-34.8%	1	⬤															○
Fry colonization	Mar-May	1.0%	-4.3%	4	●				⬤	●	●									⬤
0-age active rearing	Mar-Oct	0.7%	-10.0%	2	●		●		●	●	⬤				●	●		●		●
0-age migrant	Oct-Nov	1.0%	-1.0%	8							●						●			
0-age inactive	Oct-Mar	0.7%	-8.5%	3	⬤				⬤	●	⬤									●
1-age active rearing	Mar-May	0.7%	-4.7%	5	●		●		●	●	●									●
1-age migrant	Mar-Jun	0.7%	-0.1%	11							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	-0.1%	10													•			
Prespawning holding	Oct-Dec	1.0%	-0.8%	7													●			⬤
All Stages Combined		1.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	○
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Misc Lower Clearwater Tribs			**Stream:**	
Reach:	Mouth to unnamed trib 0030			**Reach Length (mi):**	0.65
				Reach Code:	Wildcat-1
Restoration Benefit Category:1/	C	**Productivity Rank:1/**	10	**Potential % change in productivity:2/**	5.5%
Overall Restoration Potential Rank:1/	10	**Average Abundance (Neq) Rank:1/**	10	**Potential % change in Neq:2/**	2.3%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	5	**loss in productivity with degradation:2/**	-9.0%
Overall Preservation Rank:1/	4	**Average Abundance (Neq) Rank:1/**	7	**% loss in Neq with degradation:2/**	-6.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	4	**% loss in diversity with degradation:2/**	-10.6%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-2.2%	6							●						●			○
Egg incubation	Oct-May	1.0%	-33.9%	1	⬤												⬤			○
Fry colonization	Mar-May	1.2%	-8.3%	5	●				⬤	●	⬤						●			●
0-age active rearing	Mar-Oct	1.2%	-7.7%	3	●				⬤	⬤	⬤				●		•			•
0-age migrant	Oct-Nov	1.3%	-1.1%	8							●						●			
0-age inactive	Oct-Mar	0.8%	-11.6%	2	●				⬤	●	⬤									•
1-age active rearing	Mar-May	0.8%	-5.9%	5	●				⬤	●	⬤									•
1-age migrant	Mar-Jun	0.8%	0.0%	11							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%	12													•			
Prespawning holding	Oct-Dec	1.0%	-1.8%	7					•		●						●			
All Stages Combined		1.3%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Misc Lower Clearwater Tribs			**Stream:**	
Reach:	Hunt Ck mouth to Waring Ck mouth			**Reach Length (mi):**	0.09
				Reach Code:	Hunt-1
Restoration Benefit Category:1/	C	**Productivity Rank:1/**	10	**Potential % change in productivity:2/**	5.5%
Overall Restoration Potential Rank:1/	10	**Average Abundance (Neq) Rank:1/**	10	**Potential % change in Neq:2/**	2.3%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	5	**loss in productivity with degradation:2/**	-9.0%
Overall Preservation Rank:1/	4	**Average Abundance (Neq) Rank:1/**	7	**% loss in Neq with degradation:2/**	-6.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	4	**% loss in diversity with degradation:2/**	-10.6%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-1.9%	3							●						●			○
Egg incubation	Oct-May	1.0%	-21.0%	1	⬤															○
Fry colonization	Mar-May	2.3%	-0.8%	2	●				●	•	●									⬤
0-age active rearing	Mar-Oct	0.2%	-7.1%	5	•		•		•	•	•			•	•	•				•
0-age migrant	Oct-Nov	1.2%	-0.1%	8							•						•			
0-age inactive	Oct-Mar	0.2%	-8.2%	4	●				●	•	•									•
1-age active rearing	Mar-May	0.2%	-4.0%	7	•		•		•	•	•									•
1-age migrant	Mar-Jun	0.8%	0.0%	9																
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	4.0%	0.0%	10																
Prespawning holding	Oct-Dec	1.0%	-1.1%	6							●						●			•
All Stages Combined		4.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Misc Lower Clearwater Tribs			**Stream:**	
Reach:	Waring ck mouth to coho limit (fork)			**Reach Length (mi):**	1.95
				Reach Code:	Hunt-2
Restoration Benefit Category:1/	C	**Productivity Rank:1/**	10	**Potential % change in productivity:2/**	5.5%
Overall Restoration Potential Rank:1/	10	**Average Abundance (Neq) Rank:1/**	10	**Potential % change in Neq:2/**	2.3%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	5	**loss in productivity with degradation:2/**	-9.0%
Overall Preservation Rank:1/	4	**Average Abundance (Neq) Rank:1/**	7	**% loss in Neq with degradation:2/**	-6.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	4	**% loss in diversity with degradation:2/**	-10.6%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	2.0%	-1.9%	4							●						●			○
Egg incubation	Oct-May	2.0%	-9.3%	1	⬤															○
Fry colonization	Mar-May	2.0%	-2.5%	3	●				●	●	●									●
0-age active rearing	Mar-Oct	1.2%	-5.5%	2	•		●		●	●	●			●	●	●	•			●
0-age migrant	Oct-Nov	1.2%	-0.5%	8							●						●			
0-age inactive	Oct-Mar	0.5%	-6.4%	5	●				●	●	●									
1-age active rearing	Mar-May	0.5%	-3.3%	7	●		•		●	●	●									
1-age migrant	Mar-Jun	0.5%	-0.2%	9							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	2.0%	0.0%	10													•			
Prespawning holding	Oct-Dec	2.0%	-1.0%	6													●			○
All Stages Combined		2.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Misc Lower Clearwater Tribs			**Stream:**	
Reach:	Waring ck mouth to road crossing			**Reach Length (mi):**	0.36
				Reach Code:	Waring-1
Restoration Benefit Category:1/	C	**Productivity Rank:1/**	10	**Potential % change in productivity:2/**	5.5%
Overall Restoration Potential Rank:1/	10	**Average Abundance (Neq) Rank:1/**	10	**Potential % change in Neq:2/**	2.3%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	5	**loss in productivity with degradation:2/**	-9.0%
Overall Preservation Rank:1/	4	**Average Abundance (Neq) Rank:1/**	7	**% loss in Neq with degradation:2/**	-6.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	4	**% loss in diversity with degradation:2/**	-10.6%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-2.5%	3							●						●			
Egg incubation	Oct-May	1.0%	-9.8%	1	⬤															○
Fry colonization	Mar-May	1.0%	-1.5%	4	●				●	●	●									●
0-age active rearing	Mar-Oct	0.5%	-6.5%	2	•		●		●	●	⬤			●	●	●	•			•
0-age migrant	Oct-Nov	0.5%	-0.9%	8							●						●			
0-age inactive	Oct-Mar	0.2%	-7.1%	5	●				●	●	●									
1-age active rearing	Mar-May	0.2%	-4.6%	6	●		•		●	●	●									
1-age migrant	Mar-Jun	0.2%	0.0%	10																
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%	9																
Prespawning holding	Oct-Dec	1.0%	-0.7%	7													●			
All Stages Combined		1.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Misc Lower Clearwater Tribs			**Stream:**	
Reach:	Cougar Ck mouth to Cougar Creek 1/4 mile			**Reach Length (mi):**	0.33
				Reach Code:	Cougar-1
Restoration Benefit Category:1/	C	**Productivity Rank:1/**	10	**Potential % change in productivity:2/**	5.5%
Overall Restoration Potential Rank:1/	10	**Average Abundance (Neq) Rank:1/**	10	**Potential % change in Neq:2/**	2.3%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	5	**loss in productivity with degradation:2/**	-9.0%
Overall Preservation Rank:1/	4	**Average Abundance (Neq) Rank:1/**	7	**% loss in Neq with degradation:2/**	-6.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	4	**% loss in diversity with degradation:2/**	-10.6%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-1.5%	6							●						●			
Egg incubation	Oct-May	1.0%	-36.8%	1	⬤												⬤			
Fry colonization	Mar-May	1.2%	-2.0%	5	●				●	●	●						•			●
0-age active rearing	Mar-Oct	0.5%	-13.3%	2	●				⬤	●	⬤				●		•			●
0-age migrant	Oct-Nov	0.5%	-0.6%	9							●						•			
0-age inactive	Oct-Mar	0.2%	-11.6%	5	●				●	●	●									•
1-age active rearing	Mar-May	0.2%	-3.5%	7	•				●	•	●									•
1-age migrant	Mar-Jun	0.2%	0.0%	11																
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%	10																
Prespawning holding	Oct-Dec	1.0%	-2.4%	3					●		●						●			●
All Stages Combined		1.2%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Misc Lower Clearwater Tribs			**Stream:**	
Reach:	Elkhorn Ck mouth to road crossing @ mainline gravel pit			**Reach Length (mi):**	0.63
				Reach Code:	Elkhorn-1
Restoration Benefit Category:1/	C	**Productivity Rank:1/**	10	**Potential % change in productivity:2/**	5.5%
Overall Restoration Potential Rank:1/	10	**Average Abundance (Neq) Rank:1/**	10	**Potential % change in Neq:2/**	2.3%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	5	**loss in productivity with degradation:2/**	-9.0%
Overall Preservation Rank:1/	4	**Average Abundance (Neq) Rank:1/**	7	**% loss in Neq with degradation:2/**	-6.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	4	**% loss in diversity with degradation:2/**	-10.6%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-1.5%	7							●						●			○
Egg incubation	Oct-May	1.0%	-2.6%	4	⬤															○
Fry colonization	Mar-May	1.0%	-4.0%	2	●				⬤	⬤	●									●
0-age active rearing	Mar-Oct	0.8%	-5.6%	1	●				⬤	⬤	⬤				●		•			●
0-age migrant	Oct-Nov	0.8%	-0.5%	8							●						●			
0-age inactive	Oct-Mar	0.5%	-5.5%	3	●				●	●	●									●
1-age active rearing	Mar-May	0.5%	-3.4%	6	●				●	●	●									●
1-age migrant	Mar-Jun	0.5%	-0.1%	9							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%	10																
Prespawning holding	Oct-Dec	1.0%	-1.8%	5					•		●						●			
All Stages Combined		1.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Misc Lower Clearwater Tribs			**Stream:**	
Reach:	Mink Ck mouth to Trib0039 mouth			**Reach Length (mi):**	0.68
				Reach Code:	Mink-1
Restoration Benefit Category:1/	C	**Productivity Rank:1/**	10	**Potential % change in productivity:2/**	5.5%
Overall Restoration Potential Rank:1/	10	**Average Abundance (Neq) Rank:1/**	10	**Potential % change in Neq:2/**	2.3%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	5	**loss in productivity with degradation:2/**	-9.0%
Overall Preservation Rank:1/	4	**Average Abundance (Neq) Rank:1/**	7	**% loss in Neq with degradation:2/**	-6.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	4	**% loss in diversity with degradation:2/**	-10.6%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-2.2%	6							●						●			○
Egg incubation	Oct-May	1.0%	-33.7%	1	⬤												⬤			○
Fry colonization	Mar-May	1.2%	-5.4%	2	●				⬤	●	⬤						●			⬤
0-age active rearing	Mar-Oct	0.7%	-7.6%	4	•				●	●	⬤				●					●
0-age migrant	Oct-Nov	1.2%	-0.7%	8							●						●			
0-age inactive	Oct-Mar	0.5%	-11.7%	3	●				●	●	⬤									●
1-age active rearing	Mar-May	0.5%	-6.0%	5	●				●	●	●									●
1-age migrant	Mar-Jun	0.8%	-0.1%	9							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	2.0%	0.0%	10																
Prespawning holding	Oct-Dec	1.0%	-1.7%	7							●						●			
All Stages Combined		2.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Misc Lower Clearwater Tribs			**Stream:**	
Reach:	Trib0039 mouth to fish limit			**Reach Length (mi):**	0.98
				Reach Code:	Mink unnamed LB trib # 0039
Restoration Benefit Category:1/	C	**Productivity Rank:1/**	10	**Potential % change in productivity:2/**	5.5%
Overall Restoration Potential Rank:1/	10	**Average Abundance (Neq) Rank:1/**	10	**Potential % change in Neq:2/**	2.3%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	5	**loss in productivity with degradation:2/**	-9.0%
Overall Preservation Rank:1/	4	**Average Abundance (Neq) Rank:1/**	7	**% loss in Neq with degradation:2/**	-6.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	4	**% loss in diversity with degradation:2/**	-10.6%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-2.1%	5							●						●			○
Egg incubation	Oct-May	1.0%	-2.4%	4	●															○
Fry colonization	Mar-May	1.0%	-7.1%	1	•				●	●	●									●
0-age active rearing	Mar-Oct	0.8%	-7.0%	2	•				●	●	●				•		•			•
0-age migrant	Oct-Nov	0.8%	-0.6%	8							•						●			
0-age inactive	Oct-Mar	0.3%	-10.3%	3	•				●	•	●									•
1-age active rearing	Mar-May	0.3%	-4.4%	7	•				•	•	•									•
1-age migrant	Mar-Jun	0.3%	-0.1%	9							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%	10													•			
Prespawning holding	Oct-Dec	1.0%	-1.9%	6					•		●						●			
All Stages Combined		1.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Shale Creek			**Stream:**	
Reach:	Shale Ck mouth to Iska Ck (0042)			**Reach Length (mi):**	0.70
				Reach Code:	Shale-1
Restoration Benefit Category:1/	B	**Productivity Rank:1/**	5	**Potential % change in productivity:2/**	9.7%
Overall Restoration Potential Rank:1/	7	**Average Abundance (Neq) Rank:1/**	8	**Potential % change in Neq:2/**	3.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	6	**loss in productivity with degradation:2/**	-6.0%
Overall Preservation Rank:1/	6	**Average Abundance (Neq) Rank:1/**	6	**% loss in Neq with degradation:2/**	-6.7%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	7	**% loss in diversity with degradation:2/**	-6.4%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-1.4%	6							•						•			○
Egg incubation	Oct-May	1.0%	-54.1%	1	●												●			○
Fry colonization	Mar-May	2.0%	-2.5%	4	•				●	●	●						•			•
0-age active rearing	Mar-Oct	1.2%	-5.1%	3	•		•		•	●	●				•	•				•
0-age migrant	Oct-Nov	2.5%	-0.4%	7							•						•			
0-age inactive	Oct-Mar	1.2%	-6.5%	2	●				●	●	●									•
1-age active rearing	Mar-May	1.2%	-3.5%	5	•		•		●	•	●									•
1-age migrant	Mar-Jun	4.9%	-0.1%	9							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	7.0%	0.0%	10																
Prespawning holding	Oct-Dec	1.0%	-0.9%	8													•			•
All Stages Combined		7.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	●	◯
Extreme	●	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Shale Creek			**Stream:**	
Reach:	Iska Ck mouth to Unnamed RB Trib0045			**Reach Length (mi):**	2.33
				Reach Code:	Shale-2
Restoration Benefit Category:1/	B	**Productivity Rank:1/**	5	**Potential % change in productivity:2/**	9.7%
Overall Restoration Potential Rank:1/	7	**Average Abundance (Neq) Rank:1/**	8	**Potential % change in Neq:2/**	3.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	6	**loss in productivity with degradation:2/**	-6.0%
Overall Preservation Rank:1/	6	**Average Abundance (Neq) Rank:1/**	6	**% loss in Neq with degradation:2/**	-6.7%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	7	**% loss in diversity with degradation:2/**	-6.4%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	2.0%	-1.1%	6							●						●			•
Egg incubation	Oct-May	2.0%	-51.8%	1	⬤												⬤			●
Fry colonization	Mar-May	2.3%	-2.7%	4	●				●	●	●						•			•
0-age active rearing	Mar-Oct	1.8%	-4.4%	3	•		●		●	●	●				●	●				○
0-age migrant	Oct-Nov	3.2%	-0.5%	8							●						●			
0-age inactive	Oct-Mar	1.8%	-4.7%	2	●				●	●	●									○
1-age active rearing	Mar-May	1.8%	-2.6%	5	●		•		●	●	●									○
1-age migrant	Mar-Jun	3.2%	0.0%								•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	5.0%	0.0%	9													•			
Prespawning holding	Oct-Dec	2.0%	-0.9%	7													●			○
All Stages Combined		5.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Shale Creek			**Stream:**	
Reach:	Unnamed RB Trib0045 mouth to unnamed LB Trib0047 mouth			**Reach Length (mi):**	1.55
				Reach Code:	Shale-3
Restoration Benefit Category:1/	B	**Productivity Rank:1/**	5	**Potential % change in productivity:2/**	9.7%
Overall Restoration Potential Rank:1/	7	**Average Abundance (Neq) Rank:1/**	8	**Potential % change in Neq:2/**	3.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	6	**loss in productivity with degradation:2/**	-6.0%
Overall Preservation Rank:1/	6	**Average Abundance (Neq) Rank:1/**	6	**% loss in Neq with degradation:2/**	-6.7%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	7	**% loss in diversity with degradation:2/**	-6.4%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-0.8%	8							●						●			•
Egg incubation	Oct-May	1.0%	-53.4%	1	⬤												⬤			•
Fry colonization	Mar-May	2.0%	-2.5%	3	●				●	●	●						•			●
0-age active rearing	Mar-Oct	1.7%	-4.7%	2	•		●		●	●	●				●	●				•
0-age migrant	Oct-Nov	2.3%	-0.6%	6							●						●			
0-age inactive	Oct-Mar	1.0%	-4.8%	4	●				●	●	●									
1-age active rearing	Mar-May	1.0%	-2.7%	5	●		•		●	●	●									•
1-age migrant	Mar-Jun	1.3%	0.0%								•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	3.0%	0.0%	9													•			
Prespawning holding	Oct-Dec	1.0%	-0.9%	7													●			○
All Stages Combined		3.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Shale Creek			**Stream:**	
Reach:	Unnamed LB Trib0047 mouth to coho limit			**Reach Length (mi):**	0.61
				Reach Code:	Shale-4
Restoration Benefit Category:1/	B	**Productivity Rank:1/**	5	**Potential % change in productivity:2/**	9.7%
Overall Restoration Potential Rank:1/	7	**Average Abundance (Neq) Rank:1/**	8	**Potential % change in Neq:2/**	3.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	6	**loss in productivity with degradation:2/**	-6.0%
Overall Preservation Rank:1/	6	**Average Abundance (Neq) Rank:1/**	6	**% loss in Neq with degradation:2/**	-6.7%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	7	**% loss in diversity with degradation:2/**	-6.4%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-2.0%	4							●						●			○
Egg incubation	Oct-May	1.0%	-49.7%	1	⬤												⬤			○
Fry colonization	Mar-May	1.0%	-3.5%	2	●				⬤	●	●						●			●
0-age active rearing	Mar-Oct	0.7%	-5.0%	3	•		●		●	●	⬤				●	●				●
0-age migrant	Oct-Nov	0.7%	-0.7%	8							●						●			
0-age inactive	Oct-Mar	0.2%	-5.7%	5	●				●	●	●									•
1-age active rearing	Mar-May	0.2%	-3.4%	7	•		•		●	•	●									•
1-age migrant	Mar-Jun	0.2%	-0.1%	9							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%	10													•			
Prespawning holding	Oct-Dec	1.0%	-0.9%	6													●			●
All Stages Combined		1.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Misc Upper Clearwater Tribs			**Stream:**	
Reach:	Iska Ck. mouth to coho limit			**Reach Length (mi):**	0.55
				Reach Code:	Iska-1
Restoration Benefit Category:1/	D	**Productivity Rank:1/**	16	**Potential % change in productivity:2/**	1.8%
Overall Restoration Potential Rank:1/	17	**Average Abundance (Neq) Rank:1/**	16	**Potential % change in Neq:2/**	0.6%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	9	**loss in productivity with degradation:2/**	-3.5%
Overall Preservation Rank:1/	10	**Average Abundance (Neq) Rank:1/**	14	**% loss in Neq with degradation:2/**	-2.0%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	7	**% loss in diversity with degradation:2/**	-6.4%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-1.8%	6							●						●			
Egg incubation	Oct-May	1.0%	-40.8%	1	⬤												⬤			
Fry colonization	Mar-May	1.0%	-5.1%	2	●				⬤	●	⬤						●			
0-age active rearing	Mar-Oct	0.5%	-9.3%	4	●		●		●	●	⬤				●	●				
0-age migrant	Oct-Nov	0.8%	-1.0%	8							●						•			
0-age inactive	Oct-Mar	0.5%	-9.7%	3	●				⬤	●	⬤									
1-age active rearing	Mar-May	0.5%	-5.0%	5	●		●		●	●	●									
1-age migrant	Mar-Jun	0.5%	-0.1%	10							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%	11																
Prespawning holding	Oct-Dec	1.0%	-1.2%	7					●		●						●			
All Stages Combined		1.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Shale Creek			**Stream:**	
Reach:	Unnamed Trib0047 mouth to coho limit			**Reach Length (mi):**	0.66
				Reach Code:	Shale-unnamed LB trib # 0047
Restoration Benefit Category:1/	B	**Productivity Rank:1/**	5	**Potential % change in productivity:2/**	9.7%
Overall Restoration Potential Rank:1/	7	**Average Abundance (Neq) Rank:1/**	8	**Potential % change in Neq:2/**	3.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	6	**loss in productivity with degradation:2/**	-6.0%
Overall Preservation Rank:1/	6	**Average Abundance (Neq) Rank:1/**	6	**% loss in Neq with degradation:2/**	-6.7%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	7	**% loss in diversity with degradation:2/**	-6.4%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-2.1%	4							●						●			
Egg incubation	Oct-May	1.0%	-34.7%	1	●												●			
Fry colonization	Mar-May	1.0%	-4.0%	2	●				●	●	●									
0-age active rearing	Mar-Oct	0.3%	-7.9%	3			●		●	●	●			●	●	●				
0-age migrant	Oct-Nov	0.3%	-1.8%	7							●						●			
0-age inactive	Oct-Mar	0.2%	-7.2%	5	●				●	●	●									
1-age active rearing	Mar-May	0.2%	-2.4%	8	•		•		●	•	•									
1-age migrant	Mar-Jun	0.2%	-0.1%	10							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%	9													•			
Prespawning holding	Oct-Dec	1.0%	-0.8%	6							●						●			
All Stages Combined		1.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	●	○
Extreme	●	○

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Miller Creek	**Stream:**	
Reach:	Miller Ck mouth to East Fork Miller Confluence	**Reach Length (mi):**	0.44
		Reach Code:	Miller-1

Restoration Benefit Category:1/	A	**Productivity Rank:1/**	2	**Potential % change in productivity:2/**	29.0%
Overall Restoration Potential Rank:1/	2	**Average Abundance (Neq) Rank:1/**	2	**Potential % change in Neq:2/**	12.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	3	**loss in productivity with degradation:2/**	-14.0%
Overall Preservation Rank:1/	3	**Average Abundance (Neq) Rank:1/**	3	**% loss in Neq with degradation:2/**	-15.6%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	2	**% loss in diversity with degradation:2/**	-13.6%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-2.9%	7							●						•			○
Egg incubation	Oct-May	1.0%	-47.6%	1	⬤												⬤			○
Fry colonization	Mar-May	2.3%	-5.3%	4	●				●	●	●						•			●
0-age active rearing	Mar-Oct	1.0%	-12.8%	3	•		•		•	●	●				•	•				•
0-age migrant	Oct-Nov	1.7%	-1.8%	6							●						•			
0-age inactive	Oct-Mar	0.8%	-18.9%	2	●				●	•	●									•
1-age active rearing	Mar-May	0.8%	-5.5%	5	•		•		●	•	●									•
1-age migrant	Mar-Jun	10.9%	-0.1%	8							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	13.1%	0.0%	10																
Prespawning holding	Oct-Dec	1.0%	-1.0%	9							•						•			•
All Stages Combined		13.1%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Miller Creek	**Stream:**	
Reach:	Miller East/West Fork confluence mouth to unnamed RB Trib # 0057	**Reach Length (mi):**	2.27
		Reach Code:	Miller-2

Restoration Benefit Category:1/	A	**Productivity Rank:1/**	2	**Potential % change in productivity:2/**	29.0%
Overall Restoration Potential Rank:1/	2	**Average Abundance (Neq) Rank:1/**	2	**Potential % change in Neq:2/**	12.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	3	**loss in productivity with degradation:2/**	-14.0%
Overall Preservation Rank:1/	3	**Average Abundance (Neq) Rank:1/**	3	**% loss in Neq with degradation:2/**	-15.6%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	2	**% loss in diversity with degradation:2/**	-13.6%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	2.0%	-2.0%	7							●						●			○
Egg incubation	Oct-May	2.0%	-47.9%	1	⬤												⬤			○
Fry colonization	Mar-May	2.3%	-6.9%	4	●				●	●	●						●			●
0-age active rearing	Mar-Oct	2.0%	-9.4%	3	●		●		●	●	⬤				•	●				●
0-age migrant	Oct-Nov	3.4%	-1.5%	7							●						●			
0-age inactive	Oct-Mar	3.2%	-11.5%	2	⬤				●	●	⬤									●
1-age active rearing	Mar-May	3.2%	-4.9%	5	●		●		●	●	●									●
1-age migrant	Mar-Jun	6.9%	-0.2%	9							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	7.0%	0.0%	10													•			
Prespawning holding	Oct-Dec	2.0%	-1.0%	8													●			●
All Stages Combined		7.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Miller Creek			**Stream:**	
Reach:	Unnamed Miller RB trib0057 mouth to Trib0062 mouth			**Reach Length (mi):**	3.66
				Reach Code:	Miller-3
Restoration Benefit Category:1/	A	**Productivity Rank:1/**	2	**Potential % change in productivity:2/**	29.0%
Overall Restoration Potential Rank:1/	2	**Average Abundance (Neq) Rank:1/**	2	**Potential % change in Neq:2/**	12.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	3	**loss in productivity with degradation:2/**	-14.0%
Overall Preservation Rank:1/	3	**Average Abundance (Neq) Rank:1/**	3	**% loss in Neq with degradation:2/**	-15.6%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	2	**% loss in diversity with degradation:2/**	-13.6%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	3.0%	-1.9%	7							●						●			
Egg incubation	Oct-May	3.0%	-40.8%	1	⬤												⬤			
Fry colonization	Mar-May	3.4%	-5.4%	3	●				⬤	●	●						●			●
0-age active rearing	Mar-Oct	3.0%	-7.6%	2	●		●		⬤	●	⬤				●	●	•			●
0-age migrant	Oct-Nov	3.0%	-1.4%	8							●						●			
0-age inactive	Oct-Mar	2.0%	-8.7%	4	⬤				●	●	⬤									●
1-age active rearing	Mar-May	2.0%	-3.8%	5	●		●		●	●	●									•
1-age migrant	Mar-Jun	3.7%	-0.3%	9							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	5.0%	0.0%	10													•			
Prespawning holding	Oct-Dec	3.0%	-2.0%	6					•		●						●			•
All Stages Combined		5.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Miller Creek			**Stream:**	
Reach:	Unnamed Trib # 0062 to coho limit;			**Reach Length (mi):**	2.61
				Reach Code:	Miller-4
Restoration Benefit Category:1/	A	**Productivity Rank:1/**	2	**Potential % change in productivity:2/**	29.0%
Overall Restoration Potential Rank:1/	2	**Average Abundance (Neq) Rank:1/**	2	**Potential % change in Neq:2/**	12.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	3	**loss in productivity with degradation:2/**	-14.0%
Overall Preservation Rank:1/	3	**Average Abundance (Neq) Rank:1/**	3	**% loss in Neq with degradation:2/**	-15.6%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	2	**% loss in diversity with degradation:2/**	-13.6%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	2.0%	-2.0%	6							●						•			
Egg incubation	Oct-May	2.0%	-41.6%	1	●												●			
Fry colonization	Mar-May	2.0%	-6.9%	3	●				●	●	●						•			•
0-age active rearing	Mar-Oct	1.7%	-8.3%	4	•		•		●	●	●				•	•	•			○
0-age migrant	Oct-Nov	1.7%	-1.9%	8							●						•			
0-age inactive	Oct-Mar	1.7%	-10.3%	2	●				●	•	●									•
1-age active rearing	Mar-May	1.7%	-5.5%	5	•		•		●	•	●									○
1-age migrant	Mar-Jun	1.7%	-0.2%	9							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	2.0%	0.0%	10													•			
Prespawning holding	Oct-Dec	2.0%	-1.7%	7					•		•						●			○
All Stages Combined		2.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	●	◯
Extreme	●	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Miller Creek			**Stream:**	
Reach:	East Fork Miller mouth to Gaf creek			**Reach Length (mi):**	3.14
				Reach Code:	MillerEFk-1
Restoration Benefit Category:1/	A	**Productivity Rank:1/**	2	**Potential % change in productivity:2/**	29.0%
Overall Restoration Potential Rank:1/	2	**Average Abundance (Neq) Rank:1/**	2	**Potential % change in Neq:2/**	12.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	3	**loss in productivity with degradation:2/**	-14.0%
Overall Preservation Rank:1/	3	**Average Abundance (Neq) Rank:1/**	3	**% loss in Neq with degradation:2/**	-15.6%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	2	**% loss in diversity with degradation:2/**	-13.6%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	3.0%	-0.9%	7							●						●			○
Egg incubation	Oct-May	3.0%	-45.6%	1	⬤												⬤			○
Fry colonization	Mar-May	3.2%	-3.4%	4	●				●	●	●						●			●
0-age active rearing	Mar-Oct	2.2%	-6.0%	2	●		●		●	●	●				●	●	•			•
0-age migrant	Oct-Nov	2.5%	-0.8%	8							●						●			
0-age inactive	Oct-Mar	1.7%	-7.1%	3	●				●	●	●									•
1-age active rearing	Mar-May	1.7%	-3.5%	5	●		●		●	●	●									•
1-age migrant	Mar-Jun	3.2%	-0.3%	9							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	5.0%	0.0%	10													•			
Prespawning holding	Oct-Dec	3.0%	-0.9%	6													●			○
All Stages Combined		5.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Miller Creek			**Stream:**	
Reach:	Trib # 0053 mouth to coho limit, road crossing @ Sec 10, a.k.a. Gaf Ck			**Reach Length (mi):**	0.51
				Reach Code:	Gaf-1
Restoration Benefit Category:1/	A	**Productivity Rank:1/**	2	**Potential % change in productivity:2/**	29.0%
Overall Restoration Potential Rank:1/	2	**Average Abundance (Neq) Rank:1/**	2	**Potential % change in Neq:2/**	12.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	3	**loss in productivity with degradation:2/**	-14.0%
Overall Preservation Rank:1/	3	**Average Abundance (Neq) Rank:1/**	3	**% loss in Neq with degradation:2/**	-15.6%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	2	**% loss in diversity with degradation:2/**	-13.6%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-0.9%	7							●						●			○
Egg incubation	Oct-May	1.0%	-33.3%	1	⬤												⬤			○
Fry colonization	Mar-May	1.0%	-3.9%	3	●				⬤	⬤	●						●			⬤
0-age active rearing	Mar-Oct	1.0%	-6.1%	2	•		●		⬤	⬤	⬤				●	●	•			⬤
0-age migrant	Oct-Nov	1.2%	-0.6%	8							●						●			
0-age inactive	Oct-Mar	0.7%	-5.1%	4	●				●	●	●									●
1-age active rearing	Mar-May	0.7%	-3.5%	5	●		●		●	●	●									●
1-age migrant	Mar-Jun	0.7%	-0.1%	10							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%	11																
Prespawning holding	Oct-Dec	1.0%	-1.0%	6					•								●			⬤
All Stages Combined		1.2%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Miller Creek			**Stream:**	
Reach:	Gaf Ck mouth to coho limit			**Reach Length (mi):**	1.42
				Reach Code:	MillerEFk-2
Restoration Benefit Category:1/	A	**Productivity Rank:1/**	2	**Potential % change in productivity:2/**	29.0%
Overall Restoration Potential Rank:1/	2	**Average Abundance (Neq) Rank:1/**	2	**Potential % change in Neq:2/**	12.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	3	**loss in productivity with degradation:2/**	-14.0%
Overall Preservation Rank:1/	3	**Average Abundance (Neq) Rank:1/**	3	**% loss in Neq with degradation:2/**	-15.6%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	2	**% loss in diversity with degradation:2/**	-13.6%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-1.1%	6							●						●			○
Egg incubation	Oct-May	1.0%	-41.3%	1	⬤												⬤			○
Fry colonization	Mar-May	1.0%	-4.0%	4	●				●	⬤	●						●			⬤
0-age active rearing	Mar-Oct	0.8%	-5.8%	3	•		●		●	⬤	⬤				●	●	•			●
0-age migrant	Oct-Nov	1.0%	-0.9%	8							●						●			
0-age inactive	Oct-Mar	0.8%	-6.0%	2	⬤				⬤	●	⬤									●
1-age active rearing	Mar-May	0.8%	-3.2%	5	●		●		●	●	●									●
1-age migrant	Mar-Jun	0.8%	-0.1%	10							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%	11													•			
Prespawning holding	Oct-Dec	1.0%	-0.7%	7					•								●			•
All Stages Combined		1.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Christmas Creek	**Stream:**	
Reach:	Christmas Ck mouth to Christmas Pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM; location of pond in question by Lestelle)	**Reach Length (mi):**	0.10
		Reach Code:	Christmas-01A

Restoration Benefit Category:1/	B	**Productivity Rank:1/**	9	**Potential % change in productivity:2/**	5.7%
Overall Restoration Potential Rank:1/	7	**Average Abundance (Neq) Rank:1/**	7	**Potential % change in Neq:2/**	3.3%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	13	**loss in productivity with degradation:2/**	-2.1%
Overall Preservation Rank:1/	11	**Average Abundance (Neq) Rank:1/**	11	**% loss in Neq with degradation:2/**	-3.5%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	10	**% loss in diversity with degradation:2/**	-5.9%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	0.2%	-0.2%	1																
0-age active rearing																				
0-age migrant	Oct-Nov	1.0%	0.0%	2																
0-age inactive																				
1-age active rearing																				
1-age migrant	Mar-Jun	4.5%	0.0%																	
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	5.7%	0.0%	3																
Prespawning holding																				
All Stages Combined		5.7%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Christmas Creek	**Stream:**	
Reach:	Christmas Pond outlet to mainline crossing (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM; location of pond in question but Lestelle)	**Reach Length (mi):**	0.47
		Reach Code:	Christmas-01B

Restoration Benefit Category:1/	B	**Productivity Rank:1/**	9	**Potential % change in productivity:2/**	5.7%
Overall Restoration Potential Rank:1/	7	**Average Abundance (Neq) Rank:1/**	7	**Potential % change in Neq:2/**	3.3%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	13	**loss in productivity with degradation:2/**	-2.1%
Overall Preservation Rank:1/	11	**Average Abundance (Neq) Rank:1/**	11	**% loss in Neq with degradation:2/**	-3.5%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	10	**% loss in diversity with degradation:2/**	-5.9%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning																				
Egg incubation																				
Fry colonization	Mar-May	0.3%	-0.8%	4	•				•											•
0-age active rearing	Mar-Oct	0.2%	-13.2%	1	•		•		•	•	•				•	•		●		
0-age migrant	Oct-Nov	1.2%	-0.1%	6													•			
0-age inactive	Oct-Mar	0.2%	-10.4%	2	●				•	•	•									
1-age active rearing	Mar-May	0.2%	-2.5%	3	•				•	•	•									
1-age migrant	Mar-Jun	4.5%	0.0%	5							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	5.7%	0.0%	7																
Prespawning holding																				
All Stages Combined		5.7%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	●	○
Extreme	●	○

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Christmas Creek			**Stream:**	
Reach:	Mainline crossing to Trib0066 (Samuelson's Trib)			**Reach Length (mi):**	5.93
				Reach Code:	Christmas-02
Restoration Benefit Category:1/	B	**Productivity Rank:1/**	9	**Potential % change in productivity:2/**	5.7%
Overall Restoration Potential Rank:1/	7	**Average Abundance (Neq) Rank:1/**	7	**Potential % change in Neq:2/**	3.3%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	13	**loss in productivity with degradation:2/**	-2.1%
Overall Preservation Rank:1/	11	**Average Abundance (Neq) Rank:1/**	11	**% loss in Neq with degradation:2/**	-3.5%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	10	**% loss in diversity with degradation:2/**	-5.9%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	3.7%	-0.9%	8							●						●			○
Egg incubation	Oct-May	3.7%	-46.7%	1	⬤												⬤			○
Fry colonization	Mar-May	4.4%	-4.2%	4	⬤				●	●	●						●			●
0-age active rearing	Mar-Oct	4.0%	-13.0%	2	●		●		⬤	⬤	⬤				●	●		⬤		●
0-age migrant	Oct-Nov	4.9%	-0.8%	7							●						●			
0-age inactive	Oct-Mar	3.9%	-7.2%	3	⬤				⬤	●	⬤									●
1-age active rearing	Mar-May	3.9%	-4.0%	5	●		●		●	●	●									●
1-age migrant	Mar-Jun	4.4%	-0.4%	9							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	5.7%	-0.1%	10													•			
Prespawning holding	Oct-Dec	3.7%	-2.0%	6					•		●						●			●
All Stages Combined		5.7%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Christmas Creek			**Stream:**	
Reach:	Trib0066 (Samuelson's trib) to coho limit			**Reach Length (mi):**	1.17
				Reach Code:	Christmas-03
Restoration Benefit Category:1/	B	**Productivity Rank:1/**	9	**Potential % change in productivity:2/**	5.7%
Overall Restoration Potential Rank:1/	7	**Average Abundance (Neq) Rank:1/**	7	**Potential % change in Neq:2/**	3.3%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	13	**loss in productivity with degradation:2/**	-2.1%
Overall Preservation Rank:1/	11	**Average Abundance (Neq) Rank:1/**	11	**% loss in Neq with degradation:2/**	-3.5%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	10	**% loss in diversity with degradation:2/**	-5.9%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-2.1%	5							●						•			○
Egg incubation	Oct-May	1.0%	-43.4%	1	⬤												⬤			○
Fry colonization	Mar-May	1.0%	-4.9%	3	•				⬤	•	⬤						•			●
0-age active rearing	Mar-Oct	0.5%	-13.8%	2	•		•		⬤	•	⬤				•	•		⬤		●
0-age migrant	Oct-Nov	0.5%	-1.1%	8							●						●			
0-age inactive	Oct-Mar	0.3%	-14.0%	4	•				⬤	•	⬤									●
1-age active rearing	Mar-May	0.3%	-5.8%	6	•		•		•	•	•									●
1-age migrant	Mar-Jun	0.3%	-0.2%	9							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%	10													•			
Prespawning holding	Oct-Dec	1.0%	-1.8%	7							●						●			●
All Stages Combined		1.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Christmas Creek			**Stream:**	
Reach:	Christmas Ck to coho limit			**Reach Length (mi):**	1.20
				Reach Code:	Samuelsons Trib
Restoration Benefit Category:1/	B	**Productivity Rank:1/**	9	**Potential % change in productivity:2/**	5.7%
Overall Restoration Potential Rank:1/	7	**Average Abundance (Neq) Rank:1/**	7	**Potential % change in Neq:2/**	3.3%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	13	**loss in productivity with degradation:2/**	-2.1%
Overall Preservation Rank:1/	11	**Average Abundance (Neq) Rank:1/**	11	**% loss in Neq with degradation:2/**	-3.5%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	10	**% loss in diversity with degradation:2/**	-5.9%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-0.8%	6							●						●			
Egg incubation	Oct-May	1.0%	-35.1%	1	⬤												⬤			
Fry colonization	Mar-May	1.0%	-5.8%	3	●				⬤	⬤	⬤						●			⬤
0-age active rearing	Mar-Oct	0.8%	-9.8%	2	•		●		⬤	⬤	⬤				●	●	•	⬤		⬤
0-age migrant	Oct-Nov	0.8%	-0.6%	8							●						●			
0-age inactive	Oct-Mar	0.2%	-7.4%	4	●				●	●	●									●
1-age active rearing	Mar-May	0.2%	-5.1%	7	•		•		●	●	●									●
1-age migrant	Mar-Jun	0.2%	-0.2%	9							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%	10													•			
Prespawning holding	Oct-Dec	1.0%	-1.1%	5					●								●			⬤
All Stages Combined		1.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Misc Lower Clearwater Tribs			**Stream:**	
Reach:	Peterson Ck. mouth to coho limit; section line road crossing			**Reach Length (mi):**	1.05
				Reach Code:	Peterson-1
Restoration Benefit Category:1/	C	**Productivity Rank:1/**	10	**Potential % change in productivity:2/**	5.5%
Overall Restoration Potential Rank:1/	10	**Average Abundance (Neq) Rank:1/**	10	**Potential % change in Neq:2/**	2.3%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	B	**Productivity Rank:1/**	5	**loss in productivity with degradation:2/**	-9.0%
Overall Preservation Rank:1/	4	**Average Abundance (Neq) Rank:1/**	7	**% loss in Neq with degradation:2/**	-6.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	4	**% loss in diversity with degradation:2/**	-10.6%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-2.3%	6							●						●			●
Egg incubation	Oct-May	1.0%	-38.5%	1	⬤												⬤			●
Fry colonization	Mar-May	1.0%	-4.1%	4	●				⬤	●	⬤						•			⬤
0-age active rearing	Mar-Oct	0.7%	-9.3%	2	●				⬤	●	⬤				●	●		●		●
0-age migrant	Oct-Nov	0.7%	-1.3%	8							●						●			
0-age inactive	Oct-Mar	0.5%	-9.7%	3	⬤				⬤	●	⬤									●
1-age active rearing	Mar-May	0.5%	-5.3%	5	●				⬤	●	●									●
1-age migrant	Mar-Jun	0.5%	-0.2%	9							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%	10													•			
Prespawning holding	Oct-Dec	1.0%	-1.8%	7							●						●			●
All Stages Combined		1.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Deception Creek			**Stream:**	
Reach:	Deception Ck mouth to Prairie Creek			**Reach Length (mi):**	0.25
				Reach Code:	Deception-1
Restoration Benefit Category:1/	D	**Productivity Rank:1/**	12	**Potential % change in productivity:2/**	3.5%
Overall Restoration Potential Rank:1/	14	**Average Abundance (Neq) Rank:1/**	14	**Potential % change in Neq:2/**	1.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	D	**Productivity Rank:1/**	12	**loss in productivity with degradation:2/**	-2.3%
Overall Preservation Rank:1/	16	**Average Abundance (Neq) Rank:1/**	17	**% loss in Neq with degradation:2/**	-1.4%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	12	**% loss in diversity with degradation:2/**	-4.0%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-3.7%	4							●						●			○
Egg incubation	Oct-May	1.0%	-52.1%	1	⬤												⬤			○
Fry colonization	Mar-May	1.8%	-2.7%	3	●				●	●	●						•			●
0-age active rearing	Mar-Oct	0.2%	-14.9%	7	•				●	•	●				•	•		●		
0-age migrant	Oct-Nov	0.7%	-1.2%	8							●						•			
0-age inactive	Oct-Mar	0.5%	-14.3%	2	●				●	●	●									•
1-age active rearing	Mar-May	0.5%	-6.5%	5	●				●	•	●									•
1-age migrant	Mar-Jun	2.2%	-0.1%	9							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	4.0%	0.0%	10																
Prespawning holding	Oct-Dec	1.0%	-2.9%	6							●						●			
All Stages Combined		4.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Deception Creek			**Stream:**	
Reach:	Prairie Ck mouth to section 29/30 line; coho limit			**Reach Length (mi):**	1.08
				Reach Code:	Deception-2
Restoration Benefit Category:1/	D	**Productivity Rank:1/**	12	**Potential % change in productivity:2/**	3.5%
Overall Restoration Potential Rank:1/	14	**Average Abundance (Neq) Rank:1/**	14	**Potential % change in Neq:2/**	1.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	D	**Productivity Rank:1/**	12	**loss in productivity with degradation:2/**	-2.3%
Overall Preservation Rank:1/	16	**Average Abundance (Neq) Rank:1/**	17	**% loss in Neq with degradation:2/**	-1.4%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	12	**% loss in diversity with degradation:2/**	-4.0%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-3.3%	7							●						●			○
Egg incubation	Oct-May	1.0%	-44.5%	1	⬤												⬤			○
Fry colonization	Mar-May	1.3%	-8.1%	4	⬤				⬤	•	⬤						•			●
0-age active rearing	Mar-Oct	1.0%	-15.2%	3	●				⬤	•	⬤				●	●	•	⬤		●
0-age migrant	Oct-Nov	1.3%	-2.1%	8							⬤						●			
0-age inactive	Oct-Mar	1.0%	-18.3%	2	⬤				⬤	•	⬤									●
1-age active rearing	Mar-May	1.0%	-6.7%	5	●				⬤	•	⬤									•
1-age migrant	Mar-Jun	1.3%	-0.3%	9							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	2.0%	0.0%	10													•			
Prespawning holding	Oct-Dec	1.0%	-3.4%	6					•		⬤						●			
All Stages Combined		2.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Deception Creek			**Stream:**	
Reach:	Trib # 0075 mouth to fish limit			**Reach Length (mi):**	0.76
				Reach Code:	Deception-4
Restoration Benefit Category:1/	D	**Productivity Rank:1/**	12	**Potential % change in productivity:2/**	3.5%
Overall Restoration Potential Rank:1/	14	**Average Abundance (Neq) Rank:1/**	14	**Potential % change in Neq:2/**	1.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	D	**Productivity Rank:1/**	12	**loss in productivity with degradation:2/**	-2.3%
Overall Preservation Rank:1/	16	**Average Abundance (Neq) Rank:1/**	17	**% loss in Neq with degradation:2/**	-1.4%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	12	**% loss in diversity with degradation:2/**	-4.0%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-3.4%	5							●						•			
Egg incubation	Oct-May	1.0%	-47.2%	1	⬤												⬤			
Fry colonization	Mar-May	1.0%	-5.8%	4	⬤				⬤	•	⬤						•			⬤
0-age active rearing	Mar-Oct	0.7%	-15.0%	2	•				⬤	⬤	⬤				•	•		⬤		⬤
0-age migrant	Oct-Nov	0.7%	-1.6%	8							⬤						•			
0-age inactive	Oct-Mar	0.3%	-19.3%	3	⬤				⬤	•	⬤									•
1-age active rearing	Mar-May	0.3%	-8.6%	6	•				⬤	•	•									•
1-age migrant	Mar-Jun	0.3%	-0.2%	9							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%	10													•			
Prespawning holding	Oct-Dec	1.0%	-2.7%	7					•		⬤						•			
All Stages Combined		1.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Deception Creek			**Stream:**	
Reach:	Prairie Ck mouth to coho dist			**Reach Length (mi):**	0.25
				Reach Code:	Prairie-1
Restoration Benefit Category:1/	D	**Productivity Rank:1/**	12	**Potential % change in productivity:2/**	3.5%
Overall Restoration Potential Rank:1/	14	**Average Abundance (Neq) Rank:1/**	14	**Potential % change in Neq:2/**	1.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	D	**Productivity Rank:1/**	12	**loss in productivity with degradation:2/**	-2.3%
Overall Preservation Rank:1/	16	**Average Abundance (Neq) Rank:1/**	17	**% loss in Neq with degradation:2/**	-1.4%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	12	**% loss in diversity with degradation:2/**	-4.0%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-2.9%	5							●						●			○
Egg incubation	Oct-May	1.0%	-4.2%	4	●															○
Fry colonization	Mar-May	1.0%	-4.4%	3	•				●	•	●									●
0-age active rearing	Mar-Oct	0.5%	-14.5%	1	•				●	•	●				•	•	•	●		•
0-age migrant	Oct-Nov	0.7%	-2.3%	8							•						●			
0-age inactive	Oct-Mar	0.3%	-15.9%	2	•				●	•	●									•
1-age active rearing	Mar-May	0.3%	-7.8%	6	•				●	•	•									•
1-age migrant	Mar-Jun	0.3%	-0.1%	10							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%	11																
Prespawning holding	Oct-Dec	1.0%	-2.4%	7							●						●			●
All Stages Combined		1.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	●	◯
Extreme	●	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Lower Snahapish River			**Stream:**	
Reach:	Snahapish Riv mouth to mainline crossing			**Reach Length (mi):**	1.48
				Reach Code:	Snahapish-1
Restoration Benefit Category:1/	C	**Productivity Rank:1/**	10	**Potential % change in productivity:2/**	5.5%
Overall Restoration Potential Rank:1/	9	**Average Abundance (Neq) Rank:1/**	9	**Potential % change in Neq:2/**	2.3%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	11	**loss in productivity with degradation:2/**	-2.7%
Overall Preservation Rank:1/	13	**Average Abundance (Neq) Rank:1/**	9	**% loss in Neq with degradation:2/**	-5.1%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	17	**% loss in diversity with degradation:2/**	-1.2%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-0.9%	9							•						•			
Egg incubation	Oct-May	1.0%	-62.8%	1	●												●			
Fry colonization	Mar-May	1.3%	-6.5%	4	●				●	•	●						•			
0-age active rearing	Mar-Oct	1.2%	-11.7%	3	•				•	•	●				•	•		●		
0-age migrant	Oct-Nov	2.5%	-0.6%	7							•						•			
0-age inactive	Oct-Mar	1.3%	-10.7%	2	●				●	•	●									
1-age active rearing	Mar-May	1.3%	-4.6%	5	●				●	•	●									
1-age migrant	Mar-Jun	13.1%	-0.1%	6							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	14.1%	0.0%	10													•			
Prespawning holding	Oct-Dec	1.0%	-0.9%	8							•						•			
All Stages Combined		14.1%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	●	○
Extreme	●	○

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Upper Snahapish River			**Stream:**	
Reach:	Mainline crossing to West Fork Snahapish			**Reach Length (mi):**	5.53
				Reach Code:	Snahapish-2
Restoration Benefit Category:1/	B	**Productivity Rank:1/**	3	**Potential % change in productivity:2/**	28.7%
Overall Restoration Potential Rank:1/	4	**Average Abundance (Neq) Rank:1/**	3	**Potential % change in Neq:2/**	8.7%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	2	**loss in productivity with degradation:2/**	-29.6%
Overall Preservation Rank:1/	2	**Average Abundance (Neq) Rank:1/**	2	**% loss in Neq with degradation:2/**	-31.0%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	3	**% loss in diversity with degradation:2/**	-10.8%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	4.0%	-0.9%	8													●			
Egg incubation	Oct-May	4.0%	-43.5%	1	⬤												⬤			
Fry colonization	Mar-May	4.9%	-1.6%	5	●				●	●							•			
0-age active rearing	Mar-Oct	4.5%	-7.3%	2	•				●	●	●				●	●		⬤		
0-age migrant	Oct-Nov	6.4%	-0.8%	6													●			
0-age inactive	Oct-Mar	5.2%	-3.7%	3	●				●	●	●									
1-age active rearing	Mar-May	5.2%	-1.8%	4	●				●	●	•									
1-age migrant	Mar-Jun	11.7%	0.0%																	
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	13.1%	-0.1%	9													•			
Prespawning holding	Oct-Dec	4.0%	-1.0%	7													●			
All Stages Combined		13.1%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Upper Snahapish River			**Stream:**	
Reach:	West Fk Snahapish to Octopus Creek mouth			**Reach Length (mi):**	5.68
				Reach Code:	Snahapish-3
Restoration Benefit Category:1/	B	**Productivity Rank:1/**	3	**Potential % change in productivity:2/**	28.7%
Overall Restoration Potential Rank:1/	4	**Average Abundance (Neq) Rank:1/**	3	**Potential % change in Neq:2/**	8.7%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	2	**loss in productivity with degradation:2/**	-29.6%
Overall Preservation Rank:1/	2	**Average Abundance (Neq) Rank:1/**	2	**% loss in Neq with degradation:2/**	-31.0%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	3	**% loss in diversity with degradation:2/**	-10.8%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	4.0%	0.0%																	
Egg incubation	Oct-May	4.0%	-33.1%	1	●												⬤			
Fry colonization	Mar-May	4.9%	-2.1%	4					●	●	●									
0-age active rearing	Mar-Oct	4.2%	-7.4%	2					●	●	●				●	●		⬤		
0-age migrant	Oct-Nov	5.4%	0.0%																	
0-age inactive	Oct-Mar	4.0%	-3.0%	3	●				●	●	●									
1-age active rearing	Mar-May	4.0%	-1.9%	5					●	●	●									
1-age migrant	Mar-Jun	5.0%	0.0%																	
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	7.0%	0.0%																	
Prespawning holding	Oct-Dec	4.0%	0.0%																	
All Stages Combined		7.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Upper Snahapish River			**Stream:**	
Reach:	Ocotpus Ck. to coho limit			**Reach Length (mi):**	1.60
				Reach Code:	Snahapish-4
Restoration Benefit Category:1/	B	**Productivity Rank:1/**	3	**Potential % change in productivity:2/**	28.7%
Overall Restoration Potential Rank:1/	4	**Average Abundance (Neq) Rank:1/**	3	**Potential % change in Neq:2/**	8.7%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	2	**loss in productivity with degradation:2/**	-29.6%
Overall Preservation Rank:1/	2	**Average Abundance (Neq) Rank:1/**	2	**% loss in Neq with degradation:2/**	-31.0%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	3	**% loss in diversity with degradation:2/**	-10.8%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	2.0%	0.0%																	
Egg incubation	Oct-May	2.0%	-32.5%	1	●												⬤			
Fry colonization	Mar-May	2.2%	-1.2%	3					●	●	●									
0-age active rearing	Mar-Oct	1.2%	-7.6%	2					●	●	●				●	●		⬤		
0-age migrant	Oct-Nov	1.2%	0.0%																	
0-age inactive	Oct-Mar	0.3%	-3.4%	4	•				●	●	●									
1-age active rearing	Mar-May	0.3%	-1.8%	5					●	•	•									
1-age migrant	Mar-Jun	0.3%	0.0%																	
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	2.0%	0.0%																	
Prespawning holding	Oct-Dec	2.0%	0.0%																	
All Stages Combined		2.2%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.

Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Snahapish Tribs			**Stream:**	
Reach:	West Fork Snahapish mouth to Trib0080; coho limit			**Reach Length (mi):**	1.49
				Reach Code:	W.F. Snahapish-1
Restoration Benefit Category:1/	D	**Productivity Rank:1/**	13	**Potential % change in productivity:2/**	3.3%
Overall Restoration Potential Rank:1/	12	**Average Abundance (Neq) Rank:1/**	12	**Potential % change in Neq:2/**	1.5%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	D	**Productivity Rank:1/**	13	**loss in productivity with degradation:2/**	-2.1%
Overall Preservation Rank:1/	14	**Average Abundance (Neq) Rank:1/**	13	**% loss in Neq with degradation:2/**	-2.6%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	14	**% loss in diversity with degradation:2/**	-3.1%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-2.4%	6							●						●			
Egg incubation	Oct-May	1.0%	-18.4%	1	⬤															
Fry colonization	Mar-May	1.2%	-8.5%	4	●				⬤	⬤	⬤						●			
0-age active rearing	Mar-Oct	1.0%	-14.0%	3	●		●		●	⬤	⬤				●	●		⬤		
0-age migrant	Oct-Nov	1.5%	-1.9%	8							●						●			
0-age inactive	Oct-Mar	1.0%	-14.4%	2	⬤				⬤	⬤	⬤									
1-age active rearing	Mar-May	1.0%	-6.5%	5	●		•		⬤	●	●									
1-age migrant	Mar-Jun	1.5%	-0.4%	9							●									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	2.0%	0.0%	11													•			
Prespawning holding	Oct-Dec	1.0%	-2.4%	7							●						●			
All Stages Combined		2.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Snahapish Tribs			**Stream:**	
Reach:	Unnamed Trib0079 mouth to fish limit			**Reach Length (mi):**	1.16
				Reach Code:	W.F. Snahapish-2
Restoration Benefit Category:1/	D	**Productivity Rank:1/**	13	**Potential % change in productivity:2/**	3.3%
Overall Restoration Potential Rank:1/	12	**Average Abundance (Neq) Rank:1/**	12	**Potential % change in Neq:2/**	1.5%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	D	**Productivity Rank:1/**	13	**loss in productivity with degradation:2/**	-2.1%
Overall Preservation Rank:1/	14	**Average Abundance (Neq) Rank:1/**	13	**% loss in Neq with degradation:2/**	-2.6%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	14	**% loss in diversity with degradation:2/**	-3.1%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-2.2%	7							●						●			
Egg incubation	Oct-May	1.0%	-3.9%	4	●															
Fry colonization	Mar-May	1.0%	-10.4%	2	●				●	●	●						●			
0-age active rearing	Mar-Oct	0.8%	-14.7%	1	•		•		●	●	●				•	•	•	●		
0-age migrant	Oct-Nov	0.8%	-1.8%	8							●						●			
0-age inactive	Oct-Mar	0.5%	-12.5%	3	●				●	●	●									
1-age active rearing	Mar-May	0.5%	-5.9%	6	•		•		●	•	•									
1-age migrant	Mar-Jun	0.5%	-0.1%	9							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%	10																
Prespawning holding	Oct-Dec	1.0%	-3.1%	5					•		●						●			
All Stages Combined		1.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	●	◯
Extreme	●	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Snahapish Tribs			**Stream:**	
Reach:	Octopus Ck mouth to coho limit			**Reach Length (mi):**	0.57
				Reach Code:	Octopus-1
Restoration Benefit Category:1/	D	**Productivity Rank:1/**	13	**Potential % change in productivity:2/**	3.3%
Overall Restoration Potential Rank:1/	12	**Average Abundance (Neq) Rank:1/**	12	**Potential % change in Neq:2/**	1.5%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	D	**Productivity Rank:1/**	13	**loss in productivity with degradation:2/**	-2.1%
Overall Preservation Rank:1/	14	**Average Abundance (Neq) Rank:1/**	13	**% loss in Neq with degradation:2/**	-2.6%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	14	**% loss in diversity with degradation:2/**	-3.1%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-2.2%	7							●						•			○
Egg incubation	Oct-May	1.0%	-34.3%	1	●												●			○
Fry colonization	Mar-May	1.2%	-8.8%	4	●				●	●	●						•			●
0-age active rearing	Mar-Oct	1.0%	-14.7%	2	•		•		●	●	●				•	•		●		•
0-age migrant	Oct-Nov	1.0%	-1.2%	9							•						•			
0-age inactive	Oct-Mar	0.7%	-11.9%	4	●				●	●	●									•
1-age active rearing	Mar-May	0.7%	-6.3%	5	•		•		●	•	•									•
1-age migrant	Mar-Jun	0.7%	-0.1%	10							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%	11																
Prespawning holding	Oct-Dec	1.0%	-3.6%	6					•		●						•			•
All Stages Combined		1.2%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	●	○
Extreme	●	○

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Bull Creek			**Stream:**	
Reach:	Bull Ck mouth to mainline roadcrossing			**Reach Length (mi):**	0.56
				Reach Code:	Bull-1
Restoration Benefit Category:1/	D	**Productivity Rank:1/**	13	**Potential % change in productivity:2/**	3.3%
Overall Restoration Potential Rank:1/	13	**Average Abundance (Neq) Rank:1/**	13	**Potential % change in Neq:2/**	1.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	D	**Productivity Rank:1/**	13	**loss in productivity with degradation:2/**	-2.1%
Overall Preservation Rank:1/	14	**Average Abundance (Neq) Rank:1/**	15	**% loss in Neq with degradation:2/**	-2.0%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	13	**% loss in diversity with degradation:2/**	-3.5%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-2.0%	6							●						●			○
Egg incubation	Oct-May	1.0%	-40.3%	1	⬤												⬤			○
Fry colonization	Mar-May	1.8%	-2.6%	4	●				●	●	●						•			●
0-age active rearing	Mar-Oct	1.0%	-9.8%	2	●				●	●	●				●	•		●		●
0-age migrant	Oct-Nov	2.0%	-0.5%	8							●						●			
0-age inactive	Oct-Mar	0.7%	-6.5%	4	●				●	●	●									•
1-age active rearing	Mar-May	0.7%	-3.2%	5	●				●	●	●									•
1-age migrant	Mar-Jun	1.5%	-0.1%	11							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	3.0%	0.0%	12																
Prespawning holding	Oct-Dec	1.0%	-1.9%	7					•		●						●			•
All Stages Combined		3.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Bull Creek			**Stream:**	
Reach:	Mainline to coho limit			**Reach Length (mi):**	1.69
				Reach Code:	Bull-2
Restoration Benefit Category:1/	D	**Productivity Rank:1/**	13	**Potential % change in productivity:2/**	3.3%
Overall Restoration Potential Rank:1/	13	**Average Abundance (Neq) Rank:1/**	13	**Potential % change in Neq:2/**	1.2%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	D	**Productivity Rank:1/**	13	**loss in productivity with degradation:2/**	-2.1%
Overall Preservation Rank:1/	14	**Average Abundance (Neq) Rank:1/**	15	**% loss in Neq with degradation:2/**	-2.0%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	13	**% loss in diversity with degradation:2/**	-3.5%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	2.0%	-1.6%	6							●						●			○
Egg incubation	Oct-May	2.0%	-42.1%	1	⬤												⬤			○
Fry colonization	Mar-May	2.0%	-4.3%	3	●				⬤	●	⬤									⬤
0-age active rearing	Mar-Oct	1.3%	-10.0%	2	●				●	●	⬤				●	●	•	⬤		●
0-age migrant	Oct-Nov	1.5%	-0.9%	8							●						●			
0-age inactive	Oct-Mar	0.8%	-9.5%	4	●				⬤	●	⬤									●
1-age active rearing	Mar-May	0.8%	-3.8%	7	●				●	●	●									●
1-age migrant	Mar-Jun	0.8%	-0.1%	9							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	2.0%	0.0%	10																
Prespawning holding	Oct-Dec	2.0%	-1.8%	5					•		●						●			●
All Stages Combined		2.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Stequaleho Creek			**Stream:**	
Reach:	Stequaleho Ck mouth to the Falls @ RM2			**Reach Length (mi):**	2.16
				Reach Code:	Stequaleho-1
Restoration Benefit Category:1/	D	**Productivity Rank:1/**	15	**Potential % change in productivity:2/**	3.1%
Overall Restoration Potential Rank:1/	15	**Average Abundance (Neq) Rank:1/**	15	**Potential % change in Neq:2/**	1.1%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	D	**Productivity Rank:1/**	17	**loss in productivity with degradation:2/**	-1.4%
Overall Preservation Rank:1/	17	**Average Abundance (Neq) Rank:1/**	16	**% loss in Neq with degradation:2/**	-1.6%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	15	**% loss in diversity with degradation:2/**	-2.1%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	2.0%	-1.8%	6							●						●			
Egg incubation	Oct-May	2.0%	-50.1%	1	⬤												⬤			•
Fry colonization	Mar-May	2.0%	-5.5%	3	⬤				⬤	⬤	⬤						●			●
0-age active rearing	Mar-Oct	1.7%	-9.7%	2	●				⬤	⬤	⬤				●	●		⬤		●
0-age migrant	Oct-Nov	1.7%	-0.8%	7							●									
0-age inactive	Oct-Mar	1.0%	-8.0%	4	⬤				●	●	⬤									●
1-age active rearing	Mar-May	1.0%	-4.4%	5	●				●	●	●									●
1-age migrant	Mar-Jun	1.0%	-0.2%	9							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	2.0%	0.0%																	
Prespawning holding	Oct-Dec	2.0%	-0.2%	8													●			●
All Stages Combined		2.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Solleks River			**Stream:**	
Reach:	Solleks River mouth to Kloochman Creek mouth			**Reach Length (mi):**	5.05
				Reach Code:	Solleks-1
Restoration Benefit Category:1/	B	**Productivity Rank:1/**	7	**Potential % change in productivity:2/**	6.8%
Overall Restoration Potential Rank:1/	4	**Average Abundance (Neq) Rank:1/**	5	**Potential % change in Neq:2/**	4.0%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**Potential % change in diversity:2/**	2.4%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	13	**loss in productivity with degradation:2/**	-2.1%
Overall Preservation Rank:1/	11	**Average Abundance (Neq) Rank:1/**	10	**% loss in Neq with degradation:2/**	-4.3%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	11	**% loss in diversity with degradation:2/**	-5.2%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	4.0%	-3.8%	6							●						⬤			
Egg incubation	Oct-May	4.0%	-76.3%	1	⬤												⬤			•
Fry colonization	Mar-May	5.4%	-7.7%	4	⬤				⬤	●	⬤						●			●
0-age active rearing	Mar-Oct	5.0%	-15.2%	2	●				⬤	●	⬤				●	●	•	⬤		●
0-age migrant	Oct-Nov	6.2%	-2.4%	7							●						●			
0-age inactive	Oct-Mar	4.5%	-15.3%	3	⬤				⬤	●	⬤						•			●
1-age active rearing	Mar-May	4.5%	-5.7%	5	●				●	●	⬤						●			●
1-age migrant	Mar-Jun	7.0%	-0.5%	9							●						●			
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	9.0%	-0.1%	10													•			
Prespawning holding	Oct-Dec	4.0%	-2.1%	8					•								●			●
All Stages Combined		9.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Solleks River	**Stream:**	
Reach:	Kloochman Ck mouth to coho limit (Grouse Ck mouth)	**Reach Length (mi):**	1.99
		Reach Code:	Solleks-2

Restoration Benefit Category:1/	B	**Productivity Rank:1/**	7	**Potential % change in productivity:2/**	6.8%
Overall Restoration Potential Rank:1/	4	**Average Abundance (Neq) Rank:1/**	5	**Potential % change in Neq:2/**	4.0%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**Potential % change in diversity:2/**	2.4%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	13	**loss in productivity with degradation:2/**	-2.1%
Overall Preservation Rank:1/	11	**Average Abundance (Neq) Rank:1/**	10	**% loss in Neq with degradation:2/**	-4.3%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	11	**% loss in diversity with degradation:2/**	-5.2%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival**															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	2.0%	-3.5%	6							●						⬤			
Egg incubation	Oct-May	2.0%	-48.7%	1	⬤															•
Fry colonization	Mar-May	2.3%	-6.3%	4	⬤				⬤	●	⬤						●			●
0-age active rearing	Mar-Oct	1.7%	-11.3%	2	●				⬤	●	⬤				●	•	•	●		●
0-age migrant	Oct-Nov	2.0%	-1.5%	8							●						●			
0-age inactive	Oct-Mar	1.5%	-10.6%	3	⬤				⬤	●	⬤									●
1-age active rearing	Mar-May	1.5%	-5.1%	5	●				⬤	●	●						●			●
1-age migrant	Mar-Jun	1.8%	-0.3%	9							●						•			
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	3.0%	0.0%	10													•			
Prespawning holding	Oct-Dec	2.0%	-2.2%	7					•								⬤			●
All Stages Combined		3.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Solleks River			**Stream:**	
Reach:	Grouse Ck to Grouse Ck fish limit			**Reach Length (mi):**	0.45
				Reach Code:	Grouse-1
Restoration Benefit Category:1/	B	**Productivity Rank:1/**	7	**Potential % change in productivity:2/**	6.8%
Overall Restoration Potential Rank:1/	4	**Average Abundance (Neq) Rank:1/**	5	**Potential % change in Neq:2/**	4.0%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	1	**Potential % change in diversity:2/**	2.4%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	13	**loss in productivity with degradation:2/**	-2.1%
Overall Preservation Rank:1/	11	**Average Abundance (Neq) Rank:1/**	10	**% loss in Neq with degradation:2/**	-4.3%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	11	**% loss in diversity with degradation:2/**	-5.2%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-1.6%	5							●						•			●
Egg incubation	Oct-May	1.0%	-1.9%	4	●															●
Fry colonization	Mar-May	1.0%	-5.4%	1	•				●	•	●									●
0-age active rearing	Mar-Oct	0.7%	-7.3%	2	•				●	•	●				•					●
0-age migrant	Oct-Nov	0.7%	-1.5%	7							•						•			
0-age inactive	Oct-Mar	0.3%	-9.4%	3	•				●	•	●									●
1-age active rearing	Mar-May	0.3%	-4.3%	6	•				•	•	•									•
1-age migrant	Mar-Jun	0.3%	-0.1%	9							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%	10																
Prespawning holding	Oct-Dec	1.0%	-0.9%	8							•						•			●
All Stages Combined		1.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	●	○
Extreme	●	○

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Misc Upper Clearwater Tribs			**Stream:**	
Reach:	Kloochman mouth to Kloochman coho limit			**Reach Length (mi):**	1.75
				Reach Code:	Kloochman-1
Restoration Benefit Category:1/	D	**Productivity Rank:1/**	16	**Potential % change in productivity:2/**	1.8%
Overall Restoration Potential Rank:1/	17	**Average Abundance (Neq) Rank:1/**	16	**Potential % change in Neq:2/**	0.6%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	9	**loss in productivity with degradation:2/**	-3.5%
Overall Preservation Rank:1/	10	**Average Abundance (Neq) Rank:1/**	14	**% loss in Neq with degradation:2/**	-2.0%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	7	**% loss in diversity with degradation:2/**	-6.4%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	2.0%	-2.2%	4							●						●			
Egg incubation	Oct-May	2.0%	-1.7%	6	●															
Fry colonization	Mar-May	2.2%	-4.9%	2	●				●	●	●									●
0-age active rearing	Mar-Oct	1.3%	-6.9%	2	•				●	●	●				●					●
0-age migrant	Oct-Nov	1.3%	-1.2%	8							●						●			
0-age inactive	Oct-Mar	0.7%	-8.4%	3	●				●	●	●									•
1-age active rearing	Mar-May	0.7%	-5.4%	5	●				●	●	●									•
1-age migrant	Mar-Jun	0.7%	-0.2%	10							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	2.0%	0.0%	11																
Prespawning holding	Oct-Dec	2.0%	-1.0%	7					•		●						●			
All Stages Combined		2.2%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	●	○
Extreme	●	○

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Misc Upper Clearwater Tribs			**Stream:**	
Reach:	Itswoot Ck mouth to coho limit			**Reach Length (mi):**	0.30
				Reach Code:	Itswoot-1
Restoration Benefit Category:1/	D	**Productivity Rank:1/**	16	**Potential % change in productivity:2/**	1.8%
Overall Restoration Potential Rank:1/	17	**Average Abundance (Neq) Rank:1/**	16	**Potential % change in Neq:2/**	0.6%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	9	**loss in productivity with degradation:2/**	-3.5%
Overall Preservation Rank:1/	10	**Average Abundance (Neq) Rank:1/**	14	**% loss in Neq with degradation:2/**	-2.0%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	7	**% loss in diversity with degradation:2/**	-6.4%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-0.9%	5							●						●			
Egg incubation	Oct-May	1.0%	-9.0%	1	⬤															
Fry colonization	Mar-May	1.2%	-3.1%	3	●				●	●	●									●
0-age active rearing	Mar-Oct	0.7%	-6.1%	2	•				●	●	⬤				●					●
0-age migrant	Oct-Nov	0.7%	-0.6%	8							●									
0-age inactive	Oct-Mar	0.2%	-8.3%	4	●				●	●	●									•
1-age active rearing	Mar-May	0.2%	-4.0%	7	•				●	•	●									•
1-age migrant	Mar-Jun	0.2%	0.0%	10																
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%																	
Prespawning holding	Oct-Dec	1.0%	-0.1%	9													•			
All Stages Combined		1.2%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Misc Upper Clearwater Tribs			**Stream:**	
Reach:	Kunamaskt Ck mouth to mainline/Trib0118;			**Reach Length (mi):**	1.12
				Reach Code:	Kunamaskt-1
Restoration Benefit Category:1/	D	**Productivity Rank:1/**	16	**Potential % change in productivity:2/**	1.8%
Overall Restoration Potential Rank:1/	17	**Average Abundance (Neq) Rank:1/**	16	**Potential % change in Neq:2/**	0.6%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	9	**loss in productivity with degradation:2/**	-3.5%
Overall Preservation Rank:1/	10	**Average Abundance (Neq) Rank:1/**	14	**% loss in Neq with degradation:2/**	-2.0%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	7	**% loss in diversity with degradation:2/**	-6.4%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-1.1%	5							●						●			
Egg incubation	Oct-May	1.0%	-29.4%	1	⬤															
Fry colonization	Mar-May	1.3%	-2.7%	4	●				●	●	●									●
0-age active rearing	Mar-Oct	1.0%	-4.1%	2	•				⬤	●	●				●					●
0-age migrant	Oct-Nov	1.0%	-0.4%	8							●									
0-age inactive	Oct-Mar	0.3%	-5.0%	4	●				●	●	●									●
1-age active rearing	Mar-May	0.3%	-3.0%	6	●				●	●	●									●
1-age migrant	Mar-Jun	0.3%	-0.2%	10							•									
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%																	
Prespawning holding	Oct-Dec	1.0%	-0.1%	9													•			
All Stages Combined		1.3%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Species/Component:	Coho
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Clearwater River - Coho

Geographic Area:	Misc Upper Clearwater Tribs			**Stream:**	
Reach:	Susie Ck mouth to coho limit			**Reach Length (mi):**	0.36
				Reach Code:	Susie-1
Restoration Benefit Category:1/	D	**Productivity Rank:1/**	16	**Potential % change in productivity:2/**	1.8%
Overall Restoration Potential Rank:1/	17	**Average Abundance (Neq) Rank:1/**	16	**Potential % change in Neq:2/**	0.6%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	6	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	C	**Productivity Rank:1/**	9	**loss in productivity with degradation:2/**	-3.5%
Overall Preservation Rank:1/	10	**Average Abundance (Neq) Rank:1/**	14	**% loss in Neq with degradation:2/**	-2.0%
(lowest rank possible - with ties)1/	18	**Life History Diversity Rank:1/**	7	**% loss in diversity with degradation:2/**	-6.4%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
					Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	1.0%	-1.6%	5							●						●			○
Egg incubation	Oct-May	1.0%	-2.7%	3	●															○
Fry colonization	Mar-May	1.0%	-2.9%	1	●				●	●	●									●
0-age active rearing	Mar-Oct	0.3%	-8.6%	2	•				●	●	●				●					●
0-age migrant	Oct-Nov	0.3%	-0.7%	8							●									
0-age inactive	Oct-Mar	0.2%	-11.7%	4	●				●	●	●									●
1-age active rearing	Mar-May	0.2%	-7.1%	6	●				●	●	●									●
1-age migrant	Mar-Jun	0.2%	0.0%	9																
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Nov	1.0%	0.0%																	
Prespawning holding	Oct-Dec	1.0%	-1.0%	7					•		●						•			
All Stages Combined		1.0%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	●	◯
Extreme	●	◯