EDT as Applied in the Clearwater River

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Submitted by

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INTRODUCTION

This document presents the results of an Ecosystem Diagnosis and Treatment (EDT) analysis as applied to naturally produced coho in the Clearwater River. The Clearwater EDT analysis provides an evaluation of the EDT model as a tool that can assist with the development of a plan for the restoration and protection of salmon habitat in the Clearwater River. A more detailed analysis of the results presented in this report and recommendations for using them in developing a basin plan will be described in a companion report being authored by WDNR.

This first chapter begins with a brief overview of the project, followed by a description of the specific objectives. Project components are then described and the application of the EDT method discussed. The chapter concludes with an outline of the report.

Overview

Salmon survival depends on the condition of diverse habitats along the aquatic landscape. The quality and quantity of habitats—from gravel beds in headwater streams to eelgrass beds in nearshore marine areas—affect the performance of salmon populations. Although protecting or restoring these habitats in a strategic manner requires locally based solutions suited to the needs of each watershed, protection and restoration can only be achieved through coordinated multi-jurisdictional efforts based on a rational process for identifying and prioritizing actions aimed at those factors that most affect salmon survival.

The Washington Department of Natural Resources (WDNR) is the major land management agency in the Clearwater drainage and has a significant stake in developing a plan for protecting and restoring salmon habitat in the basin. WDNR has initiated this process by undertaking, in collaboration with Mobrand Biometrics, Inc. (MBI), the EDT analysis described in this document. The data inputs to the model were provided by WDNR staff with assistance from MBI.

The EDT analysis presented here addresses eighteen watersheds within the Clearwater Basin (see Chapter 2 for a complete listing of the watersheds, streams, and reaches modeled). The analysis focused on naturally produced coho salmon.

Objectives

The project, as contracted to MBI, had as its primary objectives: applying the EDT method to the Clearwater River drainage on the Olympic Peninsula to aid in hypothesis generation for a WDNR Habitat Conservation Plan for salmon validation monitoring.

To meet this broad objective, MBI was specifically tasked with

- Assisting WDNR in completing the baseline model inputs, including delineation and characterization of reaches using the standard EDT environmental attributes
- Assisting WDNR with diagnostic model runs for the baseline condition for coho salmon

Assisting WDNR with developing a future condition (scenario) to evaluate the usefulness of the EDT model for developing a habitat plan in the watershed.

Components

The project consisted of four major components:

1. Completion of draft inputs and preliminary model runs for calibration purposes
2. Analysis of population performance for the baseline conditions: current and template (in this analysis, the template is a reconstruction of the historical condition)
3. Diagnosis of factors affecting population performance
4. Analysis of hypothetical future conditions

Two baseline reference scenarios were characterized: current conditions and template (historic) conditions. The comparison of these scenarios forms the basis of the diagnostic conclusions about how the basin and associated salmon performance have been altered by human development. The historic reference scenario also serves to define the natural limits to potential recovery actions within the Clearwater Basin.

Population performance was evaluated for the current and template scenarios at two life history points 1) number of adults surviving to spawn (i.e., number adults on the spawning grounds) and 2) number of smolts emigrating from the Clearwater River. The Clearwater Basin is unique in that a long time-series of observations for the current condition is available for both life history points.

The diagnosis was structured to provide an assessment of where conditions have degraded relative to the template condition, revealing what factors have suffered the greatest decline (as experienced by coho salmon). These conclusions can form the basis for developing a restoration strategy. Equally important, these conclusions can be used to identify high priority areas for protection—i.e., the model results may be used to evaluate the effect on population performance if a reach or group of reaches is substantially degraded from the current condition. This analysis is hypothetical, but it is useful in the development of protection strategies.

Finally, WDNR staff provided a characterization of the Clearwater Basin for a future condition that may represent a target condition for the basin as described in a habitat conservation plan (HCP). In addition, another scenario was modeled for the basin that represents properly functioning conditions (PFC) as defined by the National Marine Fisheries Service (NMFS). The PFC scenario was based on rules developed and applied in Puget Sound drainages for developing recovery targets.

Approach—Use of the EDT Method

Ecosystem Diagnosis and Treatment (EDT) is an analytical method relating habitat features and biological performance to support conservation and recovery planning (Lichatowich et al. 1995; Lestelle et al. 1996; Mobrand et al. 1997; Mobrand et al. 1998). EDT is an analytical framework that brings together information from empirical observation, local experts, and other models and analyses.

EDT emphasizes the importance of a science-based approach to recovery planning. Fundamental to the scientific method is the use of an explicit conceptual framework within which information about the natural system is gathered, organized, and analyzed. The EDT method requires that a logical linkage between actions and events within the watershed and their effect on values and objectives is presumed and explicitly addressed.

EDT differs from models often used in fish and wildlife management and offers important features that can augment conventional methods. EDT is best described as a scientific model (see Hilborn and Mangel 1997, *The Ecological Detective*). A scientific model attempts to explain the mechanisms behind a phenomenon to form an overall hypothesis. This contrasts with conventional statistical models that provide correlation-based predictions of events without necessarily explaining the underlying mechanism. As a scientific model, EDT constructs a working hypothesis of a watershed as a basis for planning and for comparison of alternative futures. This hypothesis provides metrics to gauge progress and testable hypotheses to refine knowledge. EDT helps us understand and describe the inevitable complexity of ecological systems in order to plan effective recovery strategies. A statistical model, on the other hand, seeks to reduce complexity to a small number of predictive or correlated variables. Thus, a scientific model like EDT provides the hypothesis—the rationale that links actions and expected outcomes—while a statistical model can provide the test.

Validation of a scientific model as a planning tool involves establishing the model's usefulness to the problem at hand. Three criteria or questions for judging the usefulness of such a model are suggested:

- Does it produce results that are consistent with what we observe
- How well does it explain what we observe;
- Is it useful for guiding future actions?

The EDT method has been widely applied throughout the Pacific Northwest in a variety of rivers. For example, EDT is currently being used by the Puget Sound Technical Review Team (PS-TRT) as an analytical tool to develop recovery targets for Puget Sound chinook and is being evaluated to develop basin recovery plans in the Snohomish and Puyallup rivers (case studies).

Document Organization

This document is organized into three chapters:

1. Introduction
2. The EDT Method as Applied to the Clearwater River
3. Resource Assessment: the assessment of the Clearwater River with respect to the performance of coho

Three appendixes accompany this report:

- Appendix A: The EDT Method
- Appendix B: EDT Information Structure
- Appendix C: Stream Reach Analysis for Clearwater Coho Performance

THE EDT METHOD AS APPLIED TO THE CLEARWATER WATERSHED

This chapter describes the basic components of the EDT method as it was applied in the Clearwater analysis. A more complete description of the conceptual design and application of EDT may be found at http://www.mobrand.com/library.html. Appendix A of this report also provides a brief primer of the EDT process, and Appendix B describes the information structure of EDT in detail.

The EDT method consists of three basic components:

- Conceptual and Information Framework—a way of organizing information to describe a watershed ecosystem for analyzing biological performance
- Analytical Model—a tool used to analyze environmental information and draw conclusions about the ecosystem
- Step-by-Step Procedure—the steps followed in applying EDT; these are described as applied in the Clearwater analysis

Conceptual and Information Framework

The following subsection describes the conceptual aspect of the framework employed by the EDT method. Following this discussion, the actual information structure is described.

<ins>The Framework Concept</ins>

The conceptual framework for the EDT method consists of three major elements: a vision, a set of biological objectives, and the strategies (actions) for moving the watershed toward the vision (Figure 1).

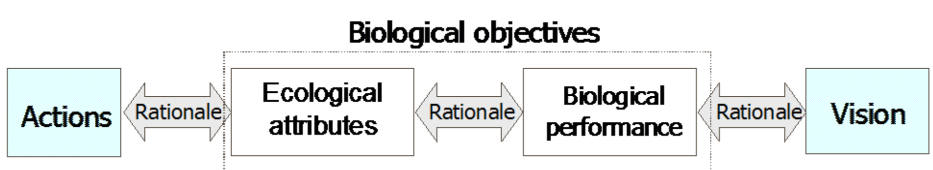


Figure 1. The EDT conceptual framework.

The vision describes a set of desired future conditions with regard to biological, economic, and social values. In an ESA context, these desired conditions address recovery objectives for salmon species. The biological objectives describe the vision with respect to the characteristics of the environment and associated biological performance of species under those conditions. The strategies are those actions intended to achieve the biological objectives.

This simple framework forms the core of the EDT method—it is the framework that has been adopted by the Northwest Power Planning Council for planning recovery actions in the Columbia Basin.

This framework is the pathway for linking various potential watershed actions to desired outcomes. It provides the rationale for identifying how actions are transferred through the ecosystem into resource outcomes. The framework explains possible consequences of actions in a manner consistent with existing knowledge and information, and it requires that assumptions necessary to watershed planning be identified—thus it becomes a vehicle for learning and communicating.

Ecological Information Structure

The information structure and associated data categories utilized in EDT are defined at three levels of organization. Together, these can be thought of as an information pyramid in which each level builds on information from the lower level (Figure 2).

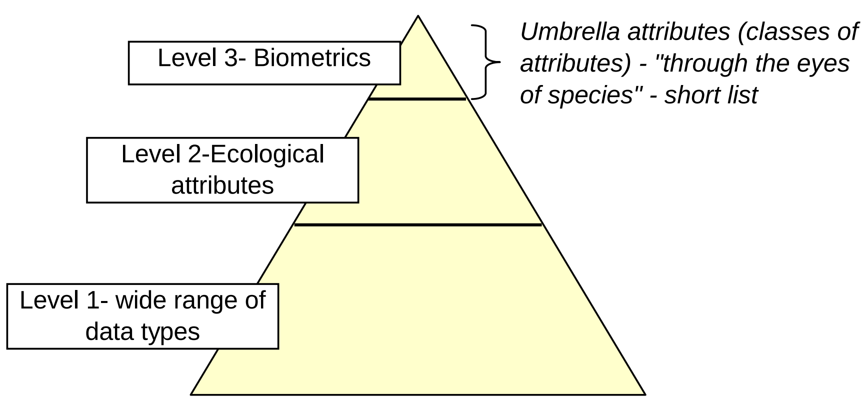


Figure 2. Data/information pyramid—information derived from supporting levels.

Moving up through the three levels presents an increasingly organism-centered view of the ecosystem. Levels 1 and 2 together characterize the environment, or ecosystem, as it can be described by different types of data, providing 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.

The organization and flow of information (as depicted in Figure 3) begins with a wide range of environmental data (Level 1 data) that describes a watershed, including all of the various types of empirically based data available. These data include reports and unpublished data. Level 1 data exist in a variety of forms and pedigrees. The Level 1 information is then summarized or synthesized into a standardized set of attributes (Level 2 ecological attributes, see Table 1) that refine the basic description of the watershed. The Level 2 attributes are descriptors that specify physical and biological characteristics about the environment relevant to the derivation of the survival and habitat capacity factors for the specific species in Level 3. Appendix B contains a more detailed description of the EDT information structure, including definitions for Level 2 and Level 3 attributes and a matrix showing associations between the two levels.

The Level 2 attributes represent conclusions that characterize conditions in the watershed at specific locations, during a particular time of year (season or month), and for an associated management scenario. Hence an attribute value is an assumed conclusion by site, time of year, and scenario. These assumptions become operating hypotheses for these attributes under specific scenarios. Where Level 1 data are sufficient, these Level 2 conclusions can be derived through simple rules. However, in many 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.

Analytical Model

The tools essential for applying the EDT method have been assembled into the EDT model: a repository of data, information, and knowledge, as well as a collection of analytical procedures. The model includes a database that stores and documents information about the geography and physical characteristics of the watersheds of interest. Also included are databases that describe and document the biology, life history characteristics, and environmental sensitivities of a set of indicator species. The EDT model includes a module for developing alternative future scenarios by defining action strategies and targeted environmental attributes.

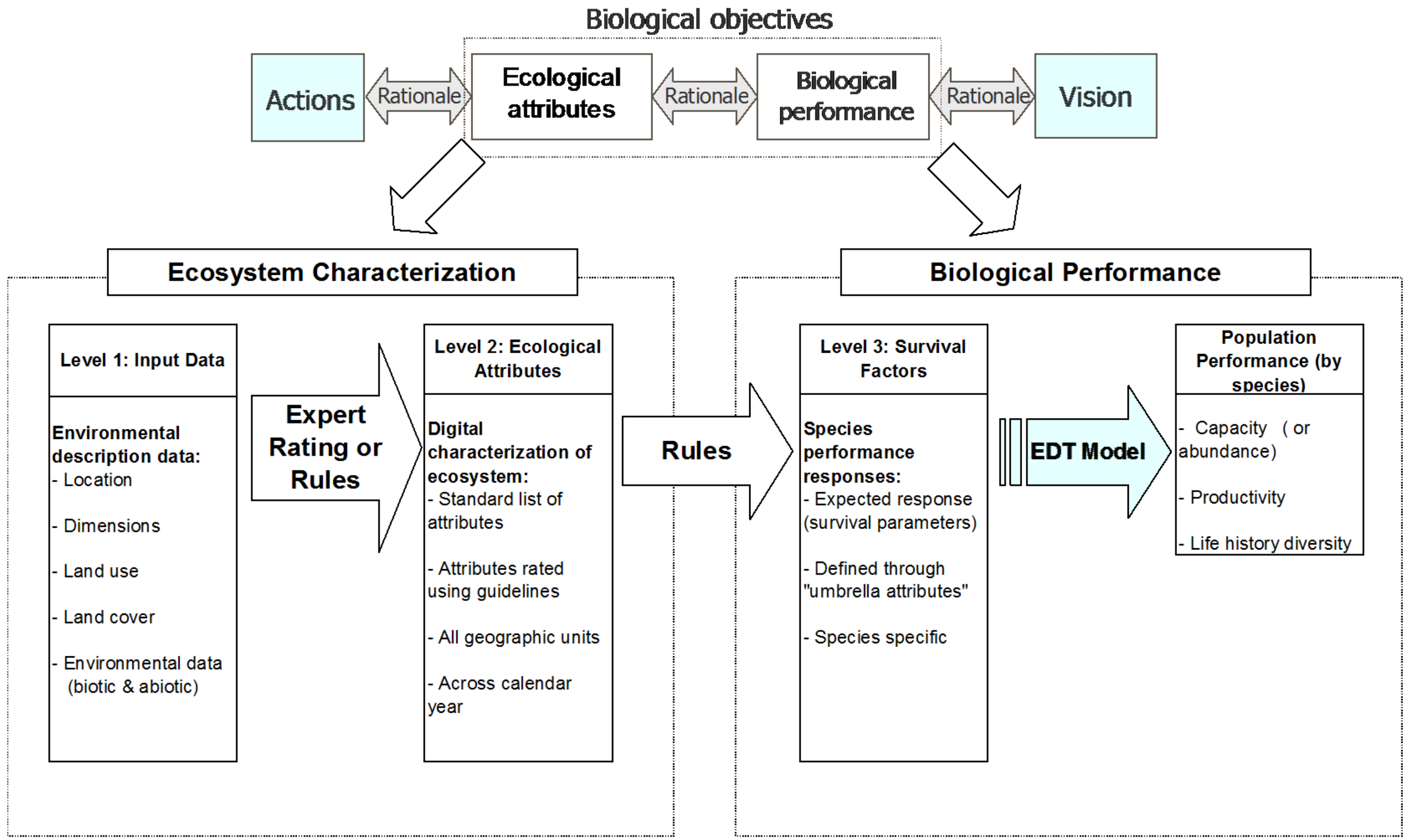


Figure 3. Ecological Information Structure.

Table 1. Hierarchical organization of Environmental Attributes (Level 2) by categories of major stream corridor features. Corresponding salmonid Survival Factors (Level 3) are shown associated with groups of Level 2 attributes (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	
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	
	Water withdrawals (impingement and entrainment)	
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)	

Table 1 continued.

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

The EDT model makes it possible to manage the complexity and quantity of detailed information needed to use the EDT method. The model facilitates the addressing of tractable issues and problems in the context of a broad framework, which integrates a wide range of scientific disciplines. The model is a tool for achieving accountability: it expandsthe ability of scientists to keep track of complex relationships and opens broader horizons for creativity.

The analytical tools included in the model compute the various diagnostic indicators described and displayed elsewhere in this document. The principal outputs are the parameter estimates of biological performance for the fish populations of interest. These parameters are then used by the model in deriving other diagnostics of interest, such as strategic priorities for conservation and recovery actions.

Biological performance is defined in terms of three elements: productivity, capacity[1], and life history diversity (Figure 4). These measures are characteristics of the ecosystem that describe persistence, abundance, and distribution potential of a population. They are the core performance measures used by NMFS as part of its viable population concept (see McElhany et al. 2000). Each measure is defined briefly below.

Productivity. This element represents the relative success of the species to complete its life cycle within the environment it experiences.[2] It

[1] The terms productivity and capacity are used here 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.

[2] The productivity rate is the reproductive rate measured over a full generation that would occur at low population density, i.e., when competition for resources among the population is minimal.

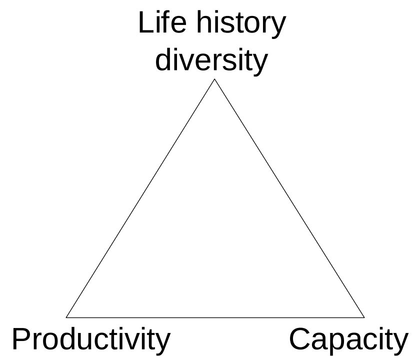


Figure 4. Measures of biological performance.

determines resilience to mortality pressures, such as from fishing, dams, and further habitat degradation. *Habitat quality* (including water quality) is a major determinant of a population's productivity. This performance element is especially important when efforts are being made to reverse long-term downward trends in population abundance. The model estimates productivity for the population of interest under specific management scenarios, expressed as the average number of adult progeny produced per parent spawner (at low population density). A life cycle productivity less than 1 for any part of the population is, by definition, unsustainable. As population productivity approaches 1 (e.g., values less than 2),[3] the population is clearly at risk.

<u>Capacity.</u> This element defines how large a population can grow within the environment it experiences, as a result of finite space and food resources. It determines the effect of this upper limit on abundance to survival and distribution. *Habitat quantity* is a major determinant of the environmental capacity to support population abundance. In the analysis presented here, we frequently refer to "abundance" rather than capacity. Here we are describing the equilibrium run size abundance (or average abundance under steady state conditions), which highly correlates with capacity. The model estimates both capacity and equilibrium abundance for the population of interest corresponding to specific management scenarios.

<u>Life History Diversity.</u> This element represents the multitude of pathways through space and time available to, and used by, a species in completing its life cycle. Populations that can sustain a wide variety of life history patterns are likely to be more resilient to the influences of environmental change. Thus a loss of life history diversity is an

[3] The life cycle productivity needed to sustain a population in the face of environmental uncertainty has not been defined.

indication of declining health of a population (Lichatowich and Mobrand 1995) and perhaps its environment. The model computes an index of life history diversity as the percentage of possible life cycle pathways (i.e., life *trajectories* in space and time that members of a population might follow across the aquatic landscape) having a productivity greater than 1.

The algorithms used to calculate population parameters are based on the Beverton-Holt survival function (after Beverton and Holt 1957). All of the estimates are made for steady state conditions.

Step-by-Step Procedure

The EDT method consists of a series of steps (see Appendix A and Lestelle et al. 1996 for a full discussion of the EDT steps):

1. Identification of goals and values
2. Resource assessment (or diagnosis)
3. Analysis of actions
4. Considerations for monitoring and implementation

This document focuses on the assessment, or diagnosis, phase. Before turning to the assessment (Chapter 3), it is useful to describe the baseline information assembly utilized in the Clearwater EDT analysis.

The Clearwater River mainstem and coho bearing tributaries were identified and divided into "environmentally homogenous" reaches that reflect the hydrography of the basin. In all, 90 reaches were defined for the Clearwater Basin (Table 2). These reaches were largely based on local knowledge of geomorphic features (valley confinement and gradient) and tributary confluences. Reach characterization was completed using information provided by WDNR and the Quinault Indian Nation Fisheries Department.

The EDT model includes assumptions about the estuarine and marine environments. The Queets River estuary was defined based on tidal influence. Marine reaches are based on broader geographic units.
The EDT model is not as well developed in these environments as in the freshwater component of the model. Model assumptions entered as survival conclusions by life stage. The model did not assume a change in survival in the estuary between the current and template condition.

Table 2. Description of physical reach characteristics used in EDT modeling coho salmon in the Clearwater Basin.

Watershed	Stream	EDT Reach Code	Length (mi)	Gradient (%)	Confinement	Description
Queets	Queets River	Queets-1	5.42	0.30%	Moderately Unconfined	Mouth of Queets River to Fisher Creek
		Queets-2	1.43	0.30%	Moderately Unconfined	Fisher Ck mouth to Clearwater Riv
Lower Clearwater mainstem	Clearwater River	Clearwater-01	0.55	0.30%	Unconfined	Mouth to Mule Pasture Pond
		Clearwater-02A	0.75	0.30%	Unconfined	Mule Pasture Pond to outlet of Dasher Pond (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)
		Clearwater-02B	0.84	0.30%	Unconfined	Dasher Pond to mouth of Hurst Ck.(NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)
		Clearwater-03A	0.10	0.30%	Unconfined	Hurst Creek mouth to Tiermeyer Pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)
		Clearwater-03B	0.57	0.30%	Unconfined	Tiemeyer Pond outlet to Morrison Pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)
		Clearwater-04A	0.71	0.30%	Unconfined	Morrison Pond outlet to Dogleg pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)
		Clearwater-04B	0.71	0.30%	Unconfined	Dogleg Pond outlet to Airport pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)
		Clearwater-05	1.11	0.30%	Unconfined	Airport Pond outlet to Wildcat Ck mouth
		Clearwater-06	2.50	0.50%	Moderately Confined	Wildcat Ck. Mouth to Hunt Ck. Mouth; includes Preacher Rapids
		Clearwater-07	1.09	0.50%	Moderately Confined	Hunt Ck. Mouth to Cougar Ck. Mouth
		Clearwater-08	0.61	0.50%	Moderately Confined	Cougar Ck. Mouth to Elkhorn Ck. Mouth
		Clearwater-09A	0.19	0.50%	Moderately Confined	Elkhorn Ck. Mouth to Paradise Pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)
		Clearwater-09B	0.19	0.50%	Moderately Confined	Paradise Pond outlet to Swamp Pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)

Table 2. continued.

Watershed	Stream	EDT Reach Code	Length (mi)	Gradient (%)	Confinement	Description
		Clearwater-09C	0.19	0.50%	Moderately Confined	Swamp Pond outlet to Mink Ck. Mouth (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)
		Clearwater-10	0.97	0.50%	Moderately Confined	Mink Ck. Mouth to Shale Ck. Mouth
		Clearwater-11	0.77	0.50%	Moderately Confined	Shale Ck mouth to Miller Ck mouth
		Clearwater-12A	0.64	0.50%	Moderately Confined	Miller Ck mouth to Pond 1 outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)
		Clearwater-12B	0.01	0.50%	Moderately Confined	Pond 1 outlet to Pond 2 outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)
		Clearwater-12C	0.98	0.50%	Moderately Confined	Pond 2 outlet to Christmas Ck (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)
		Clearwater-13	1.83	0.50%	Moderately Confined	Christmas Ck mouth to Peterson Ck mouth
		Clearwater-14A	1.58	0.50%	Moderately Confined	Peterson Ck mouth to Coppermine Bottom Pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)
		Clearwater-14B	0.80	0.50%	Moderately Confined	Coppermine Bottom Pond outlet to Deception Ck mouth (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)
		Clearwater-15	0.70	0.50%	Moderately Confined	Deception Ck mouth to Snahapish Riv mouth
Upper Clearwater mainstem		Clearwater-16	1.05	1.50%	Moderately Confined	Snahapish Riv mouth to Bull ck mouth
		Clearwater-17	1.17	3.00%	Moderately Unconfined	Bull Ck mouth to Manor Ck mouth
		Clearwater-18	2.63	3.00%	Moderately Unconfined	Manor Ck mouth to Stequaleho Ck mouth
		Clearwater-19	1.44	0.30%	Confined	Stequaleho Ck mouth to Solleks Riv mouth
		Clearwater-20A	0.68	2.20%	Confined	Solleks Riv mouth to Nancy Cr (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)
		Clearwater-20B	2.59	2.20%	Confined	Nancy Cr mouth to Itswoot mouth (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM)
		Clearwater-21	0.44	2.00%	Confined	Itswoot Ck mouth to Kunamakst Ck mouth

Table 2. continued.

Watershed	Stream	EDT Reach Code	Length (mi)	Gradient (%)	Confinement	Description
		Clearwater-22	2.12	3.00%	Confined	Kunamakst Ck mouth to Wilson Ck (#0120) mouth
		Clearwater-23	0.69	3.00%	Confined	Wilson Ck mouth (#0120) to #0122 trib
		Clearwater-24	0.49	3.00%	Confined	Trib #0122 mouth to Ding-a-ling Ck
		Clearwater-25	0.91	3.00%	Confined	Ding-a-ling Ck mouth to Susie Ck mouth
Hurst	Hurst Creek	Hurst-1	0.77	0.30%	Moderately Unconfined	Hurst ck mouth to Boulder ck mouth
		Hurst-2	0.99	0.30%	Moderately Unconfined	Boulder ck mouth to unnamed RB Trib 0027
		Hurst-3	1.05	0.30%	Moderately Unconfined	Unnamed RB Trib mouth to Trib 0028
		Hurst-4	0.77	0.35%	Moderately Unconfined	Unnamed Trib0028 to coho limit (mouth of Trib0029)
	Boulder Creek	Boulder-1	1.95	3.00%	Moderately Confined	Boulder ck mouth to road crossing in middle of section 16
	RB Trib 0025	Hurst-unnamed RB trib # 0025.5	1.15	0.30%		Hurst-2 end to fork at top of section 8
Lower Clearwater tributary	Wildcat Creek	Wildcat-1	0.65	5.00%	Confined	Mouth to unnamed trib 0030
Hunt	Hunt Creek	Hunt-1	0.09	0.30%	Moderately Confined	Hunt Ck mouth to Waring Ck mouth
		Hunt-2	1.95	0.26%	Moderately Confined	Waring ck mouth to coho limit (fork)
	Waring Creek	Waring-1	0.36	4.00%	Confined	Waring ck mouth to road crossing
Lower Clearwater tributary	Cougar Creek	Cougar-1	0.33	0.45%	Confined	Cougar Ck mouth to Cougar Creek 1/4 mile
	Elkhorn Creek	Elkhorn-1	0.63	1.00%	Moderately Unconfined	Elkhorn Ck mouth to road crossing @ mainline gravel pit
Mink	Mink Creek	Mink-1	0.68	5.00%	Confined	Mink Ck mouth to Trib0039 mouth
	RB Trib 0039	Mink unnamed LB trib # 0039	0.98	5.00%		Trib0039 mouth to fish limit
Shale	Shale Creek	Shale-1	0.70	1.20%	Moderately Confined	Shale Ck mouth to Iska Ck (0042)

Table 2. continued.

Watershed	Stream	EDT Reach Code	Length (mi)	Gradient (%)	Confinement	Description
		Shale-2	2.33	1.50%	Moderately Confined	Iska Ck mouth to Unnamed RB Trib0045
		Shale-3	1.55	2.30%	Moderately Confined	Unnamed RB Trib0045 mouth to unnamed LB Trib0047 mouth
		Shale-4	0.61	2.50%	Confined	Unnamed LB Trib0047 mouth to coho limit
	Iska Creek	Iska-1	0.55	3.00%	Confined	Iska Ck. mouth to coho limit
	Unnamed Trib 0047	Shale-unnamed LB trib # 0047	0.66	15.00%		Unnamed Trib0047 mouth to coho limit
Miller	Miller Creek	Miller-1	0.44	1.50%	Confined	Miller Ck mouth to East Fork Miller Confluence
		Miller-2	2.27	1.50%	Moderately Confined	Miller East/West Fork confluence mouth to unnamed RB Trib # 0057
		Miller-3	3.66	1.50%	Moderately Confined	Unnamed Miller RB trib0057 mouth to Trib0062 mouth
		Miller-4	2.61	2.00%	Confined	Unnamed Trib # 0062 to coho limit;
		MillerEFk-1	3.14	1.80%	Moderately Confined	East Fork Miller mouth to Gaf creek
		MillerEFk-2	1.42	2.00%	Moderately Confined	Gaf Ck mouth to coho limit
	Gaf Creek	Gaf-1	0.51	2.50%	Moderately Confined	Trib # 0053 mouth to coho limit, road crossing @ Sec 10, a.k.a. Gaf Ck
Christmas	Christmas Creek	Christmas-01A	0.10	1.60%	Unconfined	Christmas Ck mouth to Christmas Pond outlet (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM; location of pond in question by Lestelle)
		Christmas-01B	0.47	1.60%	Unconfined	Christmas Pond outlet to mainline crossing (NOTE: LESTELLE'S ESTIMATE ON REACH LENGTH-TO CONFIRM; location of pond in question by Lestelle)
		Christmas-02	5.93	2.00%	Moderately Unconfined	Mainline crossing to Trib0066 (Samuelson's Trib)
		Christmas-03	1.17	5.00%	Confined	Trib0066 (Samuelson's trib) to coho limit
	Samuelsons Creek	Samuelsons Trib	1.20	4.00%	Confined	Christmas Ck to coho limit
Peterson	Peterson Creek	Peterson-1	1.05	3.00%	Confined	Peterson Ck. mouth to coho limit; section line road crossing

Table 2. continued.

Watershed	Stream	EDT Reach Code	Length (mi)	Gradient (%)	Confinement	Description
Deception	Deception Creek	Deception-1	0.25	2.00%	Moderately Confined	Deception Ck mouth to Prairie Creek
		Deception-2	1.08	3.50%	Confined	Prairie Ck mouth to section 29/30 line; coho limit
		Deception-4	0.76	7.00%	Confined	Trib # 0075 mouth to fish limit
	Prairie Creek	Prairie-1	0.25	5.00%	Confined	Prairie Ck mouth to coho dist
Snahapish	Snahapish River	Snahapish-1	1.48	1.50%	Unconfined	Snahapish Riv mouth to mainline crossing
		Snahapish-2	5.53	1.50%	Moderately Unconfined	Mainline crossing to West Fork Snahapish
		Snahapish-3	5.68	1.00%	Moderately Confined	West Fk Snahapish to Octopus Creek mouth
		Snahapish-4	1.60	0.75%	Moderately Confined	Ocotpus Ck. to coho limit
	WF Snahapish River	W.F. Snahapish-1	1.49	3.00%	Confined	West Fork Snahapish mouth to Trib0080; coho limit
		W.F. Snahapish-2	1.16	3.00%	Moderately Confined	Unnamed Trib0079 mouth to fish limit
	Octopus Creek	Octopus-1	0.57	1.50%	Moderately Confined	Octopus Ck mouth to coho limit
Bull	Bull Creek	Bull-1	0.56	2.00%	Unconfined	Bull Ck mouth to mainline roadcrossing
		Bull-2	1.69	4.00%	Confined	Mainline to coho limit
Stequaleho	Stequaleho Creek	Stequaleho-1	2.16	1.20%	Moderately Confined	Stequaleho Ck mouth to the Falls @ RM2
Solleks	Sollecks River	Solleks-1	5.05	0.75%	Confined	Solleks River mouth to Kloochman Creek mouth
		Solleks-2	1.99	3.00%	Confined	Kloochman Ck mouth to coho limit (Grouse Ck mouth)
	Grouse Creek	Grouse-1	0.45	5.00%	Confined	Grouse Ck to Grouse Ck fish limit
	Klochman Creek	Kloochman-1	1.75	5.00%	Confined	Kloochman mouth to Kloochman coho limit
Upper Clearwater tributary	Itswoot Creek	Itswoot-1	0.30	6.00%	Confined	Itswoot Ck mouth to coho limit
	Kunamaskt Creek	Kunamaskt-1	1.12	5.00%	Confined	Kunamaskt Ck mouth to mainline/Trib0118;
	Susie Creek	Susie-1	0.36	5.00%	Confined	Susie Ck mouth to coho limit

RESOURCE ASSSEMENT

Model results are summarized for population performance for the current and template conditions and for the diagnosis of the current condition with respect to loss of quality and quanitity of habitat relative to the template condition. Finally the analysis summarizes population performance for the HCP and PFC scenarios and examines differences between the current and HCP condition.

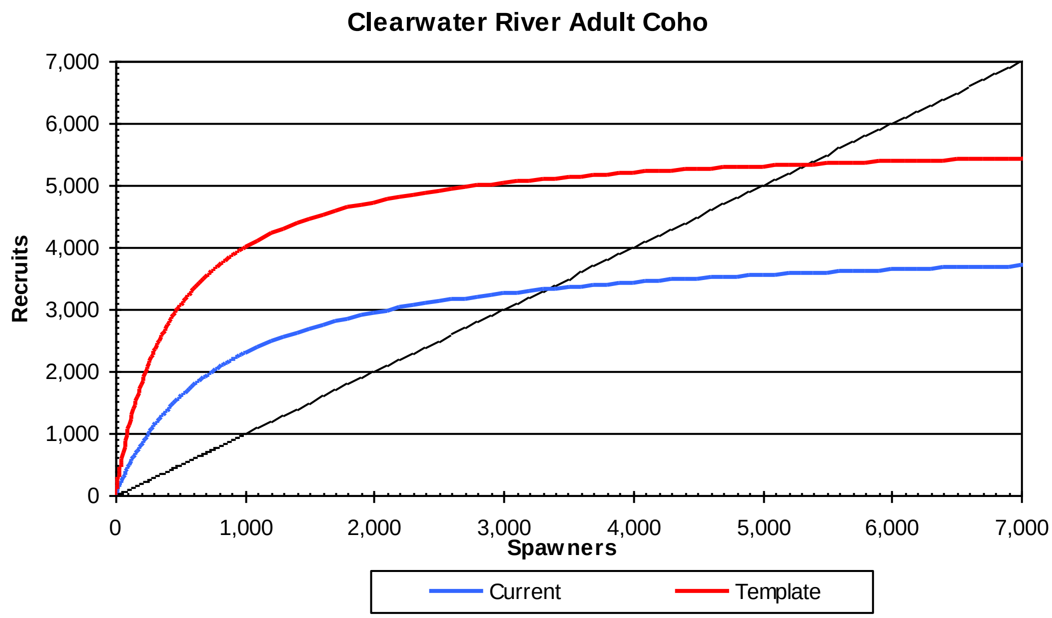
Population Performance

Model runs were completed for the current and template conditions based entirely on habitat conditions. Additional mortality from harvest and loss of genetic fitness was not included in the model results.

Based on model results, the average spawning population size of coho in the current condition was estimated to be approximately 3,300 fish (Figure 5). The template average population size was estimated to be about 5,300 fish. The model suggests that current abundance is about 60% of template abundance. Population productivity was estimated to be 5.1 returns per spawner for the current condition versus 12.9 for the template (approximately 40% of template). The life history diversity value indicates that about 95% of the template life history pathways can be successfully used in the current condition.

Model results for the template condition present a productivity value that is about half of that estimated in the model for Puget Sound streams. This difference can be explained largely by differences in marine survival between the two areas. Model assumptions for marine survival in Puget Sound have ranged from 10 – 20% (Mobrand et al. 1998), whereas model assumptions for the Clearwater analysis were about 4%.

Model results for smolts (as estimated at the mouth of the Clearwater River) indicate approximately 90,000 smolts for the current condition and 140,000 smolts for the template condition (about 65% of template abundance) (Figure 6). Smolt capacity for the current condition is about 70% of that for the template condition (110,000 versus 150,000 smolts). Model results for smolt productivity (smolts per spawner) showed the greatest decline from template conditions, with the current condition being approximately 40% of the template condition.

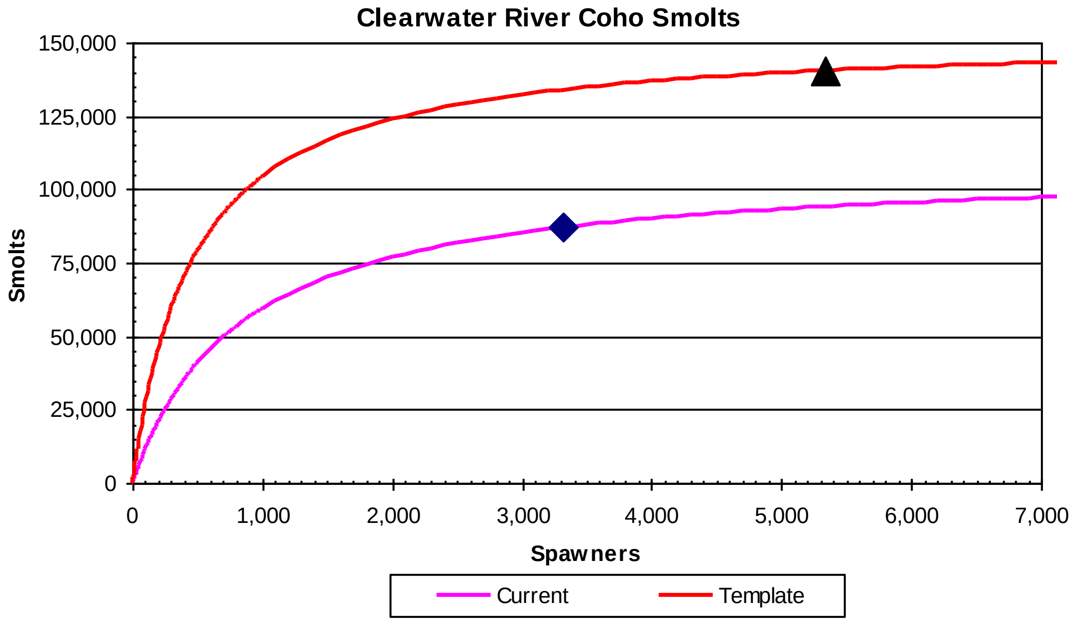


Habitat Scenario	Diversity Index	Productivity (Recruits per Spawner)	Capacity (Adult Recruits)	Equilibrium Abundance
Current	96%	5.1	4,122	3,319
Template	100%	12.9	5,781	5,333

Figure 5. Beverton-Holt population parameters for adult natural coho in the Clearwater River under two habitat scenarios and no harvest. Equilibrium abundance reported in the table is where the production curve crosses the replacement line.

Strategic Priorities for Clearwater Coho

The relative importance of the different geographic areas within the Clearwater watershed for restoration or protection benefits for coho reflects, in part, the utilization of reaches by juvenile and adult coho. The lower Clearwater River mainstem ranks high for protection and restoration (Figure 7). This geographic area should tend to rank higher for protection because all Clearwater coho are dependent on this area for a portion of their life history (juvenile rearing, migration or adult migration/holding). However, this is not always true when we consider coho. Core coho populations tend to be more centered on tributary habitat. Model results indicate high priority for actions (protection and restoration) in Miller Creek and upper Snahapish River.



Habitat Scenario	Diversity Index	Productivity (Smolts per Spawner)	Smolt Capacity	# Smolts @ Adult Equilibrium Abundance
Current	NA	131.4	108,791	87,067
Template	NA	329.1	152,733	140,506

Figure 6. Beverton-Holt population parameters for natural coho smolts in the Clearwater River (at the mouth) under two habitat scenarios and no harvest. The spawner recruit curves also indicate location on the curve for adult equilibrium abundance (ie., smolt production at Neq adults).

The principal attribute classes or factors that rank highest for coho restoration benefit are generally channel stability and sediment (Figure 8). These factors affect performance primarily during the incubation life stage. Secondary factors are flow, food (primarily loss of marine nutrients from reduced salmon carcasses), habitat diversity, and, in some reaches, temperature.

Detailed summaries of attribute priorities are presented in Appendix C (Stream Reach Analysis for Coho).

Clearwater (21) Coho

Relative Importance Of Geographic Areas For Protection and Restoration Measures

Geographic Area	Protection benefit Category	Protection benefit rank	Restoration benefit Category	Restoration benefit rank
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

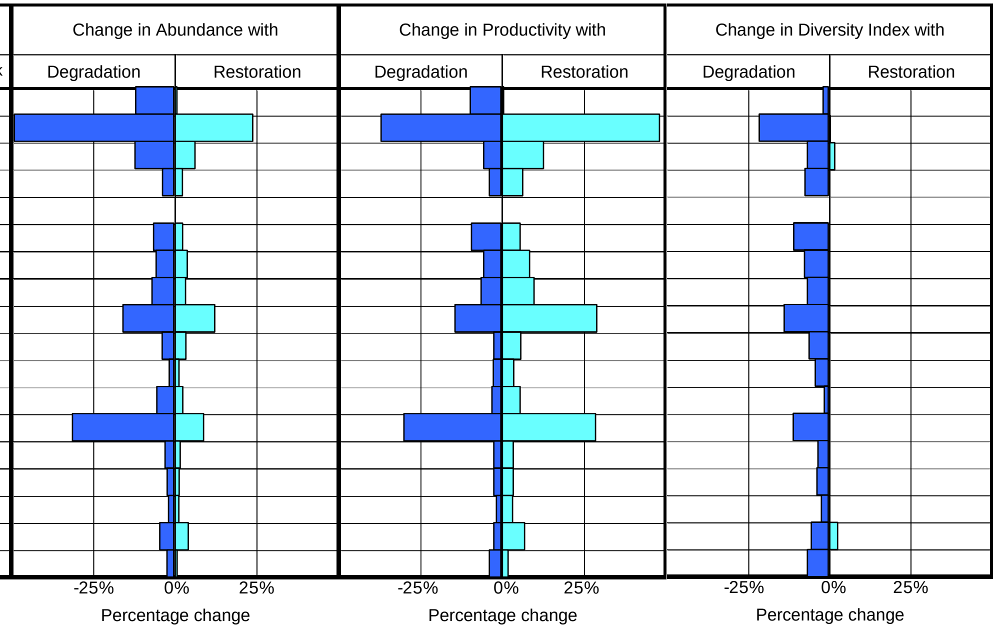


Figure 7. Relative importance of geographic areas for restoration and protection measures for Clearwater River coho salmon. Areas are ranked and assigned to benefits categories according to potential (a is highest) to affect population performance. Contribution of performance measures to ranking are graphed. Note that off-channel ponds are included in as a separate group, in fact they were modeled as part of the Clearwater mainstem groups (lower and mid mainstem).

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	Temperature	Withdrawals	Key habitat quantity
Queets River	Small				Small	Small	Small	Small								
Lower Clearwater mainstem	High		Small		Moderate	Small	Moderate				Small	Small	High	Moderate		
Mid Clearwater mainstem	Extreme		Moderate		High	High	High				Moderate	Moderate	Extreme	High		
Upper Clearwater mainstem	High		Moderate		High	High	High				Moderate	Moderate	High	Moderate		
Misc Lower Clearwater Tribs	High		Moderate		High	High	High			Moderate	Moderate	Moderate	Extreme	Moderate		High
Hurst Creek	Extreme		Moderate		High	High	High				Moderate	Moderate	High	High		High
Shale Creek	High		Moderate		High	Moderate	High			Moderate	Moderate	Moderate	Extreme			Moderate
Miller Creek	High		Moderate		High	High	High				Moderate	Moderate	Extreme			High
Christmas Creek	High		Moderate		High	High	High				Moderate	Moderate	Extreme	High		High
Deception Creek	Extreme				High	High	High				Moderate	Moderate	Extreme	High		High
Lower Snahapish River	High				Moderate	Small	Moderate				Small	Small	High	Moderate		
Upper Snahapish River	High				Moderate	Moderate	Moderate				Moderate	Moderate	Extreme	High		
Snahapish Tribs	High		Moderate		High	High	High				Moderate	Moderate	Extreme	High		High
Bull Creek	High				High	Moderate	High				Moderate	Moderate	Extreme	High		High
Stequaleho Creek	High				High	High	High				Moderate	Moderate	Extreme	High		Moderate
Solleks River	Extreme				High	Moderate	High				Moderate	Moderate	Extreme	High		Extreme
Misc Upper Clearwater Tribs	Extreme		Moderate		High	Moderate	High				Moderate	Moderate	Extreme			High

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

None / Small / Moderate / High / Extreme

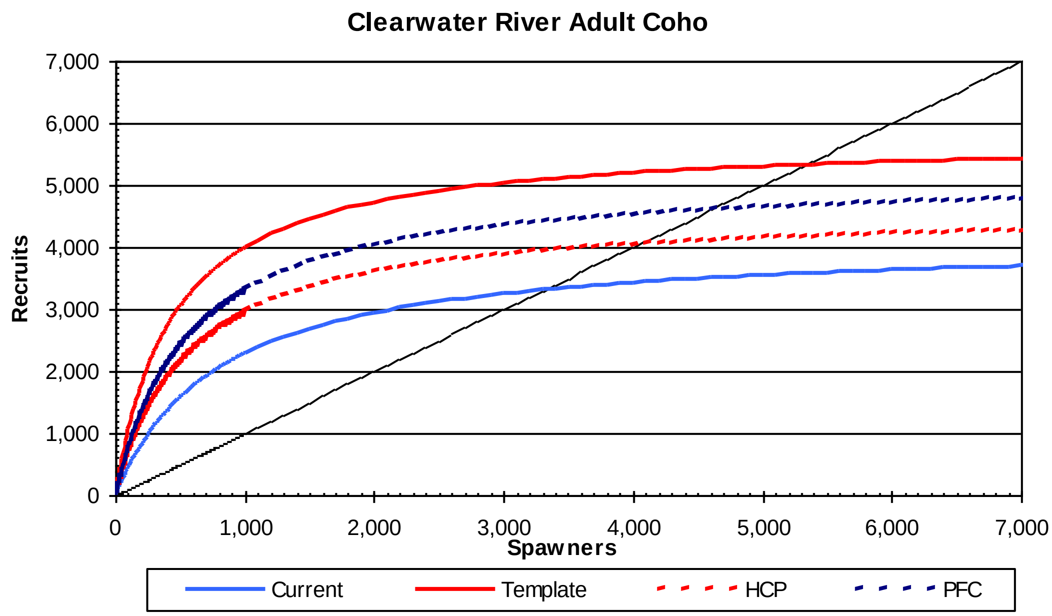
Figure 8. Summary of restoration strategic priorities for survival factors corresponding to geographic areas within the Clearwater watershed for coho salmon.

Analysis of the HCP Scenario

As discussed earlier, the HCP scenario reflects a hypothetical future condition in the Clearwater Basin that might be developed as part of a habitat conservation plan. For the current project, target conditions were described for each reach, for all attributes. These targets vary by reach depending upon a general assessment of strategies in the Basin and constraints specific to the reach. HCP targets cannot exceed template conditions.

Population performance is presented in Figure 9. Under the HCP scenario, adult abundance increased by approximately 700 fish and productivity increased from 5.1 to 8.3 adults per spawner. The HCP abundance is approximately 75% of the template abundance for the watershed.

Model results for smolts indicate a similar pattern between HCP and template scenarios (Figure 10). Smolt abundance for the HCP scenario was approximately 75% of the template. Smolt productivity was approximately 65% of template.

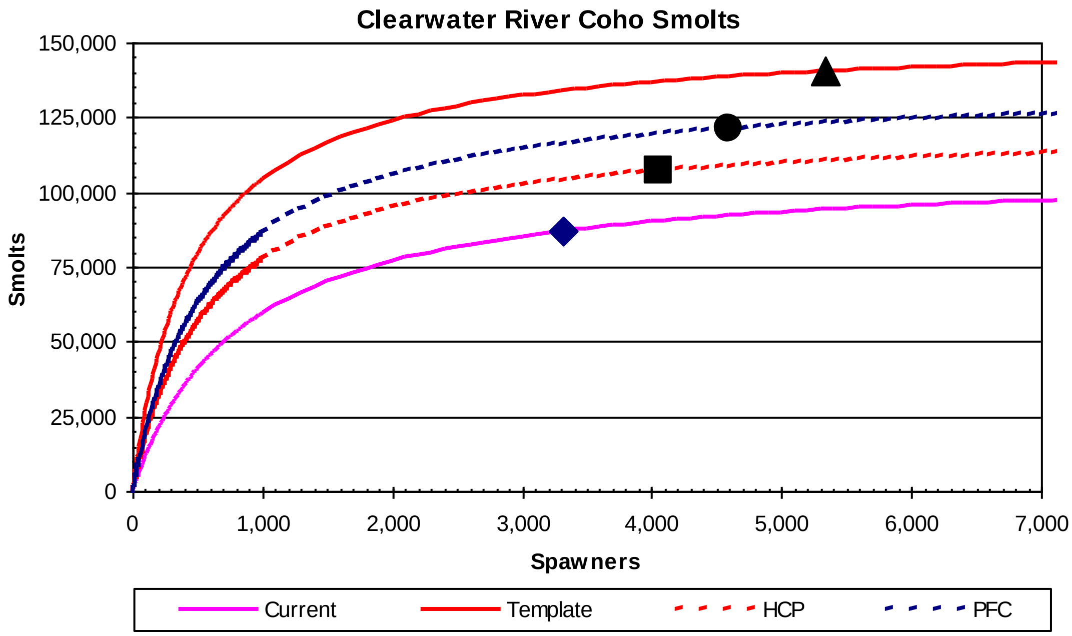


	Habitat Scenario	Diversity Index	Productivity (Recruits per Spawner)	Capacity (Adult Recruits)	Equilibrium Abundance
Clearwater River	Current	96%	5.1	4,122	3,319
	HCP	100%	8.3	4,610	4,051
	PFC	100%	9.2	5,161	4,602
	Template	100%	12.9	5,781	5,333

Figure 9. Beverton-Holt population parameters for adult natural coho in the Clearwater River under four habitat scenarios (current, template, HCP and PFC) and no harvest. Equilibrium abundance reported in the table is where the production curve crosses the replacement line.

The EDT model was used to evaluate where improvements should be made in order to achieve HCP population performance. This analysis was similar to the restoration analysis in the diagnosis. The model was run for each geographic area, replacing the current conditions with HCP conditions rather than template conditions. Each geographic area was ranked for its benefit to population performance. Theoretically, areas that ranked high would have high priority as areas that could achieve target conditions. Areas that ranked low may either be areas that are near HCP conditions or they may be areas where population performance is insensitive to contributing to the achievement of the HCP condition.

The same pattern, as seen in the diagnostic results for restoration, is evident in the HCP analysis (Figure 11). The Clearwater mainstem (lower and mid) ranked high as did Miller Creek and the Upper Snahapish River. The Sollecks River ranked high for life history diversity.



	Habitat Scenario	Diversity Index	Productivity (Smolts per Spawner)	Smolt Capacity	# Smolts @ Adult Equilibrium Abundance
Clearwater River	Current	NA	131.4	108,791	87,067
	HCP	NA	213.2	122,166	107,029
	PFC	NA	236.2	136,376	121,176
	Template	NA	329.1	152,733	140,506

Figure 10. Beverton-Holt population parameters for natural coho smolts in the Clearwater River (at the mouth) under four habitat scenarios (current, template, HCP and PFC) and no harvest. The spawner recruit curves also indicate location on the curve for adult equilibrium abundance (ie., smolt production at Neq adults).

The principal attribute classes or factors that ranked highest for HCP priority are the same as those seen for full restoration (channel stability, sediment, habitat diversity, flow and food) (Figure 12). Temperature was not as significant.

Obviously, model conclusions are largely influenced by conditions defined for the HCP scenario. Model assumptions for future conditions should be reviewed in more detail before more substantial conclusions are drawn from the analysis.

Clearwater (21) Coho

Relative Importance Of Geographic Areas For HCP Scenario

Geographic Area	HCP benefit Category	HCP benefit rank
Queets River	E	16
Lower Clearwater mainstem	A	1
Mid Clearwater mainstem	B	2
Upper Clearwater mainstem	C	7
Misc Lower Clearwater Tribs	C	10
Hurst Creek	C	7
Shale Creek	C	10
Miller Creek	B	3
Christmas Creek	C	7
Deception Creek	D	13
Lower Snahapish River	C	5
Upper Snahapish River	B	4
Snahapish Tribs	C	6
Stequaleho Creek	D	15
Solleks River	D	12
Bull Creek	D	14
Misc Upper Clearwater Tribs	E	16

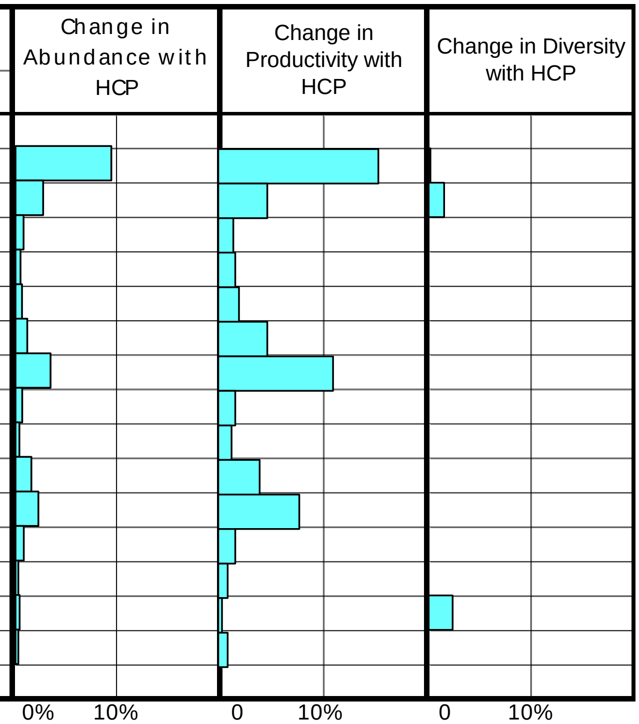


Figure 11. Relative importance of geographic areas for achieving target conditions as characterized in the HCP scenario. Results are shown as % change in each performance measure relative to current condition. Areas are ranked and assigned to benefits categories according to potential (A is highest) to affect population performance.

Population Performance with PFC Conditions

The EDT model, with an extension of the concept of properly functioning conditions as described by the NMFS in their Matrix of Pathways and Indicators (NMFS 1996), has been used to assist the Puget Sound Technical Recovery Team (TRT) with developing recovery targets for Puget Sound chinook. Because the PFC concept is applied to environmental attributes and not species, rules developed for the Puget Sound analysis can be applied to coho in the Clearwater.

PFC is modeled in EDT as a target condition for each of the environmental attributes in the model. Attributes are constrained such that PFC cannot be better than the template condition. Also, reaches and attributes that are pristine may be modeled as slightly degraded, depending upon the attribute and the PFC description.

Clearwater Coho

HCP Scenario 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	Temperature	Withdrawals	Key habitat quantity
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 [●] Extreme [⬤]

Figure 12. Summary of HCP scenario strategic priorities for survival factors corresponding to geographic areas within the Clearwater watershed for coho salmon.

PFC population results for Clearwater River coho are presented here for general comparison to current conditions and the HCP scenario. Figures 9 and 10 include PFC model results for adult and juvenile coho. Spawner abundance under PFC conditions is approximately 85% of the template condition. The HCP and PFC scenarios generally produced similar results, although the PFC scenario was slightly higher than the HCP scenario for abundance and productivity.

Conclusions

This report presented the results of an EDT analysis performed for coho salmon in the Clearwater Basin, based on inputs provided by WDNR in cooperation with MBI. A more detailed examination of the results as well as recommendations for their use in management schemes relating to DNR's Habitat Conservation Plan will be presented in a report authored by WDNR, in consultation with MBI.

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