A Multi-Species Framework Approach for the Columbia River Basin

Integrating Fish, Wildlife, and Ecological Functions

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Overview

Through the Multi-Species Framework approach, we have developed a joint fish and wildlife scientific assessment and management framework for the entire Columbia River Basin. This Framework encourages fish and wildlife biologists to share common foundations for habitat databases, population models, and a technical lexicon. This commonality will allow the region to forecast the effects of proposed actions would have on both fish (resident and anadromous) and wildlife populations and their habitats, and to guide integrated assessments of aquatic and terrestrial ecosytems.

This Multi-Species Framework is designed to help the region develop a collective vision and approach for fish and wildlife recovery in the Columbia River Basin. The Framework is based on a simple premise: our actions are designed to influence environmental attributes in a manner that changes biological performance to better meet basin management goals. We work from a set of strategies at multiple geographic scales (basin, province, and subbasin) that pertain to biological objectives also at those scales, which in turn pertain to an overall vision (Figure I.1).

A set of Scientific Principles provides the scientific foundation for this Framework. These principles form the basis for the biological objectives, working hypotheses, and strategic guidelines that will provide specific direction for program measures.

The Multi-Species Framework and associated tools can be applied over a wide range of geographic scales and can help resource managers plan, implement, and coordinate actions in areas as large as the entire Columbia River Basin, or in the smallest tributary providing that reliable data on habitats and populations are available at each scale. The Framework and tools provide a consistency among fish and wildlife analyses across multiple spatial scales. By this report, regional managers are provided a powerful tool for conducting cumulative effects analysis of actions designed to enhance fish and wildlife populations or economic development.

The ecological information structure embedded in the Framework is designed to describe the ecosystem at multiple levels of spatial and biological organization. Its purpose is to identify and organize key assumptions about the environment and about habitats for selected species of management concern, key ecological functions (KEFs) of fish and wildlife, and biological performance of populations being analyzed. This structure serves to document the rationale for expectations about the likely success of management actions to meet the goals and vision for the basin.

The Ecosystem Diagnosis and Treatment methodology (EDT) is the modeling approach used for determining fish population response to proposed actions. Using EDT entails emphasizing the need for explicit operating hypotheses on which to base management decisions. The EDT approach supports the idea that the usefulness of adaptive management depends upon the theoretical underpinnings of management strategies and actions to be explicit, clearly stated, and tested. As such, the EDT modeling approach is an explanatory-based approach that relies on empirical data, and on expert opinion when the data are not available, in contrast to purely statistically based approaches that rely solely on probabilities and correlations derived from empirical data.

In the Framework, we have developed an explicit set of biological analysis rules, or Bio-rules, to determine how changes to the environment affect salmonid performance. The Bio-rules are based on empirical data from research studies, general scientific literature, and expert opinion where appropriate. The rules are what drive the EDT model results, i.e., they produce the projections about chinook performance given implementation of management actions. Each rule is, in essence, an assumption about how the environment works and how salmonid populations respond. By documenting the rules, we document each assumption. Making the rules explicit helps reviewers to focus on the underlying assumptions in seeking explanations for inaccurate results, replacing poor assumptions with better ones, and expanding our common understanding. The debate is thus shifted away from focusing on outputs (i.e., fish numbers) to inputs (knowledge and understanding of how the system works).

Results of Fish Assessments

Current freshwater habitat productivity (from egg to smolt) has been reduced, to varying degrees, from its Historic Potential to Current Potential, in all tributaries to the Columbia-Snake Rivers. Current Potential ranges from about 25% of Historic Potential in the Columbia Plateau province to about 60% in the Mountain Snake province.

The environmental attributes that have had the greatest effect on freshwater habitat productivity are bed scour, fine sediment, riparian function, maximum monthly temperature, embeddedness, turbidity, and woody debris.

Current Potential abundances of chinook in the Columbia River Basin range 4-17% of estimated Historic Potential abundances. This result – suggesting a large decline since historic levels—is consistent with the status of several chinook populations being currently listed as threatened or endangered under the Endangered Species Act.

Chinook productivity in the Columbia River Basin has been reduced on average to less than 20% of Historic Potential productivity. A reduction in productivity means that chinook populations recover more slowly from low abundance. Actions that increase productivity would reduce the time required for chinook populations to reach recovery levels.

Reduction in chinook life history diversity ranges from 30% to 60% of the historic, dependent on race. Life history diversity refers to the multitude of life history pathways (temporally and spatially connected sequences life history segments) available for the species to complete its life cycle. The large drop in life history diversity likely makes these populations less resilient to environmental change, thereby increasing their risk of extinction.

By ESU, chinook abundance is currently 1-9% of Historic Potential abundance. Across all chinook ESUs, chinook productivity and life history diversity have been reduced to 11-30% and 16-84% of Historic Potential productivity and life history diversity, respectively.

All of the three alternatives we analyzed, regardless of their worldview basis, would likely increase overall chinook abundance by more than ~100% from current abundance levels. Therefore, the implementation of any of the three alternatives would likely result in a significant increase in chinook abundance.

The results of the analysis indicate that the actions included in Alternative 2 (dam removal, moderate-to-high level of tributary improvement) outperform all other alternatives in terms of increasing chinook population abundance, regardless of the assumptions examined.

Alternative 2 produces the greatest benefits (i.e., increases in chinook abundance) when it is assumed that chinook juvenile transportation is ineffective, in-river survival rates are low, ocean nearshore survival is high, and hatchery fish fitness and post-release survival are low.

Alternative 5 improves chinook production abundance potential to between 114% and 216% of Current Potential. This alternative performs best when it is assumed that transportation is relatively ineffective, in-river juvenile survival is low, nearshore ocean survival rates are high, and habitat restoration actions in the tributaries are effective.

Alternative 6 improves chinook performance to between 107% and 122% of Current. Most of the chinook production increase in this alternative is a result of improvements made in tributary habitat and hatchery fish fitness. Thus, this result depends on the assumptions that tributary habitats and fitness of hatchery fish most affect positively the future abundance of chinook.

Results of Wildlife Assessments

The wildlife analysis focused on species-specific issues and on system-level issues. To demonstrate the species-specific, we analyzed three species: American black bear, bald eagle, and American beaver. Key points are as follows.

We have developed a joint fish and wildlife assessment framework for the entire Columbia River Basin that uses a common approach to databases on habitats and species. The database is structured to also accommodate finer scaled data for analyses of smaller geographic areas and scales than those included in this report. In addition, the Framework fish and wildlife population assessment methods have the same theoretical basis.

All three alternatives that we analyze here demonstrated benefits for black bear and some benefits for bald eagle. Negative influences on the bald eagle habitat (as measured by a Habitat Condition Index, HCI) outweighed the beneficial influences on bald eagle habitats. A change map for the bald eagle illustrates where negative and beneficial influences were detected. At the basin scale, differences between alternatives on bald eagle and black bear were not discernable due to the very large area of the basin in relation to the relatively small amount of change proposed and our ability to depict species key habitat features through out the basin; such differences will become more obvious at finer geographic scales.

Alternative 2 could provide benefits for beaver and bald eagle due to restoration of wetland and riparian areas along reaches where dams are removed. Efforts to restore and preserve shrub-steppe, as stipulated under this alternative, will have little benefit for bald eagle and black bear, which are species that are not closely associated with shrub-steppe. Of course, it would benefit many other wildlife species that are so associated. Tributary restoration will benefit all three wildlife species evaluated.

Alternative 5 proposes restoring connectivity of shrub steppe reserves that would not particularly benefit, and that could have a negative influence on key environmental correlates for, black bear and bald eagle. Increased effort to restore tributary habitat, especially forested and riparian habitats would benefit all three wildlife species evaluated. Benefits for the black bear could occur more in poorer quality habitat (i.e., shrub steppe adjacent to forested area) and as a result of decreased roading. The bear analysis included input from the chinook analysis. For example, the actions in some alternatives resulted in an additional 75 6-HUCs having increased salmon carcass abundance, which is a key environmental correlate for black bear.

Quantitative analyses for the beaver failed due to the lack of consistent fine scale data of key habitat features across the entire basin. Nonetheless, subbasin managers should not abandon analyses for the beaver at finer geographic scales. Finer scale data on habitat variables such as tributary gradient will likely be more available at the subbasin and watershed scales.

Alternative 6 proposes less preservation along mainstem Columbia River and less restoration in tributary habitat especially on private land. This will result in less benefit for all three wildlife species assessed. The reliance on hatcheries would not benefit the 110 species of wildlife that use salmon carcasses; in fact, de-emphasizing the natural breeding and carcass stages of anadromous fish (especially salmon) in favor of hatchery use may provide poorly for these 110 wildlife species.

Results of Integrated Fish-Wildlife Assessments

Ecological relationships between salmon and wildlife indicate that the strongest associations in fresh water habitat are between 110 species of wildlife and salmon carcasses, and between 50 species of wildlife and salmon smolts.

Losses in ecological function of terrestrial wildlife communities may have occurred across the basin between Historic Potential and Current Potential conditions. These losses may be partially restored by any of the three alternatives, which would serve to at least partially restore some of the terrestrial environments that have declined since historic time.

Several key ecological functions (KEFs) of wildlife, such as transportation of seeds, would be at least partially restored to Historic Potential levels of functional redundancy (number of species with each function) by any of the three alternatives, but other KEFs, such as primary cavity excavation, might still decline because of continued loss of forest cover.

Findings Related to Scientific Uncertainty and Potential Management Risk

Predictions of biological performance depend on assumptions in each alternative, where the assumptions differ according to two different worldviews, which we call Technology Pessimistic and Technology Optimistic. We used this type of analysis to compare the alternatives by providing regional decision makers with a clear assessment of the risks and critical uncertainties embedded in each alternative and associated worldview.

In all of the alternatives, we assumed that management actions can be implemented as designed. This means that dams can be removed and habitat can be improved, in some cases dramatically, on both public and private lands. In the non-modeling world (i.e., real world) some actions may be politically impossible or practically difficult to implement or, over time, they may become socially unacceptable. Thus, the degree to which the various alternatives can be practically implemented likely vary, and our analyses do not take this variation into account.

Alternative 2 performs better for chinook population recovery under the Technology Pessimistic worldview and poorer under the Technology Optimistic view. Alternative 2 is projected to produce a larger increase in chinook abundance from current levels, than either of the other two alternatives regardless of the worldview.

Management actions under Alternative 2 would emphasize natural over hatchery production of fish. This emphasis poses greater weight on assumptions regarding our ability to improve and recover natural salmon habitat. As management actions designed to improve and recover natural salmon habitat likely will require many decades to both implement and reap fish survival benefits, the pay-off as to when the region could see the run sizes depicted for the alternative may be longer than under the other alternatives which rely more heavily on hatcheries. But there are other issues related to natural vs. hatchery stock that extend to questions of impacts on wildlife species that rely on adult salmon and salmon carcasses, and the arrays of ecological functions provided by that set of wildlife.

Because the predicted increase in chinook abundance for Alternative 2 is greater than that for the other alternatives under all scenarios (worldviews), there is less uncertainty associated with this alternative regarding the production of more chinook. Under the best-case scenario, chinook abundance may increase by as much as 381% from Current Potential levels; worst case would be 164%.

Alternative 2 is projected to substantially increase chinook abundance, productivity, and life-history diversity in all ESUs. Thus, there is less uncertainty associated with this alternative with regard to recovering listed chinook stocks.

Of the five ESUs analyzed, chinook performance increased the least in ESU 12 and ESU 13 located in the upper Columbia River. This is especially true with chinook productivity, which for ESU 12 is actually reduced under Alternatives 5 and 6. These data point to the fact that actions in all of the alternatives have been focused primarily on improving chinook performance in the Snake River (ESUs 14 and 15). To reduce the extinction risk for stocks originating in the upper Columbia River, consideration could be given to implementing more actions in these ESUs.

We estimated that the cost of implementing Alternative 2 is $765 million a year, and of implementing Alternative 5 and Alternative 6 $390 million and $210 million, respectively. Thus, to reduce uncertainty of response and recovery of chinook populations to the level shown for Alternative 2, the region may need to spend an additional $375-555 million a year (CH2MHill 2000).

Some of the actions included in Alternative 2 may not be internally consistent. Alternative 2 emphasizes natural production of chinook, yet still allows for the continuation of a large chinook hatchery production program. Because there is still considerable debate (uncertainty) as to the impact that hatchery fish have on wild stocks, either eliminating, curtailing, or reforming the hatchery program could reduce this inconsistency. In addition, at least under Alternative 2, studies should continue to quantify the effect of hatchery stock on the long-term fitness of native stock.

We project that implementation of Alternatives 5 and 6 will result in a Columbia River system heavily dependent upon hatchery production to achieve the respective chinook performance objectives of these alternatives. This is especially true if the Technology Optimistic worldview more accurately represents the State of Nature. A decision to place a large emphasis on hatchery production may pose significant risk to natural (wild) fish through the mechanisms of competition, disease, genetic introgression and harvest, and may sacrifice some of the wildlife assemblages and their ecological functions associated with feeding on mature salmon and salmon carcasses. A major assumption inherent in both Alternative 5 and 6 is that the region can maintain a large-scale hatchery program and also increase natural chinook abundance through aggressive habitat measures directed at the tributaries.

All of the alternatives require a substantial increase in freshwater productivity to increase chinook performance throughout the Columbia River Basin. Alternative 5 requires the most improvement in freshwater habitat, while Alternative 6 requires the least. At a minimum, the alternatives assume that freshwater habitat productivity can be improved by 35% over Current Potential levels. This is a relatively large improvement that may not be achievable because of either social constraints or the ineffectiveness of habitat management actions, but that lies in the purview of decision-makers, not biologists.

The preceding paragraph should not be interpreted to mean that a 35% improvement is needed in freshwater habitat in all reaches of the

Columbia River Basin. Instead, the correct interpretation is that the alternatives require that we eliminate at least 35% of the identified habitat problems. These problems may be as simple as removing a small blockage or as complex as restoring late summer stream flows in a tributary dewatered as a result of agricultural practices. Regardless, there is still considerable uncertainty that this range of improvement in freshwater habitat can be achieved. However, the exact scale of the effort, and thus probable success, will not be known until after a diagnosis has been completed for all of the subbasins. The diagnosis could be performed as part of the assessment and subbasin planning phases of the Fish and Wildlife Program.

Under the best-case scenarios, our analyses suggest that Alternatives 2, 5, and 6 may produce 992,000, 728,000, and 755,000 chinook adults, respectively. Under the worst-case scenarios, our analyses suggest that Alternative 2, 5, and 6 may result in decreases in chinook production to 898,000, 652,000 and 428,000 chinook, respectively. The difference between the best case (Alternative 2) and worst case (Alternative 6) is approximately 564,000 adults. This defines the maximum reward possible for choosing the right alternative and State of Nature. Because there is much uncertainty around this estimate, it is up to resource managers to decide whether doubling or halving the number – given our uncertainty over these numbers - would influence their selection of one approach, or set of actions, over another set.

We assumed each alternative would provide a different level of habitat restoration effort (intensity), dependent on whether the habitat is located on private or public lands. Alternative 2 places equal effort in improving habitat on private and public lands. Alternative 5 emphasizes habitat actions on public over private, whereas Alternative 6 requires the same amount of effort as Alternative 5 does for public lands but significantly less on public lands. We assumed that there is greater uncertainty about fish response associated with an alternative that requires substantial improvement in habitat on private lands in comparison to an alternative that relies on actions on public lands.

We also assumed under all alternatives that hatchery fish survival can be improved through hatchery reform initiatives and that this improvement would result in a ~50% increase in hatchery fish survival. Studies underway in Yakima and other basins should help determine the validity of this assumption in the next three years.

Recommendations on a Research, Monitoring, and Evaluation Program

Biological objectives can be used to focus monitoring and evaluation efforts to track progress towards basin and province goals. The biological objectives we used in our analyses were based on an explicit set of hypotheses as represented in the EDT model. The hypotheses (Bio-rules) themselves are derived from a synthesis of scientific literature, research studies, and specific analyses using statistical tools such as h-VSP being developed by the National Marine Fisheries Service and the models developed within PATH. The Council can use EDT to evaluate subbasin plans for their contribution to the larger scale (province and basin) vision and biological objectives. To develop biological objectives, EDT could be used to describe the amount of environmental change needed within a province or subbasin to meet the overall vision. Subbasin plans would then detail the strategies and actions needed to make this amount of change across the province.

Biological objectives could be based on three characterizations of the environment: (1) the Current Potential condition, (2) the adopted resource management program, and (3) the Historic Potential condition. The Current and Historic Potential conditions are based on information gathered at the 6-HUC level. The characterization of the future conditions could be based on the increase in performance desired and the change in quantity and quality of attributes required to achieve the desired performance. EDT can be used to determine the amount of change from current conditions to achieve a desired condition. Thus, EDT can be used to help set the biological objectives for conditions in the basin by helping to determine what is possible.

Biological objectives would be established for aquatic and terrestrial habitat and biological performance. Candidate biological objectives include changes in the 45 environmental modeled amounts of habitat, fish survival rates, and modeled parameters such fish productivity, life history diversity and abundance.

Three levels of monitoring could be included in the Framework: implementation, effectiveness, and validation.

Implementation monitoring is used to ensure that strategies and management actions are implemented as specified by management guidelines.

Effectiveness monitoring is used to determine if the rules developed for estimating an action's effect on habitat attributes are indeed correct. It is also used to determine if mid-course corrections to the management strategies are needed due to the ineffectiveness of the strategy, changing environmental conditions, or real-world limitations. Effectiveness monitoring intends to confirm that the implemented action is having the predicted effect on the targeted habitat attribute. If not, then the rule will be changed to better fit the monitoring data.

Validation monitoring is used to confirm that as habitat attributes change, salmon populations respond as predicted by the EDT model and other models used in the assessment. In other words, validation monitoring tracks trends in population performance measures that imply goals are being achieved. Validation monitoring tests the veracity of the major scientific assumptions underlying the assessments. This would require statistical trend analyses of empirical data on habitats and populations.

A Scientific Advisory Board could advise on various scientific and technical aspects of the Framework plan. These aspects are listed individually.

INTRODUCTION

The summary is organized as follows:

History and Background

Objectives

Toward Integrated Assessment and Management

Sections of this Report

History and Background

The Multi-Species Framework Project was intended to help foster a regional perspective of the ecology and management of fish, wildlife, and ecosystems of the Columbia River Basin (McConnaha 1999). The Framework Project involved a multitude of stakeholders and managers from throughout the region and produced a range of visions and potential planning alternatives. Seven of the alternatives that emerged were reassessed using the Framework approach and forecasts of their ecological and economic impacts at the basin and province scale determined (NPPC 2000a; NPPC 2000b).

Following the preliminary analyses and subsequent review and screening of the input data, three of the seven alternatives were reanalyzed. This report presents the results of this reanalysis and documents the various databases and modeling and assessment procedures, including the Ecosystem Diagnosis and Treatment (EDT) method, used to forecast potential impacts.

Objectives

The Multi-Species Framework analysis presented herein aims to:

- describe the process, Scientific Principles, and analysis tools that are incorporated into the Framework,
- show regional fish and wildlife managers how the Framework process can contribute to the development of proposed actions that are effective, based on sound science, and implemented in a biologically sound and cost-effective manner,

- illustrate databases, methods, and models that are useful in analyzing past, current, and future habitats and populations of fish and wildlife, and especially in considering an ecologically integrated approach to fish and wildlife assessment and management in the Basin,
- determine the probable effectiveness of the three alternatives analyzed to improve fish and wildlife performance in the Columbia River Basin,
- provide regional decision makers with a clear assessment of the risks and critical uncertainties embedded in each of the alternatives, and
- describe the basis for a research, monitoring, and evaluation program needed to address the critical uncertainties identified.

The primary intent of the analysis is *not* the selection of a preferred alternative for implementation — that choice is a policy decision to be made by the Northwest Power Planning Council (Council) after extensive consultation with natural resource management agencies, Indian tribes, industry, environmental groups, and the public. The analysis presented in this report will, however, help guide the selection process. The alternative ultimately selected for implementation may be among those analyzed as part of this Multi-Species Framework Project, or it might be one developed through another process, or the Council may choose to combine strategies identified in some or all of the alternatives to form a new alternative. Regardless of the particular alternative chosen, the Scientific Principles and analysis tools developed through the Framework process will contribute to the development of proposed actions that are effective, based on sound population ecology and ecosystem science, and implemented in a biologically defensible manner.

It is important to emphasize at the outset that the Framework analysis results were designed to provide input and guidance for decisions made at the *basin* and *province* levels. Conclusions regarding fish and wildlife performance at the *subbasin* or *watershed* level should not be specifically derived from the current analysis until the quality of the data is reviewed and refined for finer scale analyses. To accomplish the daunting task of describing some 259,000 miles of streams (over 7000 subwatershed units) in terms of 45 attributes for each month, and the array of terrestrial habitats throughout the basin, we relied heavily on previous efforts and on the valued input from many organizations and scientist familiar with the Columbia Basin. Where the attributes required were not available or of unacceptable quality, modeling techniques were used to estimate them. Later, data quality and resolution can be sufficiently improved in the subbasin assessment phase to reliably support subbasin scale analysis and planning.

Toward Integrated Assessment and Management

One of the major themes of this report is the move toward an integrated assessment of fish and wildlife habitats, populations, and their ecological roles in their ecosystems. This does not remove focus on species; it complements it. We still promote individual modeling, analysis, and management of single species and selected populations of conservation interest.

We provide a modeling evaluation of single species or populations of fish (principally salmon) by using a relatively new modeling approach that evaluates their habitat conditions across life history stages, landscapes, and time. Some of this modeling is based on expert judgment, but it serves to provide a basis for better understanding and depicting cause and effect of conditions that influence fish populations. We do recognize that cause and effect models are not fully substitutable for empirically based statistical models, and vice versa, and both have important and complementary roles in resource management (Kareiva and Mobrand 1999).

We also provide modeling evaluations of a few selected wildlife species to demonstrate species-specific wildlife assessments at the basin and province scales. We also develop a conceptual foundation and assessment approach to a more fully integrated evaluation of fish and wildlife species – aquatic and terrestrial ecosystems – by evaluating how habitats, populations, and ecological roles interact among species throughout the Basin. This integrative approach offers a new vision for how cumulative effects assessments and resource management can more fully span and integrate fish and wildlife systems. It also offers a framework for using existing modeling tools (e.g., Figure II.1).

Sections of This Report

This Progress Report is presented in the following sections:

<u>Section III. Methods</u>

We present the scientific and conceptual framework underlying the assessment, and details of the process used for conducting the analysis of fish, wildlife, and integrated fish-wildlife ecological functions. After reviewing this section, the reader should have a firm understanding of the

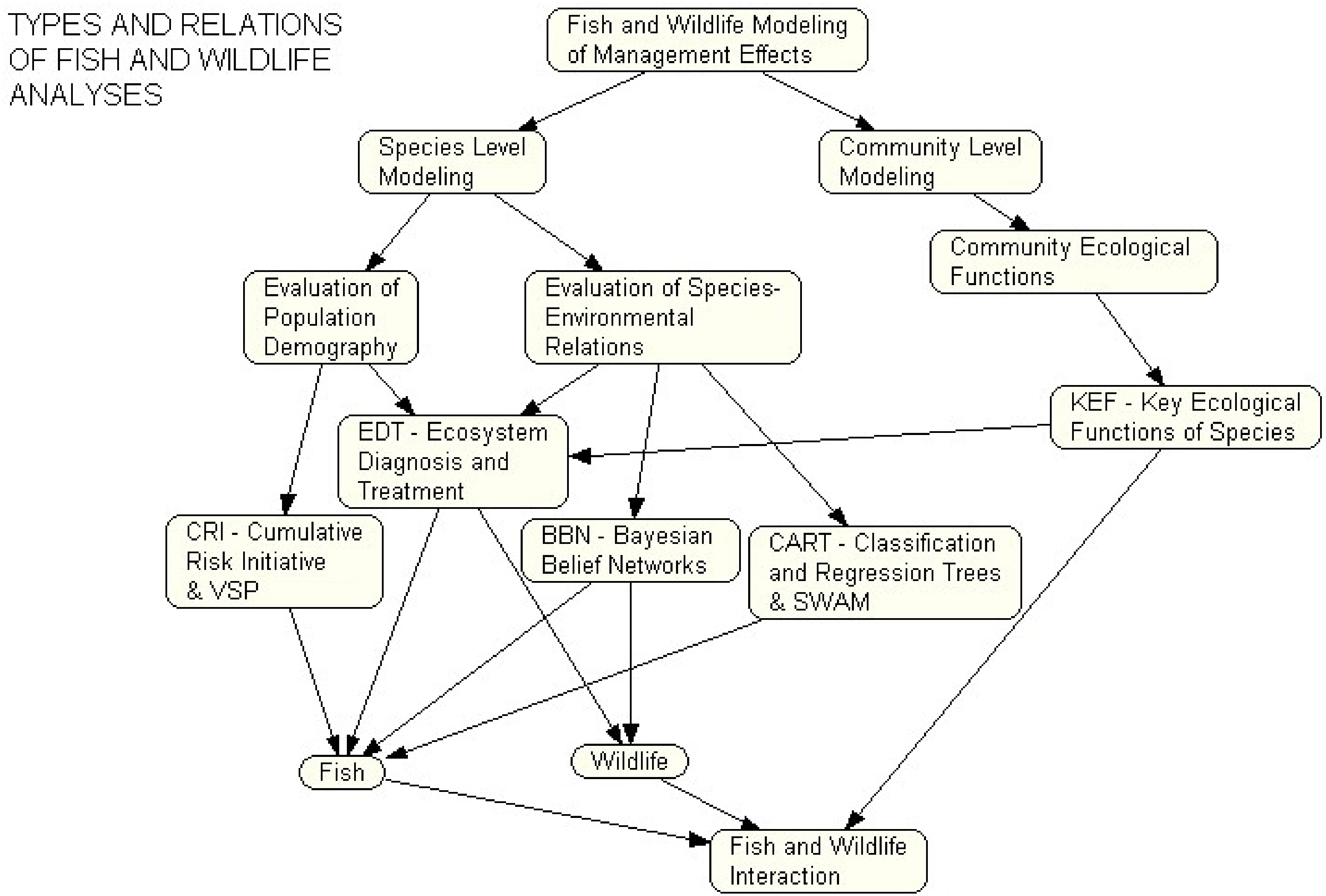


Figure II.1 Types and relations of fish and wildlife models and analyses. This figure suggests appropriate roles for various existing modeling tools and analysis approaches, in the context of an integrated fish and wildlife, species and community assessment. For example, the EDT modeling approach can serve to help evaluate populations and environment relations of species (of fish and wildlife, if the model is so parameterized), and it can also incorporate influences of key ecological functions of fish or wildlife species as they affect habitat conditions.

scientific foundation and the process used to produce the outcomes described in the results and discussion section of the report.

Section IV. Results and Discussion

We present the results of the analysis as they apply to the Framework and to each of the three alternatives examined. We compare environmental conditions as they exist today, as they may have existed without human influence in the past, and as they may exist in the future under each alternative. We present specific results on fish populations and species (principally salmon), selected wildlife species, and on integrated assessments of fish and wildlife populations and their ecological functions.

Section V. Research, Monitoring, and Evaluation

We describe the fundamental concepts underlying a research, monitoring, and evaluation program that could be developed to address critical uncertainties. The purpose of such a program is to determine whether biological objectives are being met over time.

METHODS - FISH SPECIES

This section of the Methods addresses fish; it is organized as follows:

Introduction

The Ecosystem Diagnosis and Treatment (EDT) process is a habitat–life history approach for evaluating potential future performance of fish and wildlife populations (Mobrand et al. 1997). The analytical tool used in the EDT process is an expert system—a compilation of data, information, and knowledge into a hypothesis describing past, present, and future performance of fish and wildlife populations. This expert system translates environmental attribute data into population survival parameters, thus creating a *survival landscape*. Population performance across this landscape is then estimated, based on life history characteristics of the species of interest. In this report, we detail the methods used to model the survival landscapes and perform the population analysis for the Multi-Species Framework coarse screening analysis. We define variables used, identify data sources, and describe how this data is used in the EDT model.

Development of Current Potential and Historic Potential Landscapes

This analysis defines and describes hypothetical future conditions, or alternatives, with reference to two baseline conditions, *Current* and *Historic*. The current baseline describes the average environment available to fish and wildlife over the most recent decade. The historic baseline is a hypothetical reconstruction of conditions prior to non-native human influences. The terms *Current Potential* and *Historic Potential* refer to the ability of the baseline conditions to support fish and wildlife. This section describes the methods used to estimate baseline environmental conditions for the coarse screening analysis.

Development of Habitat Attributes

Freshwater and marine environmental conditions are described in terms of habitat attributes. In the following subsection we identify these attributes and how they are estimated.

Freshwater

Tributaries and mainstem are discussed separately in the sections that follow.

Tributaries - Columbia and Snake River Tributaries

This section defines the environmental attributes used in Columbia River tributaries and describes the steps in translating them into the biometrics in the population analysis. A general discussion of the analytical framework and the data structure and terminology is found in Appendices A and B. In brief, three levels of data are used in EDT: Level 1 or environmental input, Level 2 or environmental attributes, and Level 3 or biological performance attributes.

Summarization and completion of Level 1 environmental input data
The initial step in the data organization procedure was to summarize all of the available Level 1 environmental input data at the 6-HUC scale. We assembled environmental data from various data sources, including: Interior Columbia Basin Ecosystem Management Project (ICBEMP) data, National Wetlands Inventory (NWI) data, EPA's STORET environmental data, StreamNet, and USGS stream flow data. Data elements that were identified as *original source* data (Table III.A.1) we summarized at the 6-HUC scale, preparing them for translation into conclusions about Level 2 environmental attributes. A more complete description of these data sources and how the data were summarized is found in a separate

Table III.A.1 Level 1 environmental input data types and their sources (o.s. = original source data set; derived = data derived through use of a rule, analysis of other data sets, or modeling; and assumed = by assumption).

Type	Name	Description	Source
Climate	Air temperature	Air temperature: a) average maximum, b) average minimum, c) average yearly for representative wet, normal, and dry years	o.s.
	Precipitation	Mean monthly precipitation	o.s.
Streamflow	Storage capacity	Ratio of total storage capacity of reservoir(s) to 6-Huc drainage area	o.s.
	Natural flow	Mean monthly flow without water diversions and regulation	derived
	Actual flow	Actual mean monthly flow with water diversions and regulation	derived
	Water diversion	Flow diversion for human use (surface withdrawals for agriculture, domestic use, etc.)	o.s.
	Alkalinity	Alkalinity of streamwater	o.s.
	Temperature	Mean monthly water temperature	derived
	Nutrients	Mean monthly nutrient concentration index	derived
	Sediment	Mean monthly fine sediment loading concentration index	derived
	Velocity	Mean monthly water velocity within the main channel	derived
Physical Geography	Soil erosion hazard	Moderate or higher soil erosion hazard factor	o.s.
	Elevation	Percent of 6-Huc watershed within each elevation category	o.s.
	Drainage size	Area of 6-Huc watershed	o.s.
	Sinuosity	Channel length to valley length	derived
	Channelization	Channel width resulting from land use	o.s.
	Stream width	Natural stream mean width	derived
	Stream gradient	Average gradient of main channel of 6-Huc	derived
	Stream gradient for beaver	Length of stream channels within 6-Huc watershed with gradient <10%	derived
	Main channel length	Length of main channel of 6-Huc watershed	derived
	Stream density	Density of streams within 6-Huc watershed	o.s.
Cultural Geography	Human population	Human population density	o.s.
	Land use	Proportion of area in each land-use group	o.s.
	Land ownership	Land ownership	o.s.
	Pollutants	Hazard index for human-related waste	o.s.
	Roads	Road density of 6-Huc watershed (includes railroads, pipelines, primary and secondary roads)	o.s.
	Grazing	Proportion of area in grazing allotments within one or more allotment categories	o.s.
	Mining	Number of mining sites within each of four ecological mining hazard levels	o.s.
	Dams present	List of dams with and without fish passage facilities	o.s.
	Passage and survival	Type of fish passage at each mainstem dam (transported, bypass, turbine, spillway) and associated survival rates	o.s.
	Mitigation hatchery releases	Number of hatchery fish by species released monthly to mitigate for habitat loss	o.s.

	Supplementation hatchery releases	Number of hatchery fish by species released monthly to supplement natural production	o.s.
	Harvest rate	Age-specific harvest rates for each indicator taxon within marine and mainstem Columbia areas	o.s.
Biology	Forest structure	Forest seral stage (structure)	o.s.
	Late-succession forest	Proportion of landscape occupied by late-successional or primary forest cover	o.s.
	Late succession forest in riparian area	Proportion of floodplain and riparian areas (within 300m of a channel or shoreline) traversing or abutting late-successional forest cover types (including deciduous gallery forests)	o.s.
	Vegetation cover	Habitat type (clustered vegetation cover)	o.s.
	Fish species	Total number of fish species present	o.s.
	Exotic fish species	Proportion of fish species that are exotic	o.s.
	Adult salmon returns	Average spawning population density of all anadromous fish species at the 4-Huc level	o.s.
	Marine mammal populations	Population abundance index of marine mammals	assumed
	Bird populations	Population abundance index of fish-eating waterbird colonies	assumed

Table III.A.1 Level 1 environmental input data types and their sources (o.s. = original source data set;

report by Battelle Pacific NW Laboratories (in preparation) (Table III.A.1).

Some Level 1 environmental input data were classified as *derived* Level 1 variables (Table III.A.1) because they required separate calculations. For example, several channel variables (such as channel slope and channel length) required independent calculations with digital elevation maps in a Geographic Information System (GIS). Tributary runoff required use of a hydrologic model to estimate the flow coming from each of the 6-HUC units. Other variables associated with water quantity and quality (e.g., flow, temperature, sediment, and nutrients) required explicit flow routing calculations to incorporate the impact of upstream processes.

Stream channel morphometry (derived data)

Basic channel morphometry was characterized using Digital Elevation Models (DEM), Digital Line Graphs, and GIS techniques. Average channel length and slope of the main channel within each 6-HUC unit was derived using a 90-meter DEM, which was the scale of data available for the entire study domain at the time the analysis was done.[1] Channel slopes from the elevation of the main channel as it leaves and enters the 6-HUC unit were estimated, and channel lengths were estimated by summing the lengths of the stream segments composing the main channel and corrected for sinuosity (described below). In headwater 6-HUC units, the slope is based on the elevation of the highest main channel reach segment and the outlet elevation, placing constraints on both the maximum and minimum slopes. In certain 6-HUC units, inadequate data were available to estimate slope; in which case, we developed similarity relationships between other 6-HUCs based on area and elevation.

Estimates of sinuosity were needed to correct the estimates of channel length and slope described above. Channel lengths derived as straight lines between reach segment endpoints, as produced from the DEM, can significantly underestimate both total channel length and slope. We derived an approximation of sinuosity as a function of the combined density of urban and agricultural lands and the channel’s uncorrected estimate of slope. These land uses generally reduce sinuosity due to channel straightening and bank hardening practices. The function is expressed as a simple 2-dimensional lookup table, relating sinuosity to both land use and the uncorrected channel slope. Channels with high slopes are less likely to meander, resulting in lower sinuosity values.

[1] At the time the analysis was performed, data at the 90-meter scale only were available for the entire study domain. Since then, 30-meter data have become available for the entire area, which could significantly increase the accuracy of the derived parameters.

Estimates of wetted channel width were derived using Manning's equation, a standard hydrologic method. The equation relates wetted width to flow, cross sectional geometry, and Manning's roughness coefficients. All channel cross-sections were assumed to have an inverted equilateral triangular shape, an assumption that tends to bias estimates on the low side. We believe that this technique, however, compensates for the possible overestimation of production in streams with wide shallow margins, resulting from the inclusion of all wetted area in the estimation of fish production. This method of estimating channel width incorporated no information about valley type—for example, whether the channel cuts across an alluvial plain or is tightly confined within a canyon. No reliable data were available to describe valley type for each 6-HUC unit. As these types of data become available, estimation of channel width using this method can be improved. We describe derivation of flow estimates, used in estimating width, below.

Data with temporal patterns and routed downstream (derived data)
Derivation of those environmental input data elements that are strongly related to stream flow, took into account seasonal runoff, temperature patterns, and flow route through the stream network. These stream flow-related attributes are runoff, natural flow, actual flow (minus diversions), water velocity, water temperature, fine sediment load, and nutrient load; they are discussed below.

Runoff defines the amount of flow generated from each 6-HUC unit into the stream network; runoff was estimated from the Distributed Hydrologic Soils Vegetation Model (DHSVM). In this model, flow is estimated before considering any anthropogenic activities (e.g. irrigation). Combining runoff from each 6-HUC unit with runoff from upstream 6-HUC units generates the estimates of natural streamflow, without consideration for water withdrawals. Each 6-HUC is divided into five elevation bands to estimate snowmelt where significant elevation changes occur, and estimates of daily minimum and maximum air temperatures and precipitation for Eastside drainages are incorporated. For the Westside drainages, data were obtained for several National Climate Data Center stations. Both of these records were combined to provide a 40-year daily climate record. The DHSVM was then used to simulate the entire 40-year record for all 6-HUC units in the basin with a 3-hour time interval. Runoff values were aggregated to a monthly time interval. A validation test performed with data from the Middle Fork Flathead River produced excellent agreement with empirical data ($r^2 \sim 0.90$). Baseflow was assumed to be a fixed fraction of the total annual precipitation that is specified as a parameter for the entire study area (a report under preparation by Battelle Pacific NW Laboratories gives a complete description of the method).

Natural stream flow departing each 6-HUC unit (i.e., flow without consideration of any upstream diversion or regulation) was estimated by accumulating upstream flows and adding the 6-HUC-specific runoff on a monthly basis, providing simple mass conserving estimates of stream flow. This procedure could not be used to characterize extreme flow events; however, extreme flow event should be incorporated in future analyses. Also, recent improvements in DHSVMs should allow refinements in estimation of base flows. Currently, the DHSVM results are only validated for the Middle Fork Flathead River, Montana. Other sites with *clean* flow data records should be used to further improve confidence in the model's calibration.

Actual flows (i.e., flows as modified by upstream regulation and diversion) were more difficult to estimate because data for diversions are limited to annual values at the 4-HUC scale. The method employed required disaggregating procedures to distribute diverted water and water withdrawals to each of the 6-HUC units within their 4-HUC basin. In general, flow regulation resulting from upstream reservoir operations was simulated by extracting a fraction of each reservoir's storage capacity from the available streamflow during certain months (storage period) and returning it to the downstream 6-HUC units during other months (release period).

We accounted for diversion losses using the following rules:

- Irrigation return flow was based on the relative 6-HUC areas defined as having a land use class of agriculture.
- Conveyance loss return flows were distributed uniformly over all of the 6-HUC units within their 4-HUC.
- Groundwater withdrawals were prorated based on total available base flow, including base flow from irrigation and conveyance losses.
- Surface water withdrawals were prorated from each 6-HUC unit based on the available flow, including upstream flow.

Each of the forty years of runoff data were routed using the same diversion and regulation schedule to provide an estimate of the long-term interannual flow variability (Battelle Pacific NW Laboratories, in preparation).

Average *water velocity* within the main channel of each 6-HUC was estimated using the Manning's equation referred to above, based on estimates of actual flow. Estimates of average velocity were developed for a specified slope, streamflow, channel cross-section geometry, and roughness coefficient. These estimates would be improved considerably by inclusion of valley type information, which was not available for this analysis.

Average *water temperatures* were estimated using a simple temperature model based on the conservation of energy and the temperature equilibrium concept (Vail, 2000, pers. comm). This approach is most applicable in areas where irrigation withdrawals occur. Water temperature in each 6-HUC unit is estimated by adiabatic mixing of upstream flows with flows from the specific 6-HUC; water coming from various sources within the 6-HUC is assumed to have specific temperatures. Once the water from both local and upstream sources is mixed, the water is further altered by allowing it to transfer energy with the atmosphere based on the temperature equilibrium concept. Base flow (including irrigation return flow and conveyance losses) contributions are assumed to enter the river at the annual average air temperature. Surface water runoff (including irrigation) is assumed to take on the average monthly air temperature. Snowmelt is assumed to take on a temperature specified as a parameter. The temperature equilibrium concept allows for surface energy exchange based on the stream's surface area (channel width times channel length), the stream's residence time (channel length divided by velocity) within the 6-HUC, and the difference between the atmospheric and stream temperatures. The model did not incorporate effects of shading associated with riparian vegetation or unusually large inputs of natural groundwater; future uses of the model would require inclusion of these effects.

In estimating *sediment load*, supply of sediment was treated as a conservative, non-reactive constituent, neglecting important, but exceptionally difficult to accurately predict, processes of sediment deposition and re-suspension. Hence the estimation of Level 1 sediment load should be considered a relative measure without a specific metric.[2] This method assumes that the index employed behaves as a conservative, fully-mixed tracer of actual sediment loading. The local loading of sediment (from a 6-HUC unit) was assumed to be a function of the surface runoff and the relative fractions of various land use classes including urban, agriculture, range, and forest. The load from all land use classes was assumed proportionate to the fraction of the area with a

[2] Notwithstanding the difficulty of addressing deposition and resuspension, the sediment load estimates were used to generate an initial set of conclusions about how sediment is passed along and manifested as intragravel fine sediment, embeddedness, and turbidity. These estimates provided an initial, yet rough, set of data for individuals who examined the results in the coarse screening procedure.

high soil erosion hazard potential. Additionally, the sediment from forested lands was assumed to be proportionate to road density and the sediment from the range land proportionate to grazing intensity. Each land use class was given a separate sediment generation term, specified as a parameter. The resultant sediment load index was treated as a concentration, mixed with sources from upstream and routed downstream in a mass conserving procedure.

We estimated *nutrient load* associated with urbanization and agriculture using a similar procedure as that applied for sediment, treating nutrients as a single, conservative, non-reactive constituent. This estimation neglects the assimilative capacity of the stream to remove nutrients. Hence the estimates of Level 1 nutrient load should be regarded as relative and not tied to a specific metric. The local load of nutrients was assumed to be a function of surface runoff, baseflow, and the relative fractions of the land use classes urban, agriculture, and range. In addition, the input of nutrients from range land was assumed to be proportionate to grazing intensity. Each land use class was given a separate nutrient generation term, specified as a parameter. The resultant sediment load index was treated as a concentration, mixed with sources from upstream and routed downstream in a mass conserving procedure.

A more complete description of the methods applied to complete the Level 1 environmental input data sets can be found in the report from Battelle Pacific NW Laboratories (in preparation).

Translation to Level 2 environmental attributes

We translated Level 1 environmental input data into conclusions about Level 2 environmental attributes using a set of explicit rules, or in some cases, by summarizing directly into the categories defined by some environmental attributes (Table III.A.2). In the latter situation, the Level 1 data elements were the same as those defined by environmental attributes; hence no rule was required. The categorical conclusions defined for each environmental attribute are listed in Appendix B. The rules used for this translation procedure are described in a report under preparation by Battelle Pacific NW Laboratories (Table III.A.2).

Translation to Level 3 biological performance attributes

We formulated a set of rules for translating Level 2 environmental attributes into the survival-related values of Level 3 biological performance attributes (Table III.A.3) for chinook salmon (Appendix B).

We developed the rules by first identifying the specific Level 2 environmental attributes that were likely to be strongly, moderately, or weakly associated with each of the Level 3 performance attributes, for

Table III.A.2 Level 2 environmental attributes. All attributes except length can be treated as categorical.

Name	Definition
Alkalinity	Alkalinity of water (conductivity can be used as a surrogate) (at moderate flows)
Bed scour	Average depth and frequency of scour on small-cobble/gravel riffles during high flow events. Frequent indicates at least one event every 1-2 years. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 7 inch diameter), large cobble (7 to 11.9 inch diameter), boulder (>11.9 inch diameter).
Benthos diversity and production	Measure of the diversity and production of the benthos community.
Channel length	Length of the primary channel contained with the stream reach -- Note: this attribute will not be given by categories but rather will be a point estimate. Length of channel is given for the main channel only--multiple channels do not add length.
Channel width - month maximum width (ft)	Average width of the wetted channel during peak flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.
Channel width - month minimum width (ft)	Average width of the wetted channel. If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.
Confinement – Hydromodifications	The extent that man-made structures within or adjacent to the stream channel constrict flow (as at bridges) or restrict flow access to the stream's floodplain (due to streamside roads, revetments, diking or levees) or the extent that the channel has been ditched or channelized.
Confinement – natural	The extent that the valley floodplain of the reach is confined by natural features. It is determined as the ratio between the width of the valley floodplain and the bankful channel width. Note: this attribute addresses the natural (pristine) state of valley confinement only.
Dissolved oxygen	Average dissolved oxygen within the water column for the specified time interval.
Embeddedness	The extent that larger cobbles or gravel are surrounded by or covered by fine sediment.
Fine sediment	Percentage of fine sediment within pool-tailouts and riffles.
Fish community richness	Measure of the richness of the fish community (no. of fish taxa).
Fish pathogens	The presence of pathogenic organisms (relative abundance and species present) having potential for affecting survival of stream fishes.
Fish species introductions	Extent of introductions of exotic fish species in the vicinity of the stream reaches under consideration.
Flow - change in interannual variability in high flows	A measure of between year variation in magnitude of high flow levels and/or the extent of change in overall high flow level during a month relative to an undisturbed watershed of comparable size, geology, and geography (or as would have existed in the pristine state).

Flow - changes in interannual variability in low flows	A measure of between year variation in the severity of low flow discharge during a month. Variation in low flows as applied here is relative to an undisturbed watershed of comparable size, geology, and geography (or as would have existed in the pristine state).
Flow - Intra daily (diel) variation	Variability in flow level during a daily period. This attribute is informative mainly for regulated rivers or when flow patterns are influenced by storm water runoff.
Flow - intra-annual flow pattern	The average extent of intra-annual flow variation during a month -- a measure of a stream's "flashiness" during a season.
Gradient	Average gradient of the main channel of the reach over its entire length.
Habitat type - backwater pools	Percentage of the wetted channel surface area comprising backwater pools.
Habitat type - beaver ponds	Percentage of the wetted channel surface area comprising beaver ponds. Note: these are pools located in the main or side channels, not part of off-channel habitat.
Habitat type - large cobble/boulder riffles	Percentage of the wetted channel surface area comprising large cobble/boulder riffles.
Habitat type - off-channel habitat factor	A multiplier used to estimate the amount of off-channel habitat based on the wetted surface area of the all combined in-channel habitat.
Habitat type - pool tailouts/glides	Percentage of the wetted channel surface area comprising pool tailouts and glides.
Habitat type - primary pools	Percentage of the wetted channel surface area comprising pools, excluding beaver ponds.
Habitat type - small cobble/gravel riffles	Percentage of the wetted channel surface area comprising small cobble/gravel riffles.
Harassment	The relative extent of poaching and/or harassment of fish within the stream reach.
Hatchery fish outplants	The magnitude of hatchery fish outplants made into the drainage over the past 10 years.
Hydrologic regime - natural	The natural flow regime within the reach of interest. Flow regime typically refers to the seasonal pattern of flow over a year; here it is inferred by identification of flow sources. This applies to an unregulated river or to the pre-regulation state of a regulated river.
Hydrologic regime – regulated	The change in the natural hydrograph caused by the operation of hydroelectric facilities in a watershed. Definition does not take into account daily flow fluctuations (See Flow-Intra-daily Variation attribute)
Icing	Extent (magnitude and frequency) of icing events.
Metals - in water column	The extent of dissolved heavy metals within the water column.
Metals/Pollutants - in sediments/soils	The extent of heavy metals and miscellaneous toxic pollutants within the stream sediments and/or soils adjacent to the stream channel.
Miscellaneous toxic pollutants - water column	The extent of miscellaneous toxic pollutants (other than heavy metals) within the water column.
Nutrient enrichment	The amount of nutrient enrichment consisting of such items as ammonia, nitrogen, phosphorous.
Obstructions to fish migration	Obstructions to fish passage by physical barriers (not dewatered channels or hindrances to migration caused by pollutants or lack of oxygen).

Predation risk	Level of predation risk on fish species due to presence of top level carnivores or unusual concentrations of other fish eating species. This is a classification of per-capita predation risk, in terms of the likelihood, magnitude and frequency of exposure to potential predators (assuming other habitat factors are constant).
Riparian function	A measure of riparian function that has been altered within the reach.
Salmon Carcasses	Relative abundance of anadromous salmonid carcasses within watershed (e.g., 5-HUC level) that can serve as nutrient sources for juvenile salmonid production.
Temperature - daily maximum (by month)	Maximum water temperatures within the stream reach during a month.
Temperature - daily minimum (by month)	Minimum water temperatures within the stream reach during a month.
Temperature - spatial variation	The extent of water temperature variation within the reach as influenced by inputs of groundwater.
Turbidity	The relative extent of turbidity episodes within the stream reach.
Water withdrawals	The number and relative size of water withdrawals in the stream reach.
Wood	The amount of wood within the reach. Note definition of "large wood" under terms/clarification.

Table III.A.2 Level 2 environmental attributes. All attributes except length can be treated as categorical.

Attribute	Definition
Channel stability	The effect of stream channel stability (within reach) on the relative survival or performance of the focus species; the extent of channel stability is with respect to its streambed, banks, and its channel shape and location.
Chemicals	The effect of toxic substances or toxic conditions on the relative survival or performance of the focus species. Substances include chemicals and heavy metals. Toxic conditions include low pH.
Competition (with hatchery fish)	The effect of competition with hatchery produced animals on the relative survival or performance of the focus species; competition might be for food or space within the stream reach.
Competition (with other species)	The effect of competition with other species on the relative survival or performance of the focus species; competition might be for food or space.
Flow	The effect of the amount of stream flow, or the pattern and extent of flow fluctuations, within the stream reach on the relative survival or performance of the focus species. Effects of flow reductions or dewatering due to water withdrawals are to be included as part of this attribute.
Food	The effect of the amount, diversity, and availability of food that can support the focus species on the its relative survival or performance.
Habitat diversity	The effect of the extent of habitat complexity within a stream reach on the relative survival or performance of the focus species.
Harassment	The effect of harassment, poaching, or non-directed harvest (i.e., as can occur through hook and release) on the relative survival or performance of the focus species.
Key habitat	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.
Obstructions	The effect of physical structures impeding movement of the focus species on its relative survival or performance within a stream reach; structures include dams and waterfalls.
Oxygen	The effect of the concentration of dissolved oxygen within the stream reach on the relative survival or performance of the focus species.
Pathogens	The effect of pathogens within the stream reach on the relative survival or performance of the focus species. The life stage when infection occurs is when this effect is accounted for.
Predation	The effect of the relative abundance of predator species on the relative survival or performance of the focus species.
Salinity	The effect of the concentration of salts within the reach on the relative survival or performance of the focus species.
Sediment load	The effect of the amount of the amount of fine sediment present in, or passing through, the stream reach on the relative survival or performance of the focus species.
Temperature	The effect of water temperature with the stream reach on the relative survival or performance of the focus species.
Withdrawals (or entrainment)	The effect of entrainment (or injury by screens) at water withdrawal structures within the stream reach on the relative survival or performance of the focus species. This effect does not include dewatering due to water withdrawals, which is covered by the flow attribute.

Table III.A.3 Level 3 biological performance attributes (biometrics). The measure of these attributes is in relation to the relative survival or performance of the focus species by life stage. These attributes act as "umbrella attributes," combining the effects of similar Level 2 attributes. Effects measured by these attributes are assessed relative to fully fit individuals when present in optimal environmental conditions.

each life stage (Appendix B). These Level 2 attributes are referred to as the primary, secondary, and tertiary environmental attributes affecting biological performance, respectively.

Figure III.A.1 and Figure III.A.2 show an example using the Level 1 attribute, sediment yield, three sediment-related Level 2 environmental attributes, and the resulting Level 3 biological performance attribute, fine sediment (Table III.A.3, Figure III.A.1).

The Level 3 biometric, fine sediment, is an estimate of the contribution of all sources of fine sediment on survival during the egg incubation life stage (egg deposition to fry emergence), as shown in Figure III.A.1 above. Intragravel fine sediment is assumed to be the primary determinant of the effect of sediment on egg survival. Sediment effects are assumed to be increased in cases of high embeddedness or turbidity. Embeddedness would limit percolation into the area of the egg pocket, while high turbidity would overwhelm any gravel cleaning accomplished by the spawner in redd construction. Thus, the Level 2 attributes, embeddedness and turbidity, are considered as secondary, or modifying attributes.

Figure III.A.2 also shows the contribution of all sources of fine sediment on survival, but for the inactive life stage (overwintering). In this life stage, embeddedness is assumed to be the primary determinant of the effect of sediment on the survival of overwintering fingerlings (loss of interstitial space). Sediment effects are assumed to be increased in cases of high turbidity (secondary) due to impairment of respiration or feeding. Intragravel fine sediment (tertiary) is assumed to further reduce survival in this life stage due to a reduction in deeper interstitial spaces.

The rules for translating Level 2 environmental attributes into the Level 3 biological performance attributes are based on an extensive set of *translation examples* put together by Chris Frissell, with further input obtained from the Bio-rules Work Group.[3] We reformatted the information from these data sets into the rule set applied here for chinook salmon, taking into account refinements in the definitions and index values of the Level 2 environmental attributes. The Bio-rules should be considered still in a state of development and refinement. Further review of the rules by regional scientists will help ensure their adequacy and consistency with up-to-date thinking and research on the effects of the attributes on salmonids. Moreover, we propose that a forum be developed to routinely review and update the rule sets as a

[3] The BioRules Work Group consisted of Bob Bilby, Pete Bisson, Chris Frissell, Larry Lestelle, and Dale McCullough.

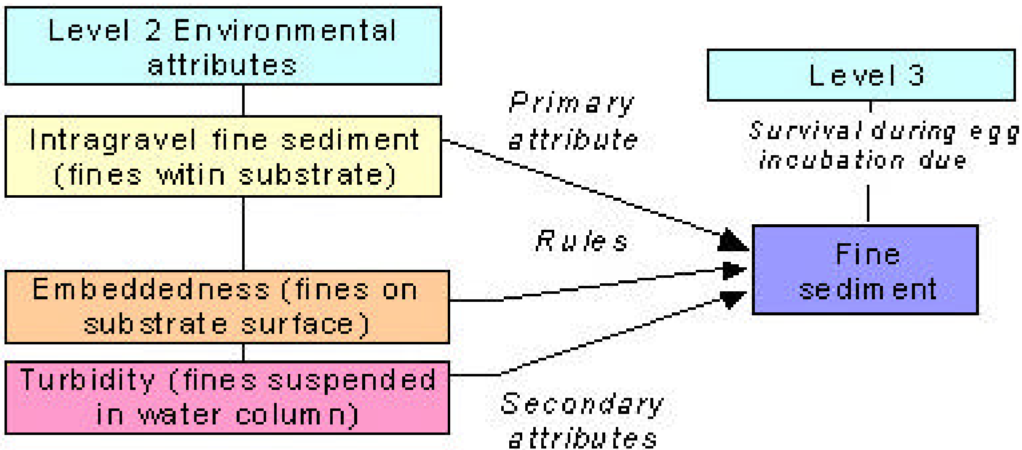


Figure III.A.1 Translation of Level 2 sediment-related attributes into a single Level 3 biometric – egg incubation life stage (chinook).

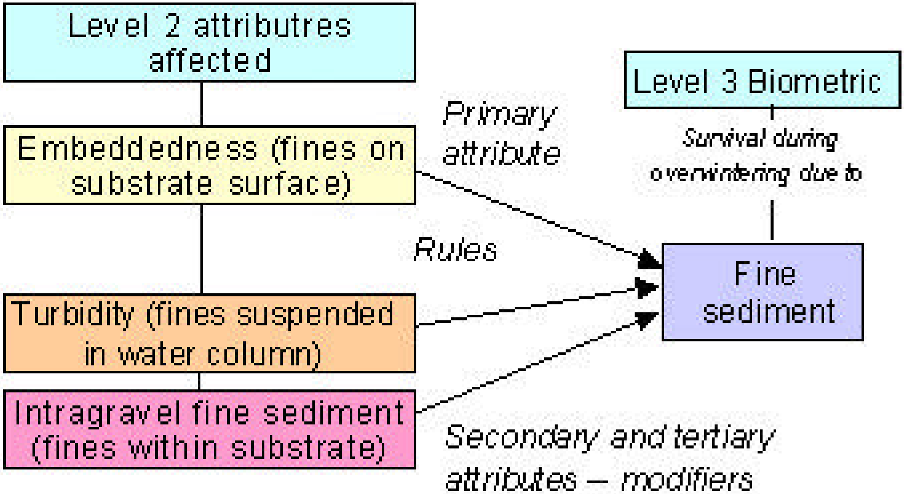


Figure III.A.2 Translation of Level 2 sediment-related attributes into a single Level 3 biometric – inactive (overwintering) life stage (chinook).

way of promoting learning about the effects of the ecological attributes on fish and wildlife performance. Such a forum would help gain wider acceptance of the application of these kinds of rule sets for assessing the effects of environmental change on biological performance.

The full set of Bio-rules, as they are currently configured, is provided in Appendix B. Similar rule sets are under development for bull trout, steelhead trout, chum and coho salmon. Extending the chinook rule set to other species is a straightforward task involving consideration of relative sensitivities of different species to the common set of environmental attributes based on species differences in behavior, physiology, and size.

Mainstem – Columbia River and Snake River Habitat

Methods used for developing habitat and survival attributes for fish utilizing the mainstem Columbia and Snake rivers are presented below for both the Historic Potential and Current Potential.

Habitat Quality and Quantity

Biological rules do not exist for deriving mainstem habitat ratings; therefore, we constructed the quality ratings for mainstem habitat, for the Historic Potential and Current Potential, based on existing literature and the professional expertise of fisheries biologists familiar with both Columbia and Snake river systems. The biologists used the existing data and their knowledge to rate the following biological performance attributes for each river reach of interest:

- Habitat Quality
- Temperature
- Predation
- Competition with Hatchery Fish
- Competition with Other Species
- Habitat Diversity

We adjusted these ratings up or down to meet the juvenile system survival values presented below. A summary of the ratings for all river reaches rated is presented in Appendix C.

The quantity of both riverine and reservoir habitat presented under both conditions were estimated from USGS Topo maps, average monthly river flow, and reservoir size and length data presented in the CRiSP 1.5 manual (Anderson et al., 1996).

River Flow

We obtained estimates of average monthly river flow for both the Columbia and Snake rivers under the Current Potential and Historic Potential from streamflow model runs developed by Council staff (Appendix D). The flow data used in modeling both conditions are summarized graphically in Table III.A.4 and Table III.A.5.

Juvenile Travel Time

We assumed that the time required for subyearling and yearling chinook to migrate through the mainstem corridor is affected by river flow (water velocity) and habitat types present (i.e., riverine or reservoir). Thus, juvenile migration speed is assumed to differ under the Current Potential (primarily reservoir) and Historic Potential (riverine).

We developed subyearling and yearling chinook travel speeds for both conditions using CRiSP Model 4. A description of the model, inherent assumptions, formulas and inputs can be found in Zabel et al. (1997). In addition, for the Historic Potential, we estimated water velocity by dividing average monthly river flow by the average cross section of each stream reach. We used travel speed and timing data in this analysis to determine the survival conditions encountered by each juvenile as it migrates through the mainstem Snake and Columbia rivers.

Juvenile Migration Timing

We approximated subyearling and yearling juvenile migration timings from data developed by the Fish Passage Center (FPC 1998). These data are summarized in Table III.A.6 and were used in modeling both the Current Potential and Historic Potential (Table III.A.6).

Dam Survival (Juveniles)

Dam survival rates for juvenile salmonids are discussed below for the Current Potential only; dams do not exist for the Historic Potential, thus survival estimates are not needed for that condition.

The survival rate of juvenile salmonids migrating past Columbia and Snake river hydroelectric projects is dependent on riverine conditions, juvenile behavior, and physical facilities present at each project. We calculated both yearling and subyearling survival rates through spillways, turbines, and juvenile bypass systems for each project using data presented in the NMFS (2000a). The monthly survival values used in this analysis for both yearling and subyearling life-history patterns are shown in Table III.A.7 and Table III.A.8. It should be noted that the survival values do not include the mortality component associated with juvenile passage through reservoirs.

Dam Survival (Adults)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Snake	37,760	39,610	48,407	89,043	107,245	100,156	50,913	43,643	22,655	24,054	20,928	32,456
Columbia	207,900	198,279	154,250	228,089	287,186	290,140	195,951	163,881	99,886	109,622	109,304	155,839
Mid-Col	153,594	139,802	87,457	124,301	171,988	177,453	135,133	114,599	71,728	79,317	77,075	107,495

Table III.A.4 Average monthly flows used in modeling the Current Potential.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Snake	32,484	38,312	50,797	81,981	120,971	111,823	40,081	20,875	21,153	24,979	28,076	31,657
Columbia	82,258	93,725	117,171	213,915	415,627	465,011	251,442	133,313	92,277	82,123	83,077	85,051
Mid-Col	42,154	46,036	57,982	126,855	294,254	350,371	207,074	108,600	67,959	54,090	50,520	47,048

Table III.A.5. Average monthly flows used in modeling the Historic Potential.

Yearling	1-Apr	2-Apr	May	June	July	1-Aug	2-Aug
Snake	0.05	0.4	0.5	0.05			
Columbia	0.05	0.15	0.75	0.05			
Subyearling	1-Apr	2-Apr	May	June	July	1-Aug	2-Aug
Snake				0.02	0.65	0.25	0.08
Columbia				0.4	0.5	0.1	

Table III.A.6 Yearling and subyearling migration timing for Snake and Columbia River reaches.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.9	0.9	0.93	0.98	0.98	0.98	0.95	0.95	0.95	0.95	0.9	0.9
Little Goose	0.9	0.9	0.93	0.98	0.98	0.98	0.95	0.95	0.95	0.95	0.9	0.9
Lower Monumental	0.9	0.9	0.93	0.96	0.96	0.96	0.94	0.94	0.94	0.94	0.9	0.9
Ice Harbor	0.9	0.9	0.94	0.97	0.97	0.97	0.97	0.97	0.95	0.95	0.9	0.9
McNary	0.9	0.9	0.94	0.98	0.98	0.98	0.98	0.98	0.97	0.97	0.97	0.97
John Day	0.9	0.9	0.93	0.96	0.96	0.96	0.96	0.96	0.94	0.94	0.9	0.9
The Dalles	0.9	0.9	0.94	0.98	0.98	0.98	0.98	0.98	0.9	0.9	0.9	0.9
Bonneville	0.9	0.9	0.92	0.95	0.95	0.95	0.95	0.95	0.93	0.93	0.9	0.9
Rocky Reach	0.89	0.89	0.89	0.95	0.95	0.95	0.95	0.95	0.89	0.89	0.89	0.89
Rock Island	0.89	0.89	0.89	0.95	0.95	0.95	0.95	0.95	0.89	0.89	0.89	0.89
Wanapum	0.89	0.89	0.89	0.95	0.95	0.95	0.95	0.95	0.89	0.89	0.89	0.89
Priest Rapids	0.89	0.89	0.89	0.95	0.95	0.95	0.95	0.95	0.89	0.89	0.89	0.89
Wells	0.9	0.9	0.9	0.97	0.97	0.97	0.97	0.97	0.89	0.89	0.89	0.89

Table III.A.7 Monthly dam survival values for yearling chinook—Current Potential.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.9	0.9	0.95	0.96	0.96	0.96	0.95	0.95	0.95	0.95	0.9	0.9
Little Goose	0.9	0.9	0.94	0.96	0.96	0.96	0.94	0.94	0.94	0.94	0.9	0.9
Lower Monumental	0.9	0.9	0.94	0.95	0.95	0.95	0.95	0.94	0.94	0.93	0.9	0.9
Ice Harbor	0.9	0.9	0.93	0.96	0.96	0.96	0.96	0.96	0.94	0.94	0.9	0.9
McNary	0.9	0.9	0.96	0.98	0.98	0.98	0.98	0.98	0.95	0.95	0.95	0.95
John Day	0.9	0.9	0.95	0.97	0.97	0.97	0.97	0.97	0.95	0.95	0.9	0.9
The Dalles	0.9	0.9	0.93	0.98	0.98	0.98	0.98	0.98	0.9	0.9	0.9	0.9
Bonneville	0.9	0.9	0.91	0.93	0.93	0.93	0.93	0.93	0.91	0.91	0.9	0.9
Rocky Reach	0.89	0.89	0.91	0.93	0.93	0.93	0.93	0.93	0.89	0.89	0.89	0.89
Rock Island	0.89	0.89	0.9	0.93	0.93	0.93	0.93	0.93	0.89	0.89	0.89	0.89
Wanapum	0.89	0.89	0.91	0.92	0.92	0.92	0.92	0.92	0.89	0.89	0.89	0.89
Priest Rapids	0.89	0.89	0.9	0.92	0.92	0.92	0.92	0.92	0.89	0.89	0.89	0.89
Wells	0.89	0.89	0.94	0.97	0.97	0.97	0.97	0.97	0.89	0.89	0.89	0.89

Table III.A.8 Monthly dam survival values for subyearling chinook—Current Potential.

Adult chinook survival past each mainstem dam was assumed to average 93 percent under the Current Potential. Thus, total adult survival through mainstem river reaches is highly dependent on the number of dams each adult must pass. For example, adult chinook returning to the Salmon River would have to pass eight mainstem dams, and thus their overall survival rate would be 60 percent (0.98^8 = 60 percent). In contrast, the survival rate for adults returning to the John Day River would be approximately 80 percent because they must migrate past only three mainstem dams.

Under the Historic Potential, adult chinook survival through the mainstem Columbia and Snake Rivers was assumed to average 92 percent.

In-river Survival (Juveniles)

The survival rates used for modeling the Current Potential for subyearling and yearling juveniles migrating in-river through the hydroelectric complex were based on the range of values presented in recently published scientific literature.

Data presented by NMFS (2000a) show that from 1993-1999 yearling survival from Lower Granite Reservoir to the tailrace of Bonneville Dam ranged from about 31 percent to 51 percent. This equates to a project survival rate of approximately 86 percent to 92 percent. For modeling the Current Potential, we assumed that yearling survival past eight hydroelectric projects averages 36 percent (88 percent per project).

For subyearling chinook we assumed that in-river survival from the head of Lower Granite Reservoir to the tailrace of Bonneville Dam was 29 percent. This equates to a project survival rate of ~85 percent. The survival value only applies to active migrants. For inactive migrants, or life history trajectories that spend more time in the reservoirs (rearing stage), mortality increases in proportion to the time spent in the reservoirs. Thus, overall survival varies dependent on the trajectory examined. This approach is consistent with the data presented in a recent NMFS document (NMFS 2000a). NMFS scientists reported that subyearling survival varied dramatically (13-51 percent) in tests conducted in the Snake River from 1995-1999. However, these survival estimates included mortality from parr to the active migrant stage.

The juvenile survival rates presented above formed the basis for model calibration with regard to overall survival through the mainstem Columbia and Snake Rivers. Because the dam survival values were fixed, the overall survival targets for both life histories required that juvenile survival rates through the reservoirs be adjusted as needed, which we achieved by modifying the habitat quality attributes for each reservoir during the key juvenile migration periods (see Juvenile Migration Timing). Resulting reservoir survival values for the Current Potential are presented in Table III.A.9 and Table III.A.10 for yearling and subyearling chinook, respectively. It should be noted that juvenile survival through the reservoirs is affected by the amount of time the juvenile spends in the reservoir and the benchmark survival value for the specific life stage (subyearling, yearling, etc.).

We set the survival benchmarks for yearling and subyearling chinook at 97.5 percent and 35 percent, respectively. These benchmark survival values were based on the assumption that yearlings require 14 days, and subyearling 56 days, to migrate from natal streams to the estuary under ideal environmental conditions. This equates to a daily survival rate of 99.8 percent ($97.5^{1/14}$) for yearlings and 98.1 percent ($0.35^{1/56}$) for subyearlings.

For each reservoir, we calculated the daily survival rate for juvenile chinook using the following formulas:

Daily Yearling Survival Rate = $(B^{1/14} * RSR^{1/30})$
Daily Subyearling Survival = $(B^{1/56} * RSR^{1/30})$

Where-

B= benchmark survival rate
RSR = Reservoir survival rate by month

Yearling and subyearling juvenile chinook survival rates used for modeling the Historic Potential are presented in Table III.A.11 and Table III.A.12. We calculated the survival values based on mainstem habitat quality, juvenile travel time through each reach, and the benchmark survival values used for each life stage.

Combining the survival data in Table III.A.11 and Table III.A.12 results in the survival estimates presented in Table III.A.13 for yearling and subyearling chinook migrating from above either Lower Granite or Wells dam to the tailrace of Bonneville Dam.

Fish Transportation (Juveniles)

Survival associated with juvenile fish transportation is presented below for Current Potential only; juvenile transport does not occur under the Historic Potential.

The percent of the yearlings and subyearling collected at each of the four lower Snake River and McNary Dam facilities is presented in Table III.A14. The values in Table III.A.14 represent the percent of the juvenile population arriving at each facility that is collected and transported to the tailrace of Bonneville Dam.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.93	0.94	0.91	0.9	0.91	0.91	0.73	0.72	0.58	0.82	0.91	0.93
Little Goose	0.93	0.93	0.91	0.9	0.91	0.91	0.69	0.65	0.64	0.81	0.9	0.92
Lower Monumental	0.94	0.95	0.93	0.92	0.93	0.93	0.77	0.62	0.69	0.85	0.92	0.94
Ice Harbor	0.94	0.94	0.92	0.91	0.92	0.92	0.72	0.65	0.61	0.83	0.91	0.93
McNary	0.95	0.95	0.91	0.9	0.91	0.91	0.76	0.66	0.62	0.84	0.92	0.94
John Day	0.93	0.93	0.86	0.83	0.85	0.86	0.65	0.49	0.41	0.77	0.88	0.91
The Dalles	0.98	0.98	0.95	0.94	0.95	0.95	0.88	0.81	0.77	0.92	0.96	0.97
Bonneville	0.96	0.96	0.92	0.9	0.91	0.91	0.78	0.67	0.61	0.86	0.93	0.95
Rocky Reach	0.98	0.98	0.95	0.94	0.95	0.96	0.93	0.87	0.84	0.93	0.97	0.98
Rock Island	0.99	0.99	0.98	0.97	0.98	0.98	0.96	0.93	0.92	0.97	0.98	0.99
Wanapum	0.98	0.98	0.96	0.95	0.96	0.96	0.93	0.88	0.85	0.94	0.97	0.98
Priest Rapids	0.99	0.99	0.98	0.97	0.98	0.98	0.97	0.94	0.92	0.97	0.98	0.99
Wells	0.99	0.99	0.97	0.96	0.97	0.97	0.95	0.9	0.88	0.95	0.98	0.98
Hanford Reach	0.98	0.98	0.95	0.97	0.98	0.98	0.93	0.87	0.86	0.93	0.96	0.97

Table III.A.9 Reservoir survival rates for yearling chinook- Current.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.86	0.87	0.89	0.95	0.96	0.95	0.85	0.83	0.56	0.72	0.68	0.83
Little Goose	0.85	0.86	0.88	0.94	0.95	0.95	0.83	0.79	0.59	0.7	0.66	0.82
Lower Monumental	0.88	0.89	0.91	0.95	0.96	0.96	0.87	0.77	0.66	0.76	0.72	0.86
Ice Harbor	0.87	0.88	0.9	0.95	0.96	0.95	0.85	0.79	0.59	0.74	0.7	0.84
McNary	0.83	0.87	0.89	0.95	0.95	0.95	0.86	0.79	0.57	0.73	0.69	0.84
John Day	0.8	0.79	0.7	0.81	0.85	0.84	0.68	0.51	0.29	0.55	0.58	0.73
The Dalles	0.93	0.93	0.89	0.93	0.95	0.95	0.89	0.82	0.69	0.83	0.84	0.9
Bonneville	0.87	0.86	0.8	0.87	0.9	0.91	0.79	0.69	0.5	0.69	0.71	0.82
Rocky Reach	0.96	0.95	0.91	0.94	0.96	0.96	0.94	0.9	0.85	0.9	0.91	0.94
Rock Island	0.98	0.98	0.96	0.97	0.98	0.98	0.97	0.95	0.92	0.95	0.95	0.97
Wanapum	0.96	0.96	0.92	0.95	0.96	0.96	0.94	0.91	0.86	0.91	0.92	0.94
Priest Rapids	0.98	0.98	0.96	0.97	0.98	0.98	0.97	0.95	0.93	0.96	0.96	0.97
Wells	0.97	0.97	0.94	0.96	0.97	0.97	0.95	0.93	0.89	0.93	0.93	0.95
Hanford Reach	0.85	0.86	0.88	0.94	0.95	0.95	0.87	0.8	0.59	0.7	0.65	0.81

Table III.A.10 Reservoir survival rates for subyearling chinook- Current Potential.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.98	0.98	0.98	0.99	0.99	0.99	0.92	0.81	0.76	0.96	0.98	0.98
Little Goose	0.98	0.98	0.98	0.99	0.99	0.99	0.9	0.75	0.84	0.96	0.98	0.98
Lower Monumental	0.98	0.99	0.98	0.99	0.99	0.99	0.92	0.79	0.89	0.97	0.98	0.98
Ice Harbor	0.98	0.99	0.98	0.99	0.99	0.99	0.9	0.74	0.81	0.97	0.98	0.98
McNary	0.97	0.97	0.96	0.98	0.99	0.99	0.91	0.74	0.76	0.95	0.97	0.97
John Day	0.94	0.95	0.93	0.96	0.98	0.98	0.86	0.63	0.58	0.91	0.94	0.94
The Dalles	0.98	0.98	0.98	0.99	0.99	0.99	0.95	0.86	0.85	0.97	0.98	0.98
Bonneville	0.97	0.97	0.96	0.97	0.99	0.99	0.92	0.76	0.73	0.94	0.97	0.97
Rocky Reach	0.98	0.98	0.97	0.99	0.99	0.99	0.98	0.93	0.91	0.97	0.98	0.98
Rock Island	0.99	0.99	0.99	0.99	1	1	0.99	0.97	0.96	0.99	0.99	0.99
Wanapum	0.98	0.98	0.98	0.99	0.99	1	0.98	0.94	0.92	0.97	0.98	0.98
Priest Rapids	0.99	0.99	0.99	0.99	1	1	0.99	0.97	0.96	0.99	0.99	0.99
Wells	0.98	0.99	0.98	0.99	1	1	0.99	0.95	0.94	0.98	0.99	0.99

Table III.A.11 Reach survival values for yearling chinook—Historic Potential.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.94	0.95	0.96	0.98	0.98	0.98	0.94	0.84	0.82	0.91	0.93	0.94
Little Goose	0.93	0.94	0.96	0.97	0.98	0.98	0.93	0.81	0.85	0.9	0.92	0.93
Lower Monumental	0.95	0.96	0.97	0.98	0.99	0.99	0.94	0.84	0.88	0.93	0.94	0.95
Ice Harbor	0.94	0.95	0.96	0.98	0.99	0.98	0.94	0.82	0.85	0.92	0.93	0.94
McNary	0.92	0.95	0.96	0.98	0.99	0.98	0.94	0.82	0.84	0.92	0.93	0.94
John Day	0.78	0.81	0.85	0.92	0.96	0.96	0.91	0.78	0.69	0.77	0.78	0.79
The Dalles	0.92	0.93	0.95	0.97	0.99	0.99	0.97	0.92	0.89	0.92	0.92	0.93
Bonneville	0.86	0.88	0.91	0.95	0.98	0.98	0.95	0.86	0.81	0.86	0.86	0.87
Rocky Reach	0.93	0.94	0.95	0.98	0.99	0.99	0.99	0.96	0.94	0.95	0.94	0.94
Rock Island	0.96	0.97	0.97	0.99	1	1	0.99	0.98	0.97	0.97	0.97	0.97
Wanapum	0.94	0.94	0.95	0.98	0.99	0.99	0.99	0.97	0.95	0.95	0.95	0.94
Priest Rapids	0.97	0.97	0.98	0.99	1	1	0.99	0.98	0.97	0.97	0.97	0.97
Wells	0.95	0.95	0.96	0.98	0.99	0.99	0.99	0.97	0.96	0.96	0.96	0.95

Table III.A.12 Reach survival values for subyearling chinook—Historic Potential.

Yearling	Apr	May	Jun	July	Aug
Lower Granite	0.85	0.91	0.91		
Wells Dam	0.85	0.92	0.93		
Subyearling	Apr	May	Jun	July	Aug
Lower Granite			0.84	0.55	0.19
Wells Dam			0.77	0.49	0.14

Table III.A.13 Average monthly survival rates for subyearling chinook migrating from above Lower Granite and Wells Dams to the tailrace of Bonneville Dam—Historic Potential.

Yearling	Apr	May	Jun	Jul	Aug	Sep
Lower Granite	39	39	39			
Little Goose	61	61	61			
Lower Monumental	47	47	47			
McNary	0	0	5			
Subyearling	Apr	May	Jun	Jul	Aug	Sep
Lower Granite			30	35	35	35
Little Goose			25	30	30	30
Lower Monumental			26	31	31	31
McNary			11	31	31	62

Table III.A.14 The percent of yearling and subyearling chinook population transported at each collection facility by month for the Current Potential (Moderate).

We assumed 98 percent of the transported juveniles survive to the point of release (NMFS 2000b). We also assumed survival rates of transported Snake River yearling and subyearling chinook once released from the barges are 50 percent and 35 percent that of juveniles migrating in-river, respectively. We selected these values based on a review of recent literature estimating the differential post-Bonneville Dam survival for in-river and transported juvenile salmonids. The 50 percent value we used for yearling chinook was based on data presented in Bouwes et al. (1999). The subyearling value (35 percent) was based on data presented in PATH (1999). We increased the transport survival rate for subyearlings transported from McNary Dam to 60 percent to maintain a transport survival benefit for subyearling chinook migrating from the mid-Columbia River.

Marine

We present the information on the three components of the marine environment listed below:

1. Estuary
2. Nearshore
3. Ocean

The nearshore area was used to describe the early ocean life of juvenile salmonids (period from ocean entry to December 31).

Because biological rules were not developed for these areas, we used data from the literature and professional expertise to determine juvenile survival in each component of the marine environment. These survival rates were applied to each of the 74 salmon stocks analyzed.

For the estuary, biologists determined impacts to salmonids by developing ratings for a subset of the biological performance attributes. The ratings were based on USGS river flow data, river temperature information, the results of bird predation studies conducted near the mouth of the Columbia River (Roby et al. 1998) and marine mammal predation studies (reviewed in Park 1993). Ratings for juveniles and adults are summarized in Table III.A.15a, Table III.A.15b, and Table III.A.15c.

Chinook ocean survival rates used for modeling purposes beginning with the first full year in the ocean were the same as those used by the Pacific Salmon Commission Chinook Technical Committee. The derivation of these rates is undocumented but are used by the CTC for chinook cohort analysis, thus are consistent with their ocean modeling

Current Potential

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Columbia River Estuary	Hab		1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3		
	Temp		-	-	-	-	-	-	-	-	-	-		
	Pred		2.0	2.0	2.0	2.3	2.3	2.0	2.0	2.0	2.0	2.0		
	CompH		-	0.5	1.0	1.0	1.0	1.0	0.5	-	-	-		
	CompO		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
	Unadj Rel Prod	NA	0.76	0.76	0.74	0.68	0.68	0.74	0.76	0.76	0.76	0.76	NA	0.72

Historic Potential

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Columbia River Estuary	Hab		-	-	-	-	-	-	-	-	-	-		
	Temp		-	-	-	-	-	-	-	-	-	-		
	Pred		1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8		
	CompH		-	-	-	-	-	-	-	-	-	-		
	CompO		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
	Unadj Rel Prod	NA	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	NA	0.86

Alternative 2

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Columbia River Estuary	Hab		1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2		
	Temp		-	-	-	-	-	-	-	-	-	-		
	Pred		1.8	1.8	1.8	2.0	2.0	1.8	1.8	1.8	1.8	1.8		
	CompH		-	0.5	1.0	1.0	1.0	1.0	0.5	-	-	-		
	CompO		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
	Unadj Rel Prod	NA	0.81	0.81	0.79	0.74	0.74	0.79	0.81	0.81	0.81	0.81	NA	0.77

Alternative 5

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Columbia River Estuary	Hab		1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2		
	Temp		-	-	-	-	-	-	-	-	-	-		
	Pred		1.8	1.8	1.8	2.0	2.0	1.8	1.8	1.8	1.8	1.8		
	CompH		-	0.5	1.0	1.0	1.0	1.0	0.5	-	-	-		
	CompO		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
	Unadj Rel Prod	NA	0.81	0.81	0.79	0.74	0.74	0.79	0.81	0.81	0.81	0.81	NA	0.77

Alternative 6

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Columbia River Estuary	Hab		1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2		
	Temp		-	-	-	-	-	-	-	-	-	-		
	Pred		1.8	1.8	1.8	2.0	2.0	1.8	1.8	1.8	1.8	1.8		
	CompH		-	0.5	1.0	1.0	1.0	1.0	0.5	-	-	-		
	CompO		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
	Unadj Rel Prod	NA	0.81	0.81	0.79	0.74	0.74	0.79	0.81	0.81	0.81	0.81	NA	0.77

Table III.A.15a Juvenile subyearling biological performance attribute ratings by alternative for the Columbia River estuary under the worldview Moderate. Note that the weighted mean relative productivity varies by race and thus is not provided.

Current Potential

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Columbia River Estuary	Hab		-	-	-	-	-	-	-	-	-	-		
	Temp		-	-	-	-	-	-	-	-	-	-		
	Pred		1.5	1.5	1.5	1.2	1.0	1.0	1.0	1.0	0.5	0.5		
	CompH		-	-	-	-	-	-	-	-	-	-		
	CompO		-	-	-	-	-	-	-	-	-	-		
	Unadj Rel Prod	NA	0.93	0.93	0.93	0.96	0.98	0.98	0.98	0.98	1.00	1.00	NA	NA

Historic Potential Conditions

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Columbia River Estuary	Hab		-	-	-	-	-	-	-	-	-	-		
	Temp		-	-	-	-	-	-	-	-	-	-		
	Pred		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
	CompH		-	-	-	-	-	-	-	-	-	-		
	CompO		-	-	-	-	-	-	-	-	-	-		
	Unadj Rel Prod	NA	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	NA	NA

Alternative 2

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Columbia River Estuary	Hab		-	-	-	-	-	-	-	-	-	-		
	Temp		-	-	-	-	-	-	-	-	-	-		
	Pred		1.5	1.5	1.5	1.2	1.0	1.0	1.0	1.0	0.5	0.5		
	CompH		-	-	-	-	-	-	-	-	-	-		
	CompO		-	-	-	-	-	-	-	-	-	-		
	Unadj Rel Prod	NA	0.93	0.93	0.93	0.96	0.98	0.98	0.98	0.98	1.00	1.00	NA	NA

Alternative 5

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Columbia River Estuary	Hab		-	-	-	-	-	-	-	-	-	-		
	Temp		-	-	-	-	-	-	-	-	-	-		
	Pred		1.5	1.5	1.5	1.2	1.0	1.0	1.0	1.0	0.5	0.5		
	CompH		-	-	-	-	-	-	-	-	-	-		
	CompO		-	-	-	-	-	-	-	-	-	-		
	Unadj Rel Prod	NA	0.93	0.93	0.93	0.96	0.98	0.98	0.98	0.98	1.00	1.00	NA	NA

Alternative 6

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Columbia River Estuary	Hab		-	-	-	-	-	-	-	-	-	-		
	Temp		-	-	-	-	-	-	-	-	-	-		
	Pred		1.5	1.5	1.5	1.2	1.0	1.0	1.0	1.0	0.5	0.5		
	CompH		-	-	-	-	-	-	-	-	-	-		
	CompO		-	-	-	-	-	-	-	-	-	-		
	Unadj Rel Prod	NA	0.93	0.93	0.93	0.96	0.98	0.98	0.98	0.98	1.00	1.00	NA	NA

Table III.A.15b Juvenile yearling biological performance attribute ratings by alternative for the Columbia River estuary under the worldview Moderate. Note that the weighted mean relative productivity varies by race and thus is not provided.

Current Potential

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Columbia River Estuary	Hab			1.3	1.3	1.3	1.3	1.3						
	Temp			-	-	-	-	-						
	Pred			2.0	2.0	2.3	2.3	2.0						
	CompH			-	0.5	0.5	0.5	-						
	CompO			-	-	-	-	-						
	Unadj Rel Prod	NA	NA	0.81	0.81	0.74	0.74	0.81	NA	NA	NA	NA	NA	0.76

Historic Potential

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Columbia River Estuary	Hab			-	-	-	-	-						
	Temp			-	-	-	-	-						
	Pred			1.8	1.8	1.8	1.8	1.8						
	CompH			-	-	-	-	-						
	CompO			-	-	-	-	-						
	Unadj Rel Prod	NA	NA	0.88	0.88	0.88	0.88	0.88	NA	NA	NA	NA	NA	0.88

Alternative 2

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Columbia River Estuary	Hab			1.1	1.1	1.1	1.1	1.1						
	Temp			-	-	-	-	-						
	Pred			1.8	1.8	2.0	2.0	1.8						
	CompH			-	0.5	0.5	0.5	-						
	CompO			-	-	-	-	-						
	Unadj Rel Prod	NA	NA	0.87	0.87	0.82	0.82	0.87	NA	NA	NA	NA	NA	0.83

Alternative 5

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Columbia River Estuary	Hab			1.1	1.1	1.1	1.1	1.1						
	Temp			-	-	-	-	-						
	Pred			1.8	1.8	2.0	2.0	1.8						
	CompH			-	0.5	0.5	0.5	-						
	CompO			-	-	-	-	-						
	Unadj Rel Prod	NA	NA	0.87	0.87	0.82	0.82	0.87	NA	NA	NA	NA	NA	0.83

Alternative 6

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Columbia River Estuary	Hab			1.1	1.1	1.1	1.1	1.1						
	Temp			-	-	-	-	-						
	Pred			1.8	1.8	2.0	2.0	1.8						
	CompH			-	0.5	0.5	0.5	-						
	CompO			-	-	-	-	-						
	Unadj Rel Prod	NA	NA	0.87	0.87	0.82	0.82	0.87	NA	NA	NA	NA	NA	0.83

Table III.A.15c Adult chinook biological performance attribute ratings by alternative for the Columbia River estuary under the worldview Moderate. Note that the weighted mean relative productivity varies by race and thus is not provided.

exercises. The rates are summarized by age (shown are ages for ocean type life history) in Table III.A.16.

We developed the nearshore / early marine survival rates based on the unexplained residual from known estuary and marine survival rates of the expected SAR rates for natural Columbia River chinook. Subyearling and yearling early marine rates were 55 percent and 40 percent, respectively.

Coarse Screening of Environmental Attributes

As noted previously, we derived the environmental attributes from easily obtainable data for each of the five provinces. The quality of these data varied by attribute, 6-HUC, and province; and it was determined early in the process that the quality was sufficient for conducting an analysis at the basin and province scales only. To help improve the quality of this data set, fisheries biologists familiar with the stream habitat present in each province reviewed a subset of the derived environmental attribute data set. Specific environmental attributes reviewed included:

1. Fine Sediment
2. Bed Scour
3. Low Flow
4. Riparian Function
5. Maximum Temperature

We selected these attributes for review based on past EDT analyses, where ratings for these attributes have shown a relatively large effect on salmon survival and resulting salmon performance. The biologists reviewed each of the five attributes for the 822 6-HUCs that are used by chinook salmon. Each biologist examined the data set and made changes to the attributes based on available data and professional opinion. We incorporated all of the changes in the environmental attributes proposed by the review biologists into the final analysis; they are, therefore, reflected in the modeling results.

Age	Ocean Survival
2	0.6
3	0.7
4	0.8
5	0.9

Table III.A.16 Ocean survival rate by age class (chinook).

Development of Hatchery Attributes

The EDT approach addresses the hatchery environment and hatchery reared populations the same way it addresses natural habitat and wild populations. Survival conditions in the hatchery environment are captured in the form of biological performance attributes, and hatchery populations are analyzed based upon the hatchery and natural environments available to them. Obtaining input data from individual hatchery facilities was beyond the scope of this study and we, therefore, focused on the performance of hatchery populations after their release.

Survival of Hatchery Fish

Where studies of direct comparisons between hatchery and natural populations in the natural environment are sparse, it is generally assumed that post release survival of hatchery fish is less than that for wild fish over the same life stages. This difference can be attributed to both first generation (non-genetic) and trans-generation (genetic) factors. Our assumptions here relied largely on the approach and conclusions presented in RASP (1992). In Table III.A.17, the genetic and non-genetic factors have been combined into one survival multiplier for post release survival. In the population analysis, we apply this additional rate of mortality from the time of release until the end of the first year in the ocean.

Based on experimental results with new culture practices intended to improve survival of hatchery fish we assumed that future supplementation programs would achieve somewhat higher survival.

Effects of Hatchery Fish on Wild Populations

In the EDT analysis, hatchery fish can affect wild / natural populations through ecological or genetic interactions. Ecological interactions involve competition for food and space, predation (directly or indirectly by affecting behavior of predators), and ecological function. Genetic interactions result from hatchery fish interbreeding with wild fish in the natural environment.

We estimated competition effects due to hatchery fish based on estimated densities of hatchery juveniles by stream reach over time and on maximum densities drawn from the literature. We computed the density of hatchery fish from time and rate of release of hatchery fish at each facility and estimated rates of downstream movement of those fish. Using the Beverton-Holt survival function and benchmark maximum density parameters, we estimated the survival impacts on wild fish for every stream reach and time period. We did not include direct and indirect effects of predation in this analysis. We did include ecological

Worldview	Culture Method	Parameter 1: Multiplier on natural production based on presence of hatchery fish				Parameter 2: Post-release survival of hatchery fish
		Percent hatchery fish spawning with naturally produced fish				
		> 50%	20-50%	10-20%	<10%	
Moderate	Conventional hatchery	75%	83%	93%	100%	25%
	Supplementation hatchery	82%	88%	95%	100%	30%

Table III.A.17 Relative survival parameters for hatchery produced fish and for natural populations influenced by hatchery fish (Moderate worldview).

effects due to nutrient enhancement from carcasses (positive increase in survival) and due to pathogens associated with hatchery programs as direct, site-specific inputs.

Hatchery fish access natural spawning grounds inadvertently through straying or as a result of supplementation with the intent to augment natural spawning. We relied on RASP (1992) for estimates of the survival (fitness) effect on natural populations of hatchery introgression as a function of the hatchery-natural composition of the spawning population (see Table III.A.17). In order to calculate the ratio of hatchery to wild and compute the demographic contribution of hatchery spawners to the subsequent generation, we somewhat arbitrarily assumed that the total escapement (hatchery plus natural) to the spawning grounds would not exceed the natural spawner capacity.

Hatchery Production

The total number of hatchery fish by species released in each alternative and condition is presented in Table III.A.18a, Table III.A.18b, and Table III.A.18c.

Supplementation

The future alternatives all assume that some of the returning hatchery fish will spawn with naturally produced fish in the wild (Figure III.A.3).

Development of Harvest Attributes

We obtained the data used in this analysis to determine the rate and location of adult harvest from the following sources:

- Fisheries Regulatory Assessment Model (FRAM)
- Chinook Technical Committee, Pacific Salmon Commission
- Status Report, Columbia River Fish Runs and Fisheries, 1938-1997. WDFW / ODFW
- 1996 All Species Review, Columbia River Fish Management Plan. US V. Oregon, Technical Advisory Committee, 1997.
- Biological Assessment, Technical Advisory Committee. 1998

For this analysis, we defined the harvest rate base period to be 1992-1996 developed harvest rates for both ocean and mainstem Columbia River fisheries (Zones 1-6). We based the harvest rates used in this analysis on published rates for ten Columbia River Harvest indicator stocks (Table III.A.18a, Table III.A.18b, and Table III.A.18c). The data presented in Table III.A.19 show the specific indicator stock that we used in setting

Subbasin	Hatch Name	Hatchery Release ID	Species	Release Stage	Current Number of Fish	Alt 1 Number of Fish	Alt 2 Number of Fish	Alt 3 Number of Fish	Alt 4 Number of Fish	Alt 5 Number of Fish	Alt 6 Number of Fish	Alt 7 Number of Fish
BLUE_MOUNTAIN												
New Production												
Grande Ronde	Grande Ronde Supplementation		Spring Chinook	Yearling	-	-	-	-	-	-	-	-
Snake, Hells Canyon	Snake Mainstem Supple	607	Fall Chinook	Subyearling	-	-	-	-	-	10,000,000	10,000,000	-
Existing Production (1994-1998 average release)												
Grande Ronde	Lookingglass Hatchery		Spring Chinook	Yearling	410,000	-	410,000	410,000	410,000	410,000	410,000	-
Imnaha	Imnaha Pond		Spring Chinook	Yearling	213,640	-	214,000	214,000	214,000	214,000	214,000	-
Snake, Hells Canyon	Hells Canyon		Spring Chinook	Yearling	205,000	-	205,000	205,000	205,000	205,000	205,000	205,000
				Total for Province:	829,000	-	829,000	829,000	829,000	10,829,000	10,829,000	205,000
MOUNTAIN_SNAKE												
New Production												
CLEARWATER	Lower Clearwater Supple	605	Summer Chinook	Subyearling	-	-	-	-	-	2,000,000	2,000,000	-
SALMON	Lower Salmon Supple	606	Summer Chinook	Subyearling	-	-	-	-	-	2,000,000	2,000,000	-
Existing Production (1994-1998 average release)												
CLEARWATER	Dworshak NFH		Spring Chinook	Yearling	744,000	-	744,000	744,000	744,000	744,000	744,000	-
CLEARWATER	Lochsa River Supple		Spring Chinook	Yearling	176,000	-	176,000	176,000	176,000	176,000	176,000	176,000
CLEARWATER	Kooskia NFH		Spring Chinook	Yearling	290,000	-	290,000	290,000	290,000	290,000	290,000	290,000
SALMON	SF Clearwater Supple		Spring Chinook	Yearling	245,000	-	245,000	245,000	245,000	245,000	245,000	245,000
SALMON	EF Salmon R Release		Spring Chinook	Yearling	12,000	-	12,000	12,000	12,000	12,000	12,000	-
SALMON	Sawtooth Hatchery		Spring Chinook	Yearling	50,000	-	50,000	50,000	50,000	50,000	50,000	50,000
SALMON	Upper Salmon Supple		Spring Chinook	Yearling	56,000	-	56,000	56,000	56,000	56,000	56,000	56,000
SALMON	Rapid River Hatchery		Spring Chinook	Yearling	1,097,000	-	1,097,000	1,097,000	1,097,000	1,097,000	1,097,000	-
SALMON	Pahsimerio Hatchery		Summer Chinook	Yearling	80,000	-	80,000	80,000	80,000	80,000	80,000	80,000
SALMON	McCall Hatchery SF Salmon		Summer Chinook	Yearling	446,000	-	446,000	446,000	446,000	446,000	446,000	446,000
				Total for Province:	3,196,000	-	3,196,000	3,196,000	3,196,000	7,196,000	7,196,000	1,343,000
COLUMBIA_CASCADE												
New Production												
Columbia, Upper Mid	Rocky Reach Pool - New production	600	Summer Chinook	Subyearling	-	-	10,000,000	10,000,000	-	10,000,000	10,000,000	-
Existing Production (1994-1998 average release)												
Entiat	Entiat Hatchery		Spring Chinook	Yearling	330,000	-	330,000	330,000	330,000	330,000	330,000	330,000
Methow	Chewuch Hatchery		Spring Chinook	Yearling	86,000	-	86,000	86,000	86,000	86,000	86,000	86,000
Methow	Methow Hatchery		Spring Chinook	Yearling	450,000	-	450,000	450,000	450,000	450,000	450,000	450,000
Methow	Twisp Hatchery		Spring Chinook	Yearling	50,000	-	50,000	50,000	50,000	50,000	50,000	50,000
Wenatchee	Leavenworth NFH		Spring Chinook	Yearling	1,500,000	-	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000
Wenatchee	Chiwawa Satelite Hatchery		Spring Chinook	Yearling	70,000	-	70,000	70,000	70,000	70,000	70,000	70,000
Columbia, Upper Mid	Well Hatchery Subyearling Rel		Summer Chinook	Subyearling	304,000	-	304,000	304,000	304,000	304,000	304,000	-
Columbia, Upper Mid	Well Hatchery Yearling Rel		Summer Chinook	Yearling	359,000	-	359,000	359,000	359,000	359,000	359,000	359,000
Lake Chelan	Chelan Hatchery		Summer Chinook	Subyearling	72,000	-	72,000	72,000	72,000	72,000	72,000	-
Methow	Methow Hatchery		Summer Chinook	Yearling	379,000	-	379,000	379,000	379,000	379,000	379,000	379,000
Okanogan / Similkameen	Similkameen Hatchery		Summer Chinook	Yearling	553,000	-	553,000	553,000	553,000	553,000	553,000	-
Wenatchee	Wenatchee Dryden Pond		Summer Chinook	Yearling	723,000	-	723,000	723,000	723,000	723,000	723,000	723,000
				Total for Province:	4,876,000	-	14,876,000	14,876,000	4,876,000	14,876,000	14,876,000	3,947,000

Table III.A.18a Total number of hatchery fish released by race, province, and alternative.

	Subbasin	Hatch Name	Hatchery Release ID	Species	Release Stage	Current Number of Fish	Alt 1 Number of Fish	Alt 2 Number of Fish	Alt 3 Number of Fish	Alt 4 Number of Fish	Alt 5 Number of Fish	Alt 6 Number of Fish	Alt 7 Number of Fish
BLUE_MOUNTAIN													
	New Production												
	Grande Ronde	Grande Ronde Supplementation		Spring Chinook	Yearling	-	-	-	-	-	-	-	-
	Snake, Hells Canyon	Snake Mainstem Supple	607	Fall Chinook	Subyearling	-	-	-	-	-	10,000,000	10,000,000	-
	Existing Production (1994-1998 average release)												
	Grande Ronde	Lookingglass Hatchery		Spring Chinook	Yearling	410,000	-	410,000	410,000	410,000	410,000	410,000	-
	Imnaha	Imnaha Pond		Spring Chinook	Yearling	213,640	-	214,000	214,000	214,000	214,000	214,000	-
	Snake, Hells Canyon	Hells Canyon		Spring Chinook	Yearling	205,000	-	205,000	205,000	205,000	205,000	205,000	205,000
					Total for Province:	829,000	-	829,000	829,000	829,000	10,829,000	10,829,000	205,000
MOUNTAIN_SNAKE													
	New Production												
	CLEARWATER	Lower Clearwater Supple	605	Summer Chinook	Subyearling	-	-	-	-	-	2,000,000	2,000,000	-
	SALMON	Lower Salmon Supple	606	Summer Chinook	Subyearling	-	-	-	-	-	2,000,000	2,000,000	-
	Existing Production (1994-1998 average release)												
	CLEARWATER	Dworshak NFH		Spring Chinook	Yearling	744,000	-	744,000	744,000	744,000	744,000	744,000	-
	CLEARWATER	Lochsa River Supple		Spring Chinook	Yearling	176,000	-	176,000	176,000	176,000	176,000	176,000	176,000
	CLEARWATER	Kooskia NFH		Spring Chinook	Yearling	290,000	-	290,000	290,000	290,000	290,000	290,000	290,000
	SALMON	SF Clearwater Supple		Spring Chinook	Yearling	245,000	-	245,000	245,000	245,000	245,000	245,000	245,000
	SALMON	EF Salmon R Release		Spring Chinook	Yearling	12,000	-	12,000	12,000	12,000	12,000	12,000	-
	SALMON	Sawtooth Hatchery		Spring Chinook	Yearling	50,000	-	50,000	50,000	50,000	50,000	50,000	50,000
	SALMON	Upper Salmon Supple		Spring Chinook	Yearling	56,000	-	56,000	56,000	56,000	56,000	56,000	56,000
	SALMON	Rapid River Hatchery		Spring Chinook	Yearling	1,097,000	-	1,097,000	1,097,000	1,097,000	1,097,000	1,097,000	-
	SALMON	Pahsimerio Hatchery		Summer Chinook	Yearling	80,000	-	80,000	80,000	80,000	80,000	80,000	80,000
	SALMON	McCall Hatchery SF Salmon		Summer Chinook	Yearling	446,000	-	446,000	446,000	446,000	446,000	446,000	446,000
					Total for Province:	3,196,000	-	3,196,000	3,196,000	3,196,000	7,196,000	7,196,000	1,343,000
COLUMBIA_CASCADE													
	New Production												
	Columbia, Upper Mid	Rocky Reach Pool - New production	600	Summer Chinook	Subyearling	-	-	10,000,000	10,000,000	-	10,000,000	10,000,000	-
	Existing Production (1994-1998 average release)												
	Entiat	Entiat Hatchery		Spring Chinook	Yearling	330,000	-	330,000	330,000	330,000	330,000	330,000	330,000
	Methow	Chewuch Hatchery		Spring Chinook	Yearling	86,000	-	86,000	86,000	86,000	86,000	86,000	86,000
	Methow	Methow Hatchery		Spring Chinook	Yearling	450,000	-	450,000	450,000	450,000	450,000	450,000	450,000
	Methow	Twisp Hatchery		Spring Chinook	Yearling	50,000	-	50,000	50,000	50,000	50,000	50,000	50,000
	Wenatchee	Leavenworth NFH		Spring Chinook	Yearling	1,500,000	-	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000
	Wenatchee	Chiwawa Satelite Hatchery		Spring Chinook	Yearling	70,000	-	70,000	70,000	70,000	70,000	70,000	70,000
	Columbia, Upper Mid	Well Hatchery Subyearling Rel		Summer Chinook	Subyearling	304,000	-	304,000	304,000	304,000	304,000	304,000	-
	Columbia, Upper Mid	Well Hatchery Yearling Rel		Summer Chinook	Yearling	359,000	-	359,000	359,000	359,000	359,000	359,000	359,000
	Lake Chelan	Chelan Hatchery		Summer Chinook	Subyearling	72,000	-	72,000	72,000	72,000	72,000	72,000	-
	Methow	Methow Hatchery		Summer Chinook	Yearling	379,000	-	379,000	379,000	379,000	379,000	379,000	379,000
	Okanogan / Similkameen	Similkameen Hatchery		Summer Chinook	Yearling	553,000	-	553,000	553,000	553,000	553,000	553,000	-
	Wenatchee	Wenatchee Dryden Pond		Summer Chinook	Yearling	723,000	-	723,000	723,000	723,000	723,000	723,000	723,000
					Total for Province:	4,876,000	-	14,876,000	14,876,000	4,876,000	14,876,000	14,876,000	3,947,000

Table III.A.18b Total number of hatchery fish released by race, province, and alternative.

					Current	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7
Subbasin	Hatch Name	Hatchery Release ID	Species	Release Stage	Number of Fish	Number of Fish	Number of Fish	Number of Fish	Number of Fish	Number of Fish	Number of Fish	Number of Fish
LOWER_COLUMBIA												
New Production												
Columbia, Lower	Lower Columbia Aquaculture		Fall Chinook	Subyearling	-	-	-	-	-	-	10,000,000	10,000,000
Existing Production (1994-1998 average release)												
Columbia, Lower	Youngs River Hatchery		Spring Chinook	Yearling	376,000	-	376,000	376,000	376,000	376,000	376,000	376,000
Columbia, Lower	Klaskanine Hatchery		Spring Chinook	Yearling	70,000	-	70,000	70,000	70,000	70,000	70,000	70,000
Cowlitz	Green R Hatchery		Spring Chinook	Yearling	118,000	-	118,000	118,000	118,000	118,000	118,000	118,000
Cowlitz	Cowlitz R Hatchery		Spring Chinook	Yearling	1,208,000	-	1,208,000	1,208,000	1,208,000	1,208,000	1,208,000	1,208,000
Kalama	Fallert Creek Hatchery		Spring Chinook	Yearling	463,000	-	463,000	463,000	463,000	463,000	463,000	463,000
Lewis	NF Lewis River		Spring Chinook	Yearling	513,000	-	513,000	513,000	513,000	513,000	513,000	513,000
Lewis	Lewis River Hatchery		Spring Chinook	Yearling	693,000	-	693,000	693,000	693,000	693,000	693,000	693,000
Sandy	Sandy River Hatchery		Spring Chinook	Yearling	431,000	-	431,000	431,000	431,000	431,000	431,000	431,000
WILLAMETTE	Mckenzie R Hatchery		Spring Chinook	Yearling	676,000	-	676,000	676,000	676,000	676,000	676,000	676,000
WILLAMETTE	Willamette Hatchery		Spring Chinook	Yearling	111,000	-	111,000	111,000	111,000	111,000	111,000	111,000
WILLAMETTE	Clackamas Hatchery		Spring Chinook	Yearling	508,000	-	508,000	508,000	508,000	508,000	508,000	508,000
WILLAMETTE	Molalla R Hatchery		Spring Chinook	Yearling	38,000	-	38,000	38,000	38,000	38,000	38,000	38,000
WILLAMETTE	SF Santiam Hatchery		Spring Chinook	Yearling	610,000	-	610,000	610,000	610,000	610,000	610,000	610,000
WILLAMETTE	NF Santiam Hatchery		Spring Chinook	Yearling	655,000	-	655,000	655,000	655,000	655,000	655,000	655,000
WILLAMETTE	MF Willamette Hatchery		Spring Chinook	Yearling	939,000	-	939,000	939,000	939,000	939,000	939,000	939,000
Columbia, Lower	Youngs Bay Net Pens		Fall Chinook	Subyearling	710,000	-	710,000	710,000	710,000	710,000	710,000	710,000
Columbia, Lower	Chinook R Hatchery (Sea Resources)		Fall Chinook	Subyearling	764,000	-	764,000	764,000	764,000	764,000	764,000	764,000
Columbia, Lower	Big Creek Hatchery		Fall Chinook	Subyearling	8,370,000	-	8,370,000	8,370,000	8,370,000	8,370,000	8,370,000	8,370,000
Cowlitz	Cowlitz R Hatchery		Fall Chinook	Subyearling	6,185,000	-	6,185,000	6,185,000	6,185,000	6,185,000	6,185,000	6,185,000
Cowlitz	Green R Hatchery		Fall Chinook	Subyearling	2,463,000	-	2,463,000	2,463,000	2,463,000	2,463,000	2,463,000	2,463,000
Elochoman	Abernathy Hatchery		Fall Chinook	Subyearling	778,000	-	778,000	778,000	778,000	778,000	778,000	778,000
Elochoman	Elochoman Hatchery		Fall Chinook	Subyearling	3,040,159	-	3,040,159	3,040,159	3,040,159	3,040,159	3,040,159	3,040,159
Kalama	Kalama Falls Hatchery		Fall Chinook	Subyearling	4,037,000	-	4,037,000	4,037,000	4,037,000	4,037,000	4,037,000	4,037,000
Kalama	Fallert Creek Hatchery		Fall Chinook	Subyearling	1,635,000	-	1,635,000	1,635,000	1,635,000	1,635,000	1,635,000	1,635,000
Sandy	Bonneville Hatchery		Fall Chinook	Subyearling	10,708,000	-	10,708,000	10,708,000	10,708,000	10,708,000	10,708,000	10,708,000
Washougal	Washougal Hatchery		Fall Chinook	Subyearling	5,840,000	-	5,840,000	5,840,000	5,840,000	5,840,000	5,840,000	5,840,000
WILLAMETTE	NF Santiam Hatchery		Fall Chinook	Subyearling	507,000	-	507,000	507,000	507,000	507,000	507,000	507,000
				Total for Province:	52,446,159	-	52,446,000	52,446,000	52,446,000	52,446,000	62,446,000	62,446,000
				Total Hatchery Release Columbia Basin:	101,870,159	-	112,680,000	122,680,000	102,680,000	136,680,000	146,680,000	108,829,000
				Hatchey Production above Bonneville Dam:	49,424,000	-	60,234,000	70,234,000	50,234,000	84,234,000	84,234,000	46,383,000
				Hatchey Production below Bonneville Dam:	52,446,159	-	52,446,000	52,446,000	52,446,000	52,446,000	62,446,000	62,446,000
				Increase over current above Bonneville----->		-100%	22%	42%	2%	70%	70%	-6%
				Increase over current Below Bonneville----->		-100%	0%	0%	0%	0%	19%	19%
				Increase over current Columbia Basin----->		-100%	11%	20%	1%	34%	44%	7%

Table III.A.18c Total number of hatchery fish released by race, province, and alternative.

Current

Columbia Up River Bright

	Ocean Age			
	1	2	3	4
Terminal Harvest	28%	28%	28%	28%
Oregon/Calif	0%	1%	3%	3%
Wash	0%	0%	0%	0%
WCVI	1%	2%	5%	4%
BC North	1%	1%	4%	4%
SE Alaska	2%	1%	10%	17%
HR by age return	31%	34%	47%	61%
HR SEAK fishery	2%	3%	12%	27%

Bonneville Pool Hatchery Fall Chinook

	Ocean Age			
	1	2	3	4
Terminal Harvest	28%	28%	28%	28%
Oregon/Calif	0%	1%	1%	0%
Wash	2%	13%	6%	1%
WCVI	1%	8%	14%	15%
BC North	0%	0%	1%	0%
SE Alaska	0%	0%	0%	0%
HR by age return	30%	45%	56%	63%
HR SEAK fishery	0%	0%	0%	0%

Snake River Fall Chinook

	Ocean Age			
	1	2	3	4
Terminal Harvest	28%	28%	28%	28%
Oregon/Calif	0%	1%	1%	1%
Wash	0%	1%	2%	4%
WCVI	1%	3%	13%	9%
BC North	1%	1%	3%	7%
SE Alaska	0%	0%	5%	5%
HR by age return	29%	34%	48%	61%
HR SEAK fishery	0%	1%	5%	10%

Columbia River Summer Chinook

	Ocean Age			
	0	1	2	3
Terminal Harvest	2%	2%	2%	2%
Oregon/Calif	0%	0%	0%	0%
Wash	0%	0%	0%	1%
WCVI	1%	2%	7%	1%
BC North	2%	1%	13%	5%
SE Alaska	1%	1%	14%	6%
HR by age return	6%	9%	37%	45%
HR SEAK fishery	1%	2%	15%	20%

Oregon Tule

	Ocean Age			
	1	2	3	4
Terminal Harvest	28%	28%	28%	28%
Oregon/Calif	0%	1%	0%	0%
Wash	2%	10%	5%	0%
WCVI	3%	13%	14%	0%
BC North	0%	0%	3%	0%
SE Alaska	0%	0%	0%	0%
HR by age return	32%	48%	59%	59%
HR SEAK fishery	0%	0%	0%	0%

Willamette River Spring Chinook

	Ocean Age			
	0	1	2	3
Terminal Harvest	7%	7%	7%	7%
Oregon/Calif	0%	0%	0%	0%
Wash	1%	0%	1%	0%
WCVI	1%	2%	3%	3%
BC North	3%	2%	5%	1%
SE Alaska	3%	1%	7%	1%
HR by age return	14%	18%	31%	34%
HR SEAK fishery	3%	4%	11%	11%

Washington Hatchery Tule

	Ocean Age			
	1	2	3	4
Terminal Harvest	28%	28%	28%	28%
Oregon/Calif	0%	1%	1%	0%
Wash	1%	2%	6%	1%
WCVI	1%	4%	14%	22%
BC North	1%	1%	4%	0%
SE Alaska	0%	0%	5%	4%
HR by age return	31%	36%	53%	65%
HR SEAK fishery	0%	1%	5%	9%

Cowlitz River Spring Chinook

	Ocean Age			
	0	1	2	3
Terminal Harvest	7%	7%	7%	7%
Oregon/Calif	0%	1%	1%	0%
Wash	0%	2%	4%	1%
WCVI	0%	2%	2%	4%
BC North	0%	0%	3%	2%
SE Alaska	0%	0%	1%	0%
HR by age return	8%	14%	23%	28%
HR SEAK fishery	0%	0%	2%	2%

Lewis River Wild Fall Chinook

	Ocean Age			
	1	2	3	4
Terminal Harvest	28%	28%	28%	28%
Oregon/Calif	0%	0%	1%	0%
Wash	0%	1%	2%	0%
WCVI	0%	1%	3%	0%
BC North	0%	0%	3%	2%
SE Alaska	0%	0%	5%	9%
HR by age return	29%	31%	40%	47%
HR SEAK fishery	0%	1%	6%	15%

Spring Chinook (Columbia Basin)

	Ocean Age			
	0	1	2	3
Terminal Harvest	7%	7%	7%	7%
Oregon/Calif	0%	0%	0%	0%
Wash	0%	0%	0%	0%
WCVI	0%	0%	0%	0%
BC North	0%	0%	0%	0%
SE Alaska	0%	0%	0%	0%
HR by age return	7%	7%	7%	7%
HR SEAK fishery	0%	0%	0%	0%

Table 3.1.19 Harvest rates by location for the ten Columbia River indicator stocks.

harvest rates for each of the 74 fish populations examined in this analysis. The analysis does not include estimates of sport or commercial harvest in the tributaries. Thus, the adult run sizes reported for each province are based on the number of fish entering each tributary.

Population Structure

The EDT analytical model is based on the analysis of life history pathways through the environment. The analytical model includes a Trajectory Generator module that generates multiple pathways, referred to as *trajectories*, through space and time. Each trajectory may vary in the duration, rate of travel, and timing of life stages (Figure III.A.4).

We use the term *life history pattern* to mean a collection of similar trajectories (Figure III.A.5). These trajectories share life history behaviors, such as ocean entry timing (e.g., age at ocean entry or seasonal timing) or migration pattern during freshwater residence (e.g., freshwater residence in natal stream or redistribution to non-natal stream for “overwintering”).

Finally, the uppermost level of organization of biological performance is the population. Trajectories are grouped into loosely defined populations based on common geographic area and common life history pattern (i.e., spring chinook in the Upper Yakima basin). We describe populations based on available documentation for a basin (status reports, harvest management units, etc).

General Chinook Life Histories

Chinook salmon exhibit a wide variety of life history patterns (Reimers 1971; reviewed by Healey 1991). At the most basic level, chinook salmon life histories are defined by *stream type* and *ocean type* behavioral patterns (Healey 1991; first described in Gilbert 1913). Stream type chinook remain in freshwater for one year before migrating to sea, which is typical of northern populations and headwater tributaries of southern rivers. Ocean type chinook migrate to sea during their first year of life, which is more common in coastal streams and rivers south of 56°N.

Taylor (1990a) hypothesized that age of seaward migration (stream vs. ocean type) is environmentally modulated (temperature and photoperiod) and shows an inheritable component to differences in growth rate and agonistic behavior between stream and ocean type chinook (Taylor, 1990b). Clarke et al. (1992) demonstrated an inheritable response to photoperiod and resulting saltwater tolerance. We conclude that, at the population level, the proportion of stream and ocean type life history patterns should be specified in the EDT model; the environment

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Snake	37,760	39,610	48,407	89,043	107,245	100,156	50,913	43,643	22,655	24,054	20,928	32,456
Columbia	207,900	198,279	154,250	228,089	287,186	290,140	195,951	163,881	99,886	109,622	109,304	155,839
Mid-Col	153,594	139,802	87,457	124,301	171,988	177,453	135,133	114,599	71,728	79,317	77,075	107,495

Table III.A.4 Average monthly flows used in modeling the Current Potential.

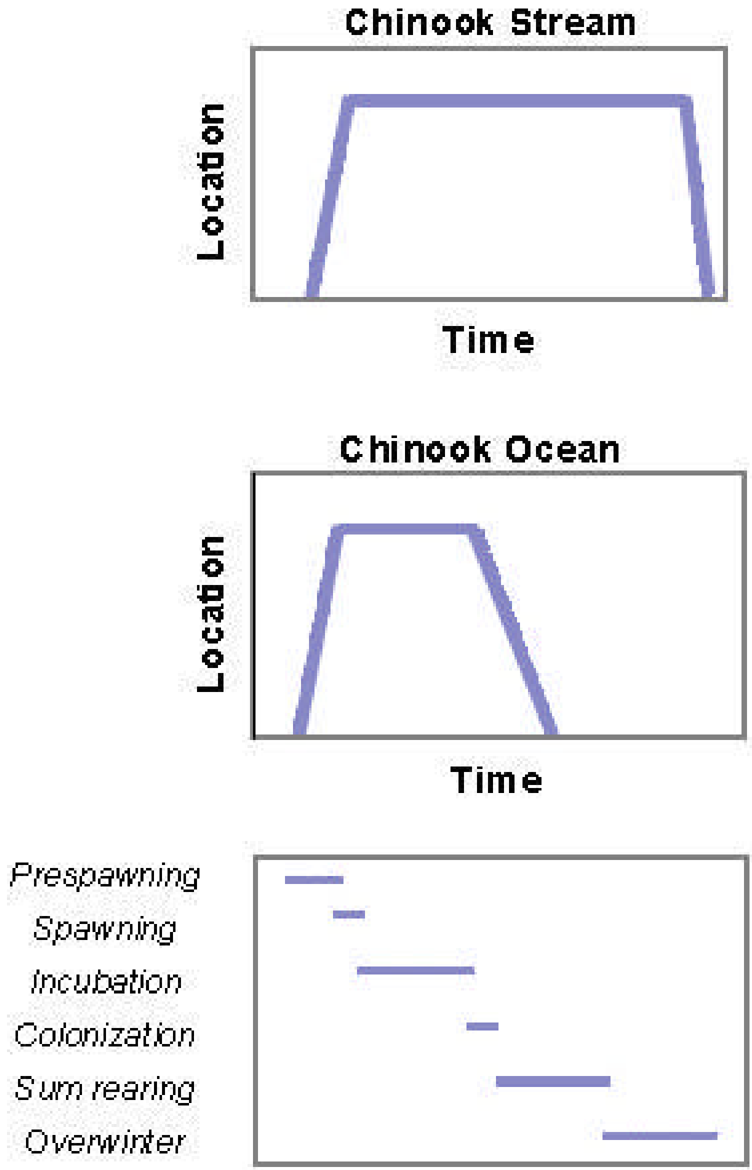


Figure III.A.5 Example of differences between two patterns for chinook salmon—stream and ocean type patterns as interpreted by the EDT model.

as described in the model is insufficient to define the frequency of these types.

Additional variation within these life history types is common for chinook. Reimers (1971) described four patterns for ocean type chinook in the Sixes River. Healey (1991) expanded on the general life history types by recognizing a tactical component to the life history model, defining additional variation within these types as adaptations to uncertainties in juvenile survival and productivity among habitat types. Under this hypothesis, expression of multiple behavioral patterns is a function of the environment. Genetically identical ocean type populations may have a different suite of expressed life history patterns depending upon the environment they encounter.

The EDT analysis includes variation in life history patterns within a life history type in our analysis of chinook performance. We hypothesize that restoration of lost life history patterns is largely a function of reestablishing connectivity of the habitat, where fragmentation of the habitat may be the result of physical (e.g., dams) or biological (e.g., temperature affected) constraints on migration or utilization.

Application to the Columbia River

Application of variation in life history patterns within the EDT analytical model is largely a function of identifying life stage durations, migration travel speeds, and timing windows. This section addresses the input parameters used in the EDT model to define a set of chinook patterns. Parameters are intended to be broad so that a pattern can be applied to multiple locations within a basin (e.g., Hanford Reach or Snake River fall chinook populations).

When a range of input values is applied, the Trajectory Generator module randomly selects a value within the range. Distribution within the range is assumed to be uniform for life stage duration and timing windows. Thus, when river entry timing is said to extend from March to May, trajectories will be generated across all dates. Migration rates (travel speed) use a non-uniform distribution. We assume that a majority (~75 percent) of the trajectories will travel in the lower 25 percent of the range (Figure III.A.6).

Stream Type Patterns

The suite of available patterns presented in the previous section can be summarized as differences in duration and migration speeds, at key life stages. For example, fry colonization (2-week period immediately following emergence) can occur very quickly and with movement downstream of less than 10 meters. In contrast, the life stage may extend

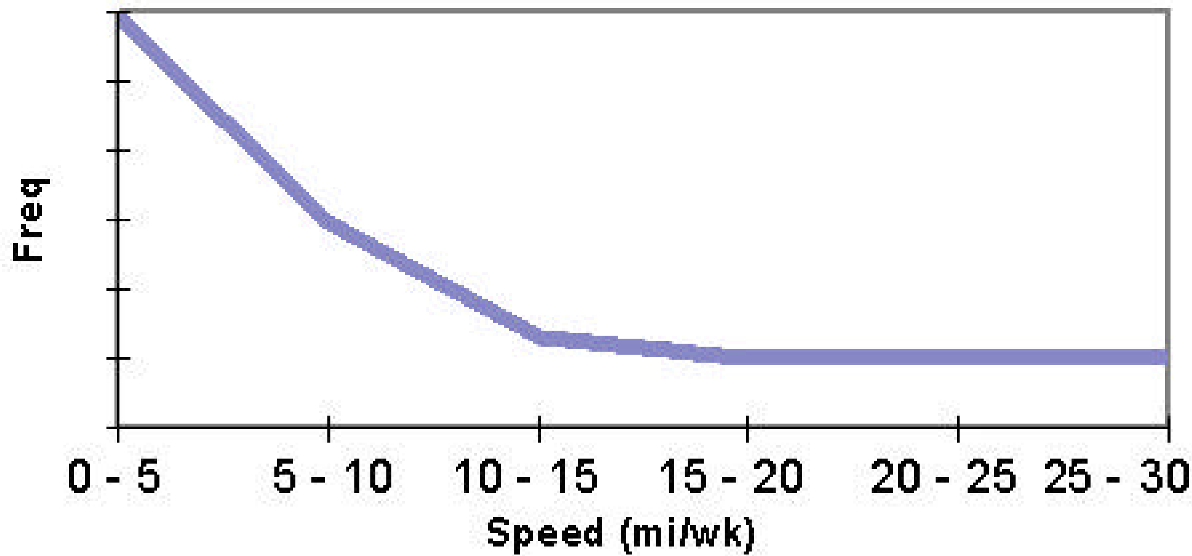


Figure III.A.6 Use of range of migration rates to determine trajectory speed. The range of values in this case is 0 to 30 mi/wk, the average across all trajectories is 8.7 mi/wk.

beyond two weeks (but less than 3 ½ weeks), and fry may colonize locations several kilometers downstream of emergence.

We included four basic patterns for generating stream type trajectories (Figure III.A.7):

- Resident—remain in natal stream throughout freshwater residence.
- Spring Dispersal—dispersal to downstream habitat during fry colonization followed by summer and winter rearing at the same location.
- Fall Redistribution—remain in natal stream through summer followed by downstream redistribution in fall; movement can vary from <1 kilometer to ~10 kilometers).
- Spring-Fall Dispersal—dispersal to downstream habitat during fry colonization; summer rearing followed by downstream redistribution in fall) (Figure III.A.7).

Ocean Type Patterns

The range of patterns reviewed from the Sixes River (Reimers 1971) can be summarized as differences in spring and early summer rearing (the range is from high rate of movement to a resident type pattern of summer rearing). Differences in estuarine residence can be described as rate of travel within this habitat type. Dispersal during fry colonization is assumed to occur for all ocean type patterns (Figure III.A.7).

The EDT analysis was limited to populations upstream of Bonneville Dam. The distance of these populations from the estuary lead us to conclude that rearing of subyearling chinook was largely riverine; time spent in the estuary was constrained to 2-4 weeks. Reimers (1971) described patterns of extended estuarine rearing (6-10 weeks), which are more common in coastal rivers. The exception was subyearling chinook collected early in the transportation system; these trajectories were constrained to spend a longer period of time (4-6 weeks) in the lower river-estuary.

Chinook Population Descriptions

We included 66 chinook populations in the analysis. Several of these existed only in the historic conditions as they are blocked by dams or inundated by reservoirs. Populations were not described for upstream of Chief Joseph or Hells Canyon. Assumptions of juvenile age (life history type), adult river timing, and spawning timing differed among populations. Each population and key assumptions are described in Table III.A.20.

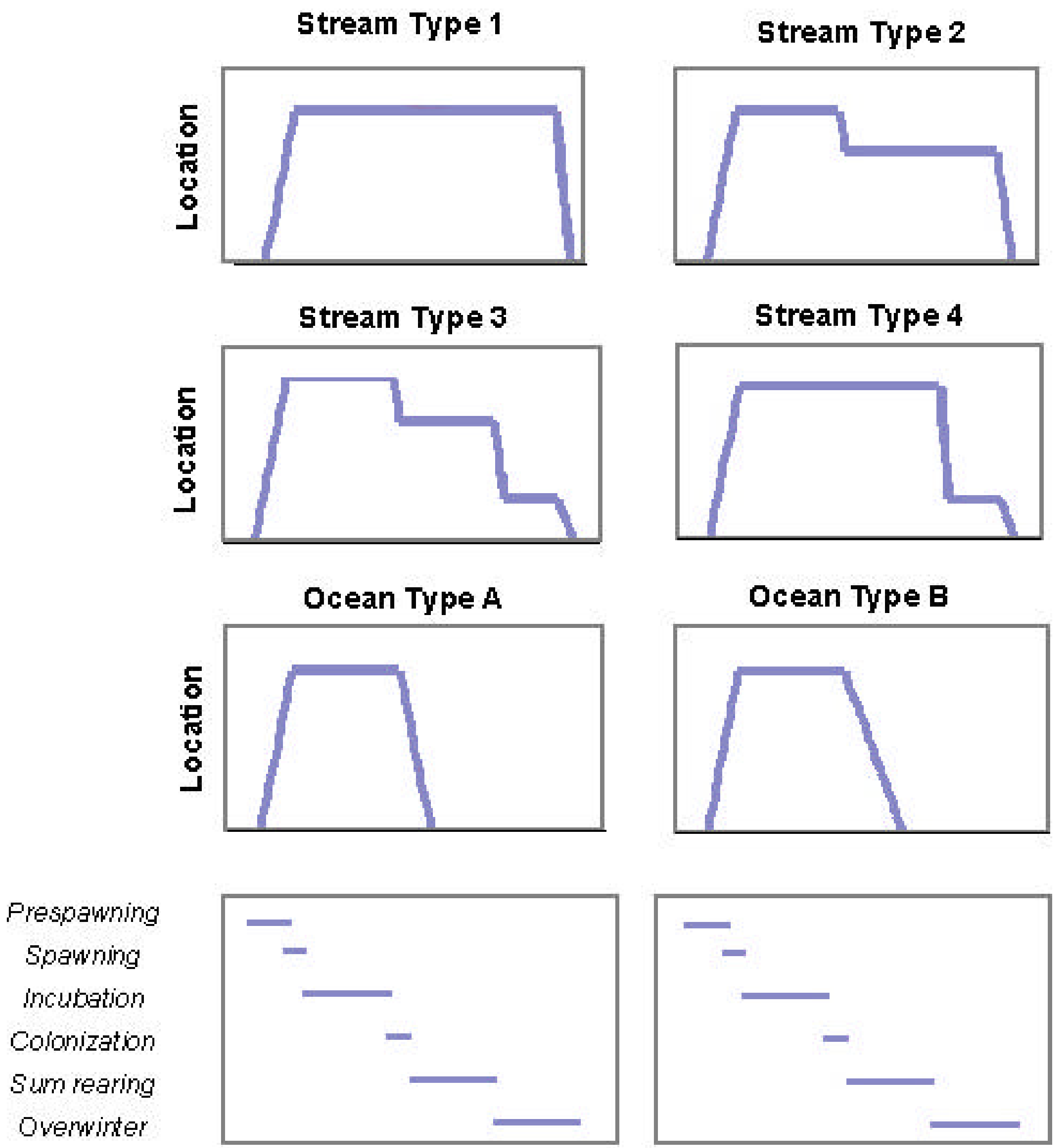


Figure III.A.7 General stream and ocean type life history patterns assumed for Columbia Basin chinook populations upstream of Bonneville Dam. Ocean type patterns differ in rate of travel during transient rearing.

Table III.A.20 Indicator stock used for determining harvest rates for each of the 74 fish populations modeled.

Population Name	Ecoregion	Subbasin	Harvest Indicator Stock
Asotin River Spr Chin	BLUE_MOUNTAIN	Asotin	Spring Chinook
Grande Ronde R Spr Chin	BLUE_MOUNTAIN	Grande Ronde	Spring Chinook
Grande Ronde Su/Fa	BLUE_MOUNTAIN	Grande Ronde	Columbia Summer Chinook
Imnaha River Spr Chin	BLUE_MOUNTAIN	Imnaha	Spring Chinook
Snk R-Clearwater to Hells	BLUE_MOUNTAIN	Snake, Hells Canyon	Snake Fall Chin
Misc Trib Chf J-Wan Su/Fa	COLUMBIA_CASCADE	Columbia, Upper Mid	Columbia Summer Chinook
Col R-Ch Joe to Wan Su/Fa	COLUMBIA_CASCADE	Columbia, Upper Mid	Columbia Summer Chinook
Entiat River Spr Chin	COLUMBIA_CASCADE	Entiat	Spring Chinook
Entiat River Su/Fa	COLUMBIA_CASCADE	Entiat	Columbia Summer Chinook
Chelan River Su/Fa	COLUMBIA_CASCADE	Lake Chelan	Columbia Summer Chinook
Methow River Spr Chin	COLUMBIA_CASCADE	Methow	Spring Chinook
Methow River Su/Fa	COLUMBIA_CASCADE	Methow	Columbia Summer Chinook
Okanagan River Su/Fa	COLUMBIA_CASCADE	Okanogan / Similkameen	Columbia Summer Chinook
Wenatchee River Spr Chin	COLUMBIA_CASCADE	Wenatchee	Spring Chinook
Wenatchee R Su/Fa	COLUMBIA_CASCADE	Wenatchee	Columbia Summer Chinook
Big White Salmon	COLUMBIA_GORGE	Big White Salmon	Spring Chinook
Col R-Dalles to Bonnev	COLUMBIA_GORGE	Columbia, Gorge	Columbia URB
Misc Tribs Bonnev Pool	COLUMBIA_GORGE	Columbia, Gorge	Oregon Tule
Hood River	COLUMBIA_GORGE	Hood	Spring Chinook
Hood River	COLUMBIA_GORGE	Hood	Oregon Tule
Klickitat River	COLUMBIA_GORGE	Klickitat	Spring Chinook
Klickitat River Fall	COLUMBIA_GORGE	Klickitat	Columbia URB
Wind River	COLUMBIA_GORGE	Wind	Spring Chinook
Col R-J Day to Dalles	COLUMBIA_PLATEAU	Columbia, Lower Mid	Columbia URB
Misc Tribs Dalles Pool	COLUMBIA_PLATEAU	Columbia, Lower Mid	Oregon Tule
Misc Tribs JnDay/McNar Pl	COLUMBIA_PLATEAU	Columbia, Lower Mid	Columbia URB
Col R- Wanap to PR Fall	COLUMBIA_PLATEAU	Columbia, Lower Mid	Columbia URB
Col R-Hanford Reach Fall	COLUMBIA_PLATEAU	Columbia, Lower Mid	Columbia URB
Col R-McNary to J Day	COLUMBIA_PLATEAU	Columbia, Lower Mid	Columbia URB
Misc Tribs Hanford Rch	COLUMBIA_PLATEAU	Columbia, Lower Mid	Columbia URB
Crab Cr Fall Chin	COLUMBIA_PLATEAU	Crab	Columbia URB
Crooked R	COLUMBIA_PLATEAU	DESCHUTES	Spring Chinook
Warm Springs	COLUMBIA_PLATEAU	DESCHUTES	Spring Chinook
Squaw Creek	COLUMBIA_PLATEAU	DESCHUTES	Spring Chinook
Metolius River	COLUMBIA_PLATEAU	DESCHUTES	Spring Chinook
Ochoco River	COLUMBIA_PLATEAU	DESCHUTES	Spring Chinook
Crooked River Su/Fa	COLUMBIA_PLATEAU	DESCHUTES	Columbia Summer Chinook
Lower Deschutes R Su/Fa	COLUMBIA_PLATEAU	DESCHUTES	Columbia Summer Chinook
Upper Deschutes Su/Fa	COLUMBIA_PLATEAU	DESCHUTES	Columbia Summer Chinook
John Day abv SF	COLUMBIA_PLATEAU	John Day	Spring Chinook
***NF John Day	COLUMBIA_PLATEAU	John Day	Spring Chinook

MF John Day River	COLUMBIA_PLATEAU	John Day	Spring Chinook
John Day Su/Fa	COLUMBIA_PLATEAU	John Day	Columbia Summer Chinook
Snk R-Mouth to Clearwater	COLUMBIA_PLATEAU	Snake, Mainstem	Snake Fall Chin
Tucannon River Spr Chin	COLUMBIA_PLATEAU	Tucannon	Spring Chinook
Tucannon River	COLUMBIA_PLATEAU	Tucannon	Snake Fall Chin
Umatilla River	COLUMBIA_PLATEAU	Umatilla	Spring Chinook
Umatilla River	COLUMBIA_PLATEAU	Umatilla	Columbia URB
Walla Walla River	COLUMBIA_PLATEAU	Walla Walla	Spring Chinook
Touchet River	COLUMBIA_PLATEAU	Walla Walla	Spring Chinook
Walla-Walla River Fall Ch	COLUMBIA_PLATEAU	Walla Walla	Columbia URB
Upper Yakima Spr Chin	COLUMBIA_PLATEAU	YAKIMA	Spring Chinook
Naches River Spr Chin	COLUMBIA_PLATEAU	YAKIMA	Spring Chinook
Lower Yakima Tribs Spr Ch	COLUMBIA_PLATEAU	YAKIMA	Spring Chinook
Lower Yakima River Fall	COLUMBIA_PLATEAU	YAKIMA	Columbia URB
Toppenish R Fall	COLUMBIA_PLATEAU	YAKIMA	Columbia URB
NF Clearwater	MOUNTAIN_SNAKE	CLEARWATER	Spring Chinook
MF Clearwater R	MOUNTAIN_SNAKE	CLEARWATER	Spring Chinook
SF Clearwater R	MOUNTAIN_SNAKE	CLEARWATER	Spring Chinook
Selway River	MOUNTAIN_SNAKE	CLEARWATER	Spring Chinook
Lochsa River	MOUNTAIN_SNAKE	CLEARWATER	Spring Chinook
Lower Clearwater R Summer	MOUNTAIN_SNAKE	CLEARWATER	Columbia Summer Chinook
Headwater Salmon R Spr Ch	MOUNTAIN_SNAKE	SALMON	Spring Chinook
Little Salmon R	MOUNTAIN_SNAKE	SALMON	Spring Chinook
MF Salmon R	MOUNTAIN_SNAKE	SALMON	Spring Chinook
Lemhi River	MOUNTAIN_SNAKE	SALMON	Spring Chinook
Upper Salmon River	MOUNTAIN_SNAKE	SALMON	Spring Chinook
Little Salmon R Summer	MOUNTAIN_SNAKE	SALMON	Columbia Summer Chinook
SF Salmon R Summer	MOUNTAIN_SNAKE	SALMON	Columbia Summer Chinook
Lower Salmon R Summer	MOUNTAIN_SNAKE	SALMON	Columbia Summer Chinook
MF Salmon R Summer	MOUNTAIN_SNAKE	SALMON	Columbia Summer Chinook
Pahsimeroi River Summer	MOUNTAIN_SNAKE	SALMON	Columbia Summer Chinook
Upper Salmon River Summer	MOUNTAIN_SNAKE	SALMON	Columbia Summer Chinook

Table III.A.20 Indicator stock used for determining harvest rates for each of the 74 fish populations modeled.

Analysis Method

The modeling component of EDT was used to produce estimates of chinook productivity, capacity, and diversity for both the Historic Potential and Current Potential (Lestelle et al., 1996). A more detailed description of the EDT Model including formulas, assumptions, and inherent workings is included in Appendix A.

Uncertainty and World View Assumptions

The major assumptions used in modeling the three worldviews (Technology Pessimistic, Moderate, and Technology Optimistic) are shown in Table III.A.21 and Table III.A.22 below. Model runs based on these worldviews were completed for the Historic and Current Potentials, as well as for Alternatives 2, 5, and 6. A more detailed discussion of the assumptions used for the Technology Pessimistic and Technology Optimistic worldviews is offered below. Assumptions used under the Moderate scenario are included in the tables for reader convenience. The Moderate assumptions were discussed earlier in this section and are, therefore, not repeated here. Dam survivals by Alternative and worldview are shown in Appendix E.

World View Assumptions

Technology Pessimistic

The Technology Pessimistic worldview will be discussed for In-river Transport Survival, Hatchery Fish Parameters, Habitat, and Marine.

In-river and Transport Survival

The in-river and transport survival rates used for modeling subyearling performance were based on data developed by PATH and NMFS for fall chinook (PATH 1999, NMFS 2000b). Based on our review of these analyses, we set typical subyearling in-river and transport survival for Snake River stocks at 27 percent and nine percent, respectively. Transport survival at McNary Dam was set at 40 percent in order to more closely match the expected in-river survival rate for both subyearlings and yearlings that migrate from this facility to the tailrace of Bonneville Dam. Under the Technology Pessimistic worldview, it is assumed that in-river survival is at the low end of recent estimates and that transport is ineffective.

Table III.A.21 Chinook population descriptions.

Species	Population Name	Geographic Area	Life History Assumptions: % Ocean Type	% Stream Type	Adult River Entry	Spawn Timing
Columbia Gorge						
Spring Chinook	Wind	Wind River	0%	100%	Apr – May	Sept
	Big White Salmon	Big White Salmon	0%	100%	Apr – May	Sept
	Klickitat	Upper Klickitat River	0%	100%	Apr – May	Sept
	Hood	Upper Hood River	0%	100%	Apr – May	Sept
Fall Chinook	Klickitat	Klickitat River below hatchery	100%	0%	Aug – Sept	Oct – Nov
	Hood	Hood River below forks	100%	0%	Aug – Sept	Oct – Nov
Columbia Plateau						
Spring Chinook	Warm Springs	Warm Spring R (Deschutes)	0%	100%	Apr – May	Sept
	Squaw	Squaw Cr. (Deschutes)	0%	100%	Apr – May	Sept
	Crooked	Crooked R. abv Ochoco (Deschutes)	0%	100%	Apr – May	Sept
	Ochoco	Ochoco R. (Deschutes)	0%	100%	Apr – May	Sept
	Metolius	Metolius R. (Deschutes)	0%	100%	Apr – May	Sept
	N.F. John Day	N.F. John Day River	0%	100%	Apr – May	Sept
	M.F. John Day	M.F. John Day River	0%	100%	Apr – May	Sept
	John Day	John Day R. abv S.F.	0%	100%	Apr – May	Sept
	Umatilla	Upper Umatilla River	0%	100%	Apr – May	Sept
	Walla Walla	Up Walla Walla R.	0%	100%	Apr – May	Sept
	Tucannon	Upper Tucannon R.	0%	100%	Apr – May	Sept
	Touchet	Touchet River	0%	100%	Apr – May	Sept
	Lower Yakima	Tribs. Lower Yakima (Satus-Logy)	0%	100%	Apr – May	Sept
	Upper Yakima	Yakima R. & tribs. abv Naches	0%	100%	Apr – May	Sept
	Naches	Naches River (Yakima)	0%	100%	Apr – May	Sept
Summer/Fall Chinook	Lower Deschutes	Deschutes R. below Pelton-Round Butte	90%	10%	June – Aug	Oct
	Upper Deschutes	Deschutes River abv Pelton-Round Butte	25%	75%	June – Aug	Oct
	Lower Crooked	Crooked R below Ochoco	25%	75%	June – Aug	Oct
	John Day	John Day R. mainstem and Tribs below S.F.	50%	50%	June – Aug	Oct
Fall Chinook	John Day Pool	Columbia R: John Day – McNary	100%	0%	Aug – Sept	Oct - Nov
	McNary Pool - Hanford	Columbia R: McNary – Priest Rapids	95%	5%	Aug – Sept	Oct - Nov
	Priest Rapids Pool	Columbia R: Priest Rapids – Wanapum	95%	5%	Aug – Sept	Oct - Nov
	Lower Snake	Snake R: Mouth to Clearwater River	95%	5%	Aug – Sept	Oct - Nov
	Umatilla	Lower Umatilla River	95%	5%	Aug – Sept	Oct - Nov
	Walla Walla	Lower Walla Walla River	95%	5%	Aug – Sept	Oct - Nov
	Tucannon	Lower Tucannon River	95%	5%	Aug – Sept	Oct - Nov
	Yakima Tribs	Lower Yakima tribs (Toppenish)	95%	5%	Aug – Sept	Oct - Nov
	Lower Yakima	Yakima River below Naches	95%	5%	Aug – Sept	Oct - Nov

Columbia Cascade						
Spring Chinook	Wenatchee	Wenatchee River abv Icicle Cr	0%	100%	Apr – May	Sept
	Entiat	Upper Entiat River	0%	100%	Apr – May	Sept
	Methow	Upper Methow River	0%	100%	Apr – May	Sept
Summer/Fall Chinook	Columbia R	Columbia R: Wanapum to Chief Joseph	75%	25%	June – Aug	Oct
	Wenatchee	Lower Wenatchee R	75%	25%	June – Aug	Oct
	Entiat	Lower Entiat River	75%	25%	June – Aug	Oct
	Methow	Lower Methow River	75%	25%	June – Aug	Oct
	Chelan	Chelan R. below lake	75%	25%	June – Aug	Oct
	Okanogan	Okanogan & Similkameen	75%	25%	June – Aug	Oct
Blue Mountain						
Spring Chinook	Asotin	Asotin River	0%	100%	Apr - May	Sept
	Grande Ronde	Grande Ronde abv Wallowa	0%	100%	Apr - May	Sept
	Imnaha	Imnaha River	0%	100%	Apr - May	Sept
Sum/Fall Chinook	Grande Ronde	Lower Grande Ronde mainstem and tribs	50%	50%	June - Aug	Oct
Fall Chinook	Snake River	Snake R: Clearwater to Hells Canyon	95%	5%	Aug - Sept	Oct – Nov
Mountain Snake						
Spring Chinook	MF Clearwater	M.F. Clearwater mainstem & tribs	0%	100%	Apr - May	Aug - Sept
	SF Clearwater	S.F. Clearwater River	0%	100%	Apr - May	Aug - Sept
	Selway	Selway River (Clearwater)	0%	100%	Apr - May	Aug - Sept
	Lochsa	Lochsa River (Clearwater)	0%	100%	Apr - May	Aug - Sept
	NF Clearwater	NF Clearwater abv Dworshak	0%	100%	Apr - May	Aug - Sept
	Little Salmon	Upper Little Salmon R. & tribs	0%	100%	Apr - May	Aug - Sept
	MF Salmon	Upper M.F. Salmon R. & tribs	0%	100%	Apr - May	Aug - Sept
	Lemhi	Lemhi River (Salmon)	0%	100%	Apr - May	Aug - Sept
	SF Salmon	Upper SF Salmon & tribs (incl E.F.)	0%	100%	Apr - May	Aug - Sept
	Upper Salmon	E.F. Salmon R to Yankee Fork	0%	100%	Apr - May	Aug - Sept
	Headwaters Salmon	Salmon River abv Yankee Fork	0%	100%	Apr - May	Aug - Sept
Summer Chinook	Lower Clearwater	Clearwater River & tribs below M.F.	10%	90%	June - July	Sept
	Lower Salmon	Salmon R mainstem & tribs below Lemhi	10%	90%	June - July	Sept
	Little Salmon	Lower Little Salmon R	10%	90%	June - July	Sept
	SF Salmon	S.F Salmon River below E.F.	10%	90%	June - July	Sept
	MF Salmon	Lower M.F. Salmon River	10%	90%	June - July	Sept
	Pahsimeroi	Pahsimeroi River (Salmon)	10%	90%	June - July	Sept
	Upper Salmon	Salmon River mainstem (Lemhi to E.F.)	10%	90%	June - July	Sept

Table III.A.21 Chinook population descriptions.

Yearling Chinook			
Worldview	%Survival Snake		% Transport Survival (Columbia - McNary)
	In-river	Transport	
Technology Pessimistic	25	25	40
Moderate	36	50	50
Technology Optimistic	51	80	80

Subyearling Chinook			
Worldview	%Survival Snake		% Transport Survival (Columbia –McNary)
	In-river	Transport	
Technology Pessimistic	27	9	40
Moderate	29	35	60
Technology Optimistic	35	60	80

Table III.A.22 Yearling and subyearling survival rate assumptions for both the in-river and transport migration paths.

Hatchery Fish Parameters

The post-release survival rate of hatchery fish under this worldview was set at 10 percent and 15 percent that of naturally produced fish for juveniles reared under conventional and supplementation type facilities, respectively. It was also assumed that as hatchery fish abundance increases on the spawning grounds, wild fish fitness decreases (Table III.A.22). The assumption under the Technology Pessimistic worldview being that hatchery fish have low survival and negatively affect the fitness of wild stocks.

Habitat

The biological rules that translate environmental attributes into survival parameters produce an estimate of relative productivity (based on Moderate assumptions) for each 6-HUC, for each month, and for each life stage. The assumed range of uncertainty of this estimate is shown in Figure III.A.8. The Technology Pessimistic worldview, assumes the lower values in this range, reflecting a greater sensitivity to habitat conditions that deviate from the optimal for each life stage.

Marine

Estuary survival rates for juvenile chinook were altered as described under the habitat section above.

The nearshore survival values used for modeling subyearling and yearling survival through this area were increased to 86 percent and 74 percent, respectively. Nearshore survival rates were changed to increase the number of adults returning to the Columbia River under the Technology Pessimistic worldview so that they were similar to those produced under the Moderate and Technology Optimistic worldviews. This step was needed to meet the assumption that each of the worldviews produces similar numbers of fish under the Current Potential. Therefore, the worldviews agree on how many fish are being produced, but disagree on why (i.e., inherent assumptions vary by worldview). In the Technology Pessimistic worldview, it is assumed that nearshore ocean conditions have less an effect on adult run sizes than factors such as hydro development and habitat degradation.

Ocean survival rates used for modeling this worldview were identical to those described for the Moderate worldview.

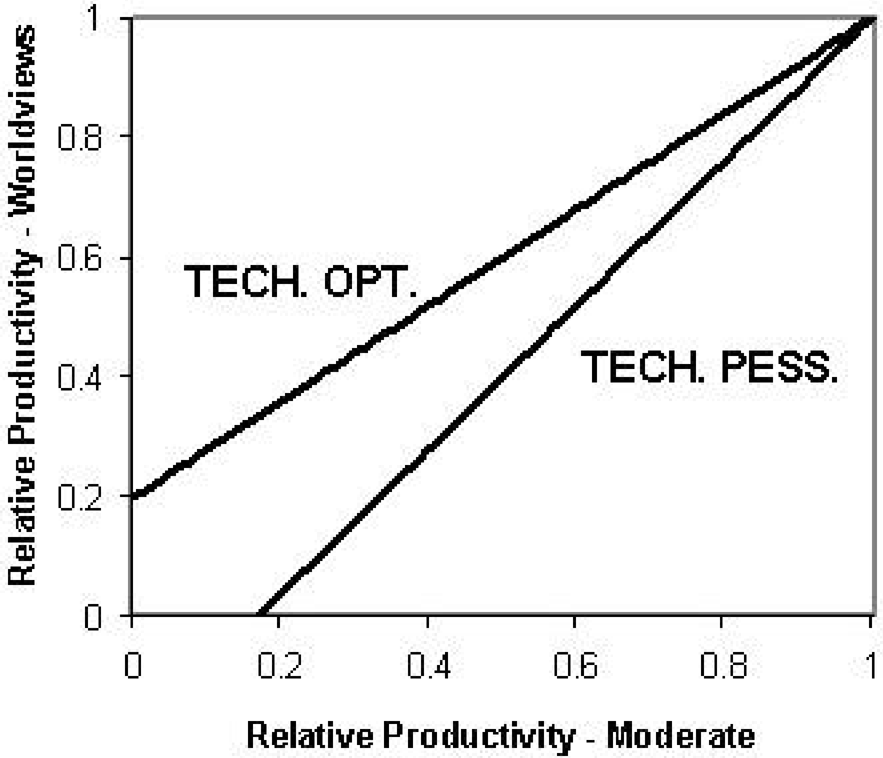


Figure III.A.8 Relative productivity for Technology Pessimistic and Technology Optimistic worldviews as a function of the Moderate productivity estimated using the biological rules.

Technology Optimistic

The Technology Optimistic worldview will be discussed for In-River and Transport Survival, Hatchery Fish Parameters, Hatchery, and Marine.

In-river and Transport Survival

The yearling in-river and transport survival values used for modeling the Technology Optimistic worldview was obtained from values developed by the NMFS (NMFS 2000b). NMFS scientists reported that in-river survival for yearling chinook migrating from the Lower Granite Reservoir to the tailrace of Bonneville Dam averaged approximately 51 percent for migration years 1997 to 1999. NMFS also reported that the “differential post-Bonneville Dam survival”, or so-called D-value, ranged from about 78 percent to 83 percent. In this worldview it was assumed that the post-release survival rate of transported yearling chinook is 80 percent.

Subyearling chinook in-river and transport survival rates were set for Snake River stocks at 35 percent and 60 percent, respectively. These values were deemed to represent the high end of recent estimates for these parameters. The McNary transport survival rate was set at 80 percent to match the values used for yearling chinook and to ensure a transport survival benefit for all stocks.

Hatchery Fish Parameters

Under the Technology Optimistic worldview, the survival rates for hatchery fish reared using conventional or supplementation type rearing practices were set at 50 percent and 60 percent. The Technology Optimistic worldview also assumes that hatchery fish impacts to wild populations are less severe than assumed under the Moderate worldview.

Habitat

The Technology Optimistic worldview, assumes the higher values in this range, reflecting a lesser sensitivity to habitat conditions that deviate from the optimal for each life stage (Figure III.A.8).

Marine

Estuary survival rates for juvenile chinook were altered as described under the habitat section above.

The nearshore survival values used for modeling subyearling and yearling survival through this area were reduced to 35 percent and 20 percent, respectively. Nearshore survival rates were lowered to decrease the number of adults returning to the Columbia River under the Technology Optimistic worldview so that they were similar to those produced under the Moderate and Technology Pessimistic worldviews. This step was needed to meet the assumption that each of the worldviews produces similar numbers of fish under the Current Potential. Thus, the worldviews agree on how many fish are being produced, but disagree on why (i.e., inherent assumptions vary by worldview). A major assumption under the Technology Optimistic worldview is that poor nearshore ocean conditions are a major factor responsible for the low adult returns observed in recent years.

Ocean survival rates were not changed under this worldview and are therefore the same as those used for modeling the Moderate worldview.

Data Quality

The amount of effort required to accurately rate habitat quality for over 259,000 miles of terrestrial and aquatic habitat is indeed daunting. The task becomes even more difficult given that the data needed to rate all 45 of the environmental attributes do not exist for some areas, are of poor quality in others, were collected over varying time frames, and assembled by multiple agencies using various methodologies. In short, there is considerable uncertainty in the quality of the data used in this analysis.

This problem was recognized at the start of the project but after reviewing the available data, we deemed it sufficient for conducting an analysis at the basin and province levels. However, data resolution is insufficient to draw inferences about habitat and salmon performance at the subbasin, watershed or reach level. The Council envisions that data quality problems will be corrected to the extent possible during the assessment phase of the Council’s program.

The data and analysis are sufficient to achieve the goal of providing planners and biologists the tools needed to identify, analyze, and prioritize actions to recover salmonid populations in their respective basins. Work products or tools resulting from this process include; 1) a future vision for the basin, 2) a set of Scientific Principles to guide recovery actions, 3) a Conceptual Framework, 4) analysis methodology, and 5) a draft data set for review and refinement for each subbasin of interest in the Columbia River Basin.

METHODS - WILDLIFE SPECIES

This section of the Methods addresses wildlife; it is organized as follows:

Introduction

To analyze wildlife at the broad scale of the entire Columbia River Basin in the U.S., we used "coarse-grain" information on environmental conditions. Analyses assess data and information on occurrence and change in overall wildlife habitat types for each 6th field HUC (subwatershed), summarized to larger areas of provinces and to the Columbia Basin as a whole; this is what constitutes "coarse-grain information." Results of these wildlife analyses should be viewed most appropriately at scales of provinces and the entire basin, as defined in the Fish and Wildlife Program Scientific Foundation (Appendix L). Wildlife analyses herein provide broad distributional patterns of habitats, potential species occurrence, and ecological functions.

Subsequent stages of the Framework analysis will summarize results from the 6-HUC to the subbasin level and then to the province and basin. Accuracy at levels finer than the province level will entail using finer-grain information on the distribution and changes in structural conditions and specific substrates and other influential conditions (key environmental correlates) within each wildlife habitat type and within each subwatershed. We did not have that information available for the current analyses.

Our analysis provides three "snapshots" of historic, current, and future habitat conditions. Historic conditions (in places referred to as Historic Potential) refers to conditions in the absence of non-native human influence, projecting back in time, approximating conditions that may have generally occurred during the early 19th century. Maps of historic conditions should be viewed as general patterns and not as depicting specific conditions within watersheds. Current condition (in places also referred to as Current Potential) is estimated using data on vegetation, which we interpreted as wildlife habitat, collected within the last ten years (i.e., 1995-2000). Data on current vegetation conditions, in most cases, has not undergone formal validation but is based on spectral classification of satellite imagery that has been related to land use/land cover types, that in turn have been determined from point or field locations. Future conditions refers to wildlife habitats that would stabilize over the long term, say on the order of 50-100 years, under the management strategies specified under each of the three planning alternatives we analyzed. L. Vail (Appendix L) developed a screening procedure to estimate the acres of wildlife habitat types for seven alternatives, three of which are used in this analysis. This procedure estimated the degree that current wildlife habitat types would shift back towards the historic wildlife habitat types for a specific alternative. Each alternative was composed of a set of strategies. The effectiveness and intensity of each strategy, as defined by McConnaha, et al. (2000), were considered in combination with the land use and land ownership for each 6-HUC. Spatial information was not considered at a spatial scale finer than the 6-HUC. This approach was consistent with the other elements of the Multi-Species Framework Project. It implies that no information about adjacency of habitat types and land ownership is known. For instance, we don't know if forest represents riparian or non-riparian regions. In our assessment, there is one historic condition, one current condition, and three alternative future conditions (one future condition for each of the three alternatives analyzed in this report).

Comparing historic to current conditions provides some understanding of how habitats have changed from recent land use practices. This provides a baseline by which to compare current to future conditions under each of the three planning alternatives we analyzed. Future potential conditions represent a range of possible future changes and whether alternatives are moving wildlife habitat quality and quantity toward or away from historic habitat conditions. This process of comparing alternative performance to current and historic performance for wildlife is similar in concept to the fish analysis process but several details differ:

The fish analysis uses historic, current and future conditions to set biological objectives for specific fish habitat attributes (usually fine-scale substrates, which we refer to as key environmental correlates, or KECs). Because of the broad scale addressed, the wildlife analysis is not based on key environmental correlates but rather on more general wildlife habitat capacity summarized at the scale of the entire basin. Since the proposed terrestrial wildlife habitat changes are relatively small in area compared to the area of the whole basin, any change in the percentage of wildlife habitats (that is, conversion of one wildlife habitat type to another type) is very small (e.g., 0.01 percent), and not particularly useful for setting biological objectives at a basin scale. When fine-scale KEC data are available within subbasins, it will be more appropriate to set local biological objectives for wildlife.

The fish EDT method assesses three demographic components of fish species performance: survival, capacity and life history diversity. These components can be combined and expressed in terms of fish population density for any of the historical, current or future conditions. Wildlife performance is expressed as habitat capacity. Survival, life history diversity and density of wildlife are not explicitly assessed at the basin level.

Fish performance expressed as density was estimated using a Beverton-Holt model, which includes both density-independent and density-dependent components. The density-dependent component of EDT is based on habitat quality times area. When habitat quality is less than optimal due to one or more management activities (i.e., mining), the reduction of habitat quality is used to reduce population density estimates. As such, optimal habitat conditions for a particular area are reduced as a function of the type, the intensity and the effectiveness of management activities. The actual population density response may or may not meet the model projections due to a variety of factors that are not related to habitat (e.g., hunting and toxics). Hence modeled conditions are referred to as potential: historic potential, current potential, and future potential. Wildlife performance, based on habitat capacity, does not include an estimator of density but does include an estimator of habitat quality based on the intensity and effectiveness of a management activity (i.e., collection of strategies) and the resulting influence on the percentage of wildlife habitat types (Vail, Appendix L).

Analyses of species' key ecological functions are based on the Northwest Habitat Institute's Species Habitat Project (SHP) database. The SHP database was initially developed for Oregon and Washington and built upon in part from the efforts of the Interior Columbia Basin Ecosystem Management Project (ICBEMP) to include the entire Columbia Basin in the United States. Increasing the area of coverage for the SHP database to the whole basin within the United States resulted in adding 12 wildlife species to the SHP database. We have made progress in including fish key ecological functions into this expanded database, but this work is not complete.

One of the fundamental features of the EDT approach is the relationship between two dimensions: habitat attributes and population productivity across the landscape. Population productivity, a dimension that drives the Ricker and Beverton-Holt models, is important to fishery biologists for setting harvest management guidelines. The implied relationship between habitat, productivity, and fish management seems reasonable but recent calls for an ecosystem–based approach imply that an additional dimension of processes, beyond habitat description, may be at play. For example, Rose (2000) cited community-level interactions, habitat complexities, and cumulative effects as three of six issues that have prevented fisheries managers from achieving their goal of sustainability. Cederholm et al. (2000), in a manner similar to Rose, discussed the need for an ecosystem approach to understand the cumulative impacts of human development on fisheries management. These, as well as other authors, call for new tools to assess these processes (community interaction, habitat complexities and cumulative effects) and to provide an additional dimension of insight to the relationship between habitat and regaining lost fish productivity and diversity.

Schlosser and Kallemeyn (2000), on the heels of the above articles, opined that there has been a fundamental shift in ecology toward a broader geographic perspective that incorporates hierarchically-structured and scale-dependent levels of variation and complexity. Their insightful article on the spatial and temporal relationship between beaver and fish abundance and diversity not only clearly demonstrates the importance and roles of wildlife-generated structures in the aquatic environment, but also documents the importance of the additional dimension of ecosystem functions as beaver dams are built, abandoned, collapse, and rebuilt in relation to changing hydrologies in space and time. The documented relationships between higher fish species diversity and the collapsed successional beaver ponds, and between higher fish abundance (lower diversity) with intact beaver dams and the nonrandom distribution of successional environments on the landscape, indicate that we need to consider the third dimension of habitat analyses, species, and ecological functions, across landscapes, to better understand and predict relationships between habitat and fish abundance and diversity.

The Framework proposes to assess this third dimension of habitat using the concept of key ecological functions (KEF) developed by Marcot et al. (1997) and expanded by Marcot and Vander Heyden (2000). Analyses of

KEFs across the landscape in the Framework hierarchical process can provide insight to both upland and aquatic functional webs that may, as Rose (2000) opined and Schlosser and Kallemeyen (2000) demonstrated, improve the understanding of how habitat attributes influence fish and wildlife sustainability.

A variety of concepts (e.g., energy flow, trophic relationships, indices of biological productivity, Lotka and Volterra predator and prey equations, and aggregated functional groups such as guilds) are available to investigate fish and wildlife interaction (Powers et al. 1995, Karr 1991, Rose 2000, and deMaynadier and Hunter 1997). These and other concepts were reviewed and considered by the Ecological Work Group. While the many concepts available to us offered their own unique insights into community relationships, none of them offered the opportunity to quickly assess and integrate the ecological functions of all species in the community from a common database. Furthermore, none of the concepts available to us could be readily linked to the population models (e.g., Beverton-Holt and Ricker) that are important to fisheries managers.

The EDT approach, which uses a Beverton-Holt hierarchical-landscape model, offers several opportunities for community level input as Level 2 Attributes. For example, beaver ponds, predation, and community interactions are Level 2 Attributes that relate directly to wildlife functions. Thus our ability to quantify and rank these Level 2 Attributes for the same landscape units (i.e., HUC 6) used by EDT will improve the quality of the variables that drive the EDT landscape assessment.

We used two basic approaches to quantify wildlife species and community input to EDT. Both of these approaches are closely associated with and rely on the SHP Wildlife Habitat Relationship (WHR) database (Johnson and O'Neil 2000). The first approach used wildlife habitat-capacity models to assess the likelihood that specific wildlife functions, such as beaver dams, are likely to occur in a given HUC 6. A Habitat Condition Index (a HEP-type analysis for large landscapes) has been developed to assess habitat condition for individual species. Output from this methodology can be the basis for: (1) ranking EDT Level 2 Attributes such as the presence of beaver ponds and (2) assigning a weight to a particular species to assign a proportional contribution to a particular ecological function. For example, a predatory species in marginal habitat (low HCI) is not likely to be a large contributor to the piscivory function.

The second approach is to harness key ecological function (KEF) analyses (Figure III.B.1) to assess EDT Level 2 Attributes such as Community Richness. For example, functional redundancy is calculated for all wildlife species, performing a function per the WHR database, for each HUC6. While this analysis is currently limited to wildlife, there is ample

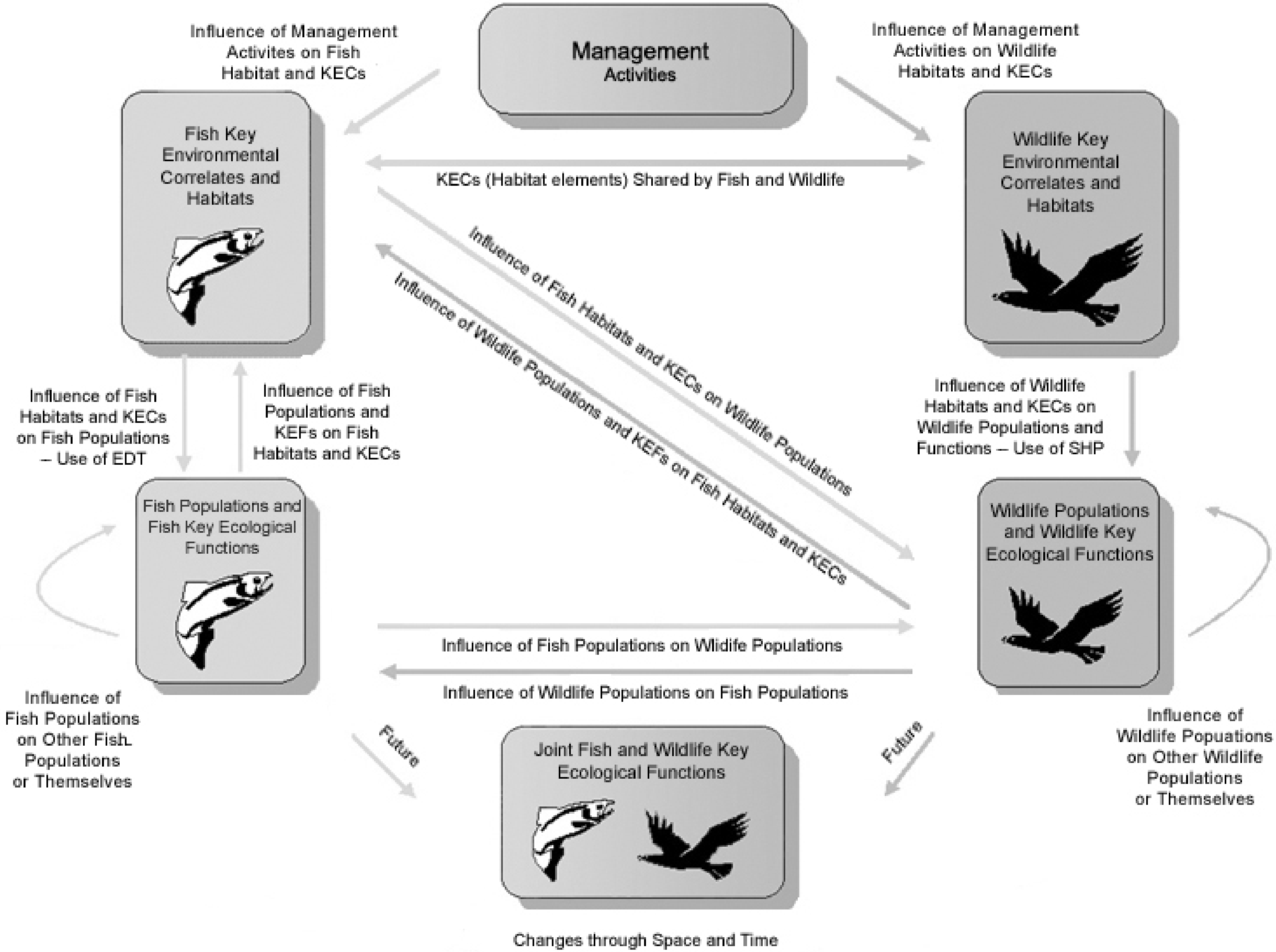


Figure III.B.1 Generalized process for evaluating fish and wildlife interactions.

opportunity for including fish and wildlife functions in this assessment method. Fish functions for chinook and bull trout have been successfully integrated with wildlife function in pilot analyses. Functional redundancy is but one of several functional analyses that can be quantified in a hierarchical analysis to examine patterns of the “functional web” of fish and wildlife.

The wildlife analyses in this report, at the basin level, are based on wildlife habitats assessed from coarse digital data from a variety of databases. They are intended to be instructive and focus on the Framework vision of a multispecies process with a salmon emphasis. We illustrate two ways fish and wildlife can be integrated and offer a procedure to assess functional influences (for fish and wildlife) that can stand on its own as well as be related to salmonid models (i.e., EDT). At the basin level we will use our analyses to question whether alternatives/strategies for salmonid recovery will: (1) provide similar benefits for wildlife, (2) have a negative influence on wildlife and (3) potentially influence functional linkages between fish and wildlife (and visa versa). This initial basin analysis is only the beginning in that it provides a Framework for similar analyses at the province and subbasin levels of the landscape hierarchy. As similar types of analyses are conducted at the lower hierarchical levels, with a finer scale of data and area specific models, the lower level analyses should be re-aggregated (Stienetz et al., 1999) at the basin level to re-assess the basic interactive questions cited above.

To summarize, the Framework process has developed a common platform (database, methodology and theory) for assessing fish and wildlife populations and ecosystem function in the Columbia Basin. Several applied examples are presented in the following report and suggestions for database and methodological advancements are presented. In addition, the platform provides the foundation for addressing ecosystem goals and biological objectives at various hierarchical scales within the basin.

Overview of Information Used

Determining Wildlife Species Information

The wildlife information that supports the Framework analysis comes from a 4-year project that recently updates databases on wildlife-habitat relationships in Oregon and Washington (Johnson and O’Neil 2001). We refer to this project as the Species Habitat Project (SHP) that was initially developed for Oregon-Washington and later expanded to include the U.S. portion of the Columbia River Basin. The SHP data set has information on

593 wildlife species occurring in Oregon and Washington; this data set was modified to include an additional 12 wildlife species known to occur in Idaho, Western Montana, Nevada, Utah or Wyoming. The initial data set was built using 18 expert panels that specified each wildlife species' association with habitats and ecological conditions or variables, and that assigned confidence levels to each wildlife species for each habitat type or structural condition. The additional 12 wildlife species we added and their habitat and ecological relationships were determined during an internal review. This review re-examined the SHP database for species with similar life histories and reviewed the ICBEMP data for these 12 species. Lastly, a literature review was conducted to develop an updated life history account for each species. The literature was also used to support the depictions of how management activities were linked to the key environmental correlates data. Species nomenclature follows Collins et al. (1990), Leonard et al. (1993), and Storm and Leonard (1995) for amphibians and reptiles; American Ornithologists' Union (1998) for birds; and Verts and Carraway (1998), Wilson and Reeder (1993), Jones et al. (1992), Hall (1981), Frost and Timm (1992) and van Zyll de Jong (1984) for mammals.

A number of primary sources were used to establish or confirm wildlife species occurrences: Csuti et al. (1997), Verts and Carraway (1998), Ingles (1965), Hall (1981), Bailey (1936), Gilligan et al. (1994), ODFW (1994), Puchy and Marshall (1993), Dvornich et al. (1997), Johnson and Cassidy (1997), Smith et al. (1997), and Brueggeman (1992). Supplemental information also came from Alexander (1996), Aubry (1982), Aubry and Houston (1992), Best (1988), and Bradley (1982).

The expert panels that developed the SHP data set had on hand range maps for each species, wildlife-habitat type and distribution maps, statewide vegetation maps, and a variety of other reference materials. These sources of material helped the panelists to determine wildlife species occurrence within a particular habitat type. To characterize the degree of association a wildlife species has with its habitat, the following categories were assigned in the SHP database:

Closely Associated - A wildlife species is widely known to depend on a habitat or structural condition for part or all of its life history requirements. Identifying this association implies that the species has an essential need for this habitat or structural condition for its maintenance and viability. Some species may be closely associated with >1 habitat or structural condition, where as others may be closely associated with only one habitat or structural condition.

Generally Associated - A wildlife species exhibits a high degree of adaptability and may be supported by a number of habitats or structural conditions. In other words, the habitats or structural conditions play a supportive role for its maintenance and viability.

Present - A wildlife species demonstrates occasional use of a habitat or structural condition. The habitat or structural condition provides marginal support to the species for its maintenance and viability.

Finally, the expert panelists assigned an overall *confidence rating* to the occurrence and activity headings for each species within each habitat type or structural condition. The confidence ratings were denoted as high (e.g., many peer-review published accounts), moderate, and low (e.g., few or no published accounts, mainly observations). By ascribing a confidence rating, the end user gets an idea of the overall strength of the scientific evidence.

Determining the Wildlife-Habitat Information

Wildlife-habitat type is defined by O'Neil and Johnson (2001) as a group of vegetation cover types that is determined based on the similarity of wildlife use. For a detailed discussion of this approach see O'Neil et al. (1995). We used the wildlife-habitat types as defined by their approach because these habitat types can be based on current vegetation and therefore can be mapped, as well as modeled to represent historic and future conditions. Wildlife-habitat types are not species-specific because they are based on the similarity of multiple wildlife species using a suite of vegetation types, and we assume they contain the essential needs for a species' maintenance and viability. However, a wildlife species' "habitat" refers to an individual, species-specific use of a wildlife-habitat type (Hall et al. 1997).

The wildlife habitat relationships SHP database depicts coarse-level wildlife-habitat types, structural conditions (structural and seral stages of vegetation), and site-specific KECs. The Framework analysis presented in this report is based only on the coarse-level wildlife-habitat type data. As the Framework process proceeds to the subbasin levels of analysis, managers will be encouraged to integrate site-specific structure and KEC data into the subbasin-scale assessment process. The hope is that knowing the species' relationship with its habitat type, structural conditions and KECs will help make better predictions for species occurrences and ecological conditions in an area. Knowing that ecological condition is based on physical parameters should also help to identify the key ecological functions that are operating (as well as missing) in an area. Key ecological function information for chinook and bull trout is being added to the array of wildlife in KEFs this data set as reported in the results.

Natural History of Selected Species

We selected 3 wildlife species for conducting and exemplifying population and species-specific assessments: American black bear, bald eagle, and American beaver.

Black Bear

Legal, Economic, and Abundance Status

The American black bear (*Ursus americanus*) is widely distributed within the Columbia River Basin and is managed according to the big game or furbearer regulations in all seven states. These regulations usually allow a general hunting season and a controlled harvest to occur annually; however, most states within the Columbia River Basin have spring and fall hunting seasons. The legitimate economic value of the black bear comes from selling hunting licenses, which in turn becomes a source of revenue for individual states' fish and wildlife agencies. An illegal economic value stems from poaching black bears and selling specific body parts (such as gall bladders) to collectors or for aphrodisiac purposes to those who highly prize their value.

Black bears occur in 32 states within the United States (Beecham and Rohlman 1994).

Life History Characteristics

The black bear is a year-round resident species in the Columbia River Basin and can be found primarily associated with forested habitats that range from sea level to 8,500 feet (2590 m) (Beecham and Rohlman 1994, Vander Heyden 1997, Verts and Carraway 1998). Black bears are large mammals whose size and weight show high variability depending on food availability. Generally, adult bears range from 35 to 40 inches (89 to 102 cm) high when standing on all fours and have a length of 4 ½ to 6 feet (1.4 to 1.9 m). An adult black bear can weigh from 125 to 600 pounds (46 to 224 kg) and males are usually larger than females. The life span of black bears in the wild can be 20 to 25 years.

Most female bears breed at three years of age, but in one study in Idaho the first age of breeding was noted as 5.5 years. Females usually produce one litter with one to three cubs every two years and can be with young any time of the year. Mating occurs in June and July and the black bear has delayed implantation so the embryo does not begin to develop until November or December (Verts and Carraway 1998). Typically, the black bears den underground, in a tree cavity, or in a cave. However, they have also been known to den on the ground or in a brush pile. Females enter their dens in October or early November, and most bears leave the den in March but some females with newborn cubs may stay until April. Young are born between mid-January to mid-February and remain with the female until they are about 16-17 months old.

Sizes of home ranges vary with quality and area of habitat and with males and females. In a coniferous forest on an island in southwestern Washington, average home ranges of females were 580 acres (235 ha), and of males 1,250 acres (506 ha). In contrast, in Idaho, home ranges of males were 27,700 acres (11,210 ha) and of females 12,085 acres (4,890 ha) (Verts and Carraway 1998). These two assessments may represent the extremes in home-range size. Home range location remains relatively constant from year to year, but bears use parts of their home ranges variably depending on food availability among the seasons.

The black bear is an omnivore. Although the majority of its diet consists of grasses, forbs, berries, nuts and fruits, bears do eat mammals (e.g., elk calves), insects, carrion and fish (Jacoby et al. 1999, Berwick et al. 1986). Food is an important element of fitness as reflected in litter size, age of breeding, and in overwintering, i.e. maintaining fat reserves during hibernation (Rogers 1977). Berry crop failures have been identified as contributing to mortality of starving subadults (Jonkel and Cowan 1971, Reynolds and Beecham 1980).

Habitat studies of black bears have shown that the most important function of cover is to enable escape. Beecham and Rohlman (1994) noted that bears tended to feed near cover (<250 yd or 228 m) from a forest edge and used riparian area and stringers of timber for travel corridors as well. Sows with cubs consistently avoided clearcuts and roads, using mature timber significantly more than males. In Idaho, bears preferred to stay more than 150 ft (46 m) from roads (Beecham and Rohlman 1994). Powell et al. (1997) found that people caused a significant amount of mortality by hunting, poaching, and road kills.

The black bear is an ecological generalist whose ecological roles are important to all categories of the wildlife-habitat types where it occurs. The black bear provides 27 categories of KEFs and in some wildlife-habitat types is the only provider of some of these functions. For example, the black bear is the only identified species to physically fragment standing wood in an upland aspen forest.

Habitats Relationships

The black bear is associated with 24 of the 32 wildlife-habitat types in the SHP database (Table III.B.2). As habitat generalists they do not have a close association with any one habitat type. This is further supported by

Habitat Type	Association	Activities	Confidence	Comments
Westside Lowlands Conifer-Hardwood Forest	Generally Associated	Feeds and Breeds	High	None noted
Alpine Grasslands and Shrublands	Generally Associated	Feeds and Breeds	High	None noted
Westside Grasslands	Present	Feeds and Breeds	Moderate	None noted
Ceanothus-Manzanita Shrublands	Generally Associated	Feeds and Breeds	High	None noted
Unsure Occurrence-Western Juniper and Mountain Mahogany woodlands	Unsure	Unsure	Low	None noted
Eastside (Interior) Canyon Shrublands	Generally Associated	Feeds and Breeds	High	None noted
Eastside (Interior) Grasslands	Present	Feeds	High	May feed in this habitat where it is near forested habitats
Shrub-steppe	Present	Feeds	Low	May feed in this habitat where it is near forested habitats
Dwarf Shrub-steppe	Present	Feeds	Low	May feed in this habitat where it is near forested habitats
Agriculture, Pastures, and Mixed Environs	Generally Associated	Feeds	High	May feed in this habitat where it is near forested habitats
Westside Oak and Dry Douglas-fir Forest and Woodlands	Generally Associated	Feeds and Breeds	High	None noted
Urban and Mixed Environs	Generally Associated	Feeds	High	None noted
Herbaceous Wetlands	Generally Associated	Feeds	High	None noted
Westside Riparian-Wetlands	Generally Associated	Feeds and Breeds	High	None noted
Mountain Coniferous Wetlands	Generally Associated	Feeds and Breeds	High	None noted
Eastside (Interior) Riparian-Wetlands	Generally Associated	Feeds and Breeds	High	None noted
Coastal Headlands and Islets	Present	Feeds	Moderate	None noted
Southwest Oregon Mixed Conifer-Hardwood Forest	Generally Associated	Feeds and Breeds	High	None noted
Montane Mixed Conifer Forest	Generally Associated	Feeds and Breeds	High	None noted
Eastside (Interior) Mixed Conifer Forest	Generally Associated	Feeds and Breeds	High	None noted
Lodgepole Pine Forest and Woodlands	Generally Associated	Feeds and Breeds	High	None noted
Ponderosa Pine Forest and Woodlands	Generally Associated	Feeds and Breeds	High	None noted
Upland Aspen Forest	Generally Associated	Feeds and Breeds	High	None noted
Subalpine Parkland	Generally Associated	Feeds and Breeds	High	None noted

Table III.B.2 Wildlife-habitat types utilized by the black bear along with their activity, association, and confidence levels.

its "Generally Associated" status for 18 habitat types and "Present" status for another 5 habitat types. Feeding and breeding activities in Table III.B.2 indicate the black bear feeds and breeds in 15 habitats and only feeds in eight habitat types. Confidence levels in determining these associations and activities were mostly high. However, two moderate confidence levels were noted (for coastal headlands and westside grasslands) along with three low confidence levels (for shrub-steppe and dwarf shrub-steppe).

Association with Salmon

Black bears are known and documented to have a strong and consistent association with salmon when there is an abundant population of salmon. The salmon life stages that bears associated with are spawning and when salmon become a carcass (Cederholm et al. 2000).

Habitat Attributes Modeled

The HCI assessment method for the black bear is diagrammed to provide an overview of the steps taken to evaluate habitat quality across the basin (Figures III.B.2a and III.B.2b). The details and code for this assessment method are outlined in Appendix F. Data were collected and analyzed for all 6-HUCs in the basin. Each 6-HUC is assigned an HCI score. Once the data were collected, we analyzed only those 6-HUCs where at least 20 percent of the 6-HUC was rated Associated (i.e., Closely or Generally Associated in Table III.B.2). If 20 percent of the HUC was rated associated, we determined if 80 percent of the HUC-6 was in the known range for the black bear. If 80 percent of the HUC was in the black bear range, we determined if 90 percent of the HUC was non-urban. If this was the case, we then determined if 50 percent or less of the HUC was in agriculture.

Sixth field HUCs that met the above conditions were assessed for three components: cover, food, and human disturbance. Cover was assessed by two variables: (1) weighted percent of the "occurrence index (Present = 1, Generally Associated = 2, Closely Associated = 3)" and (2) percent forested habitat present in the 6 - HUC being analyzed. Food was assessed by three variables: (1) weighted percent of wildlife habitat types designated as "Feeding habitat" in Table III.B.2, (2) the berry index, and (3) presence or absence of salmon carcasses in a 6-HUC. The berry index was developed for each wildlife-habitat type designated as "Feeds" or "Feeds and Breeds" in Table III.B.2. Wildlife-habitat types were given a rank depending on the number of berry-producing plant species listed in the habitat type descriptions in the SHP database (O'Neil et al. 2001). Each wildlife-habitat type habitat was assigned a high, medium, or low

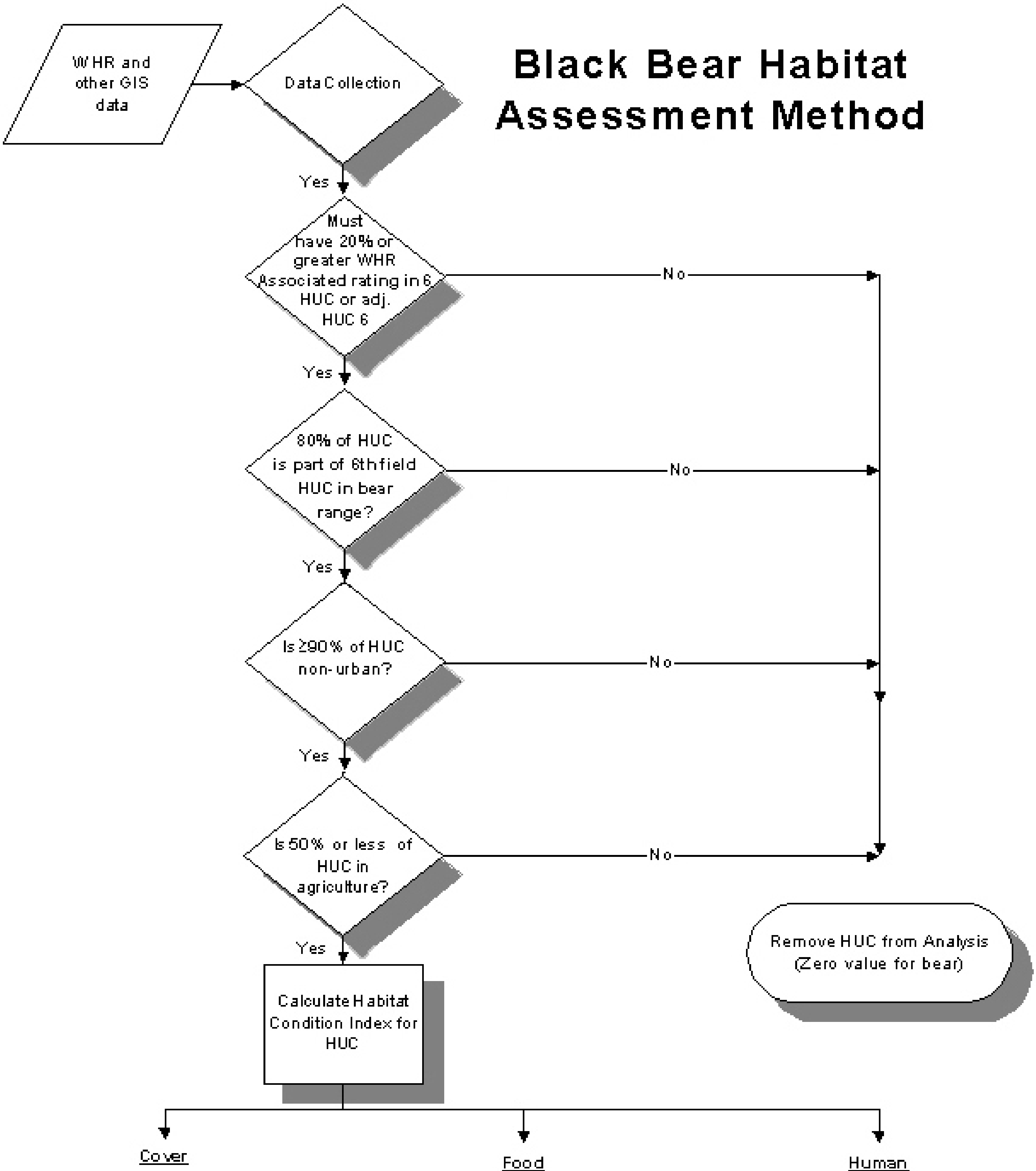


Figure III.B.2a A Habitat Condition Index (HCI) for black bear was calculated for all HUC-6s in the Columbia River Basin. The HCI assessment method integrated a number of conditions for three components of black bear habitat: cover, food, and human disturbance.

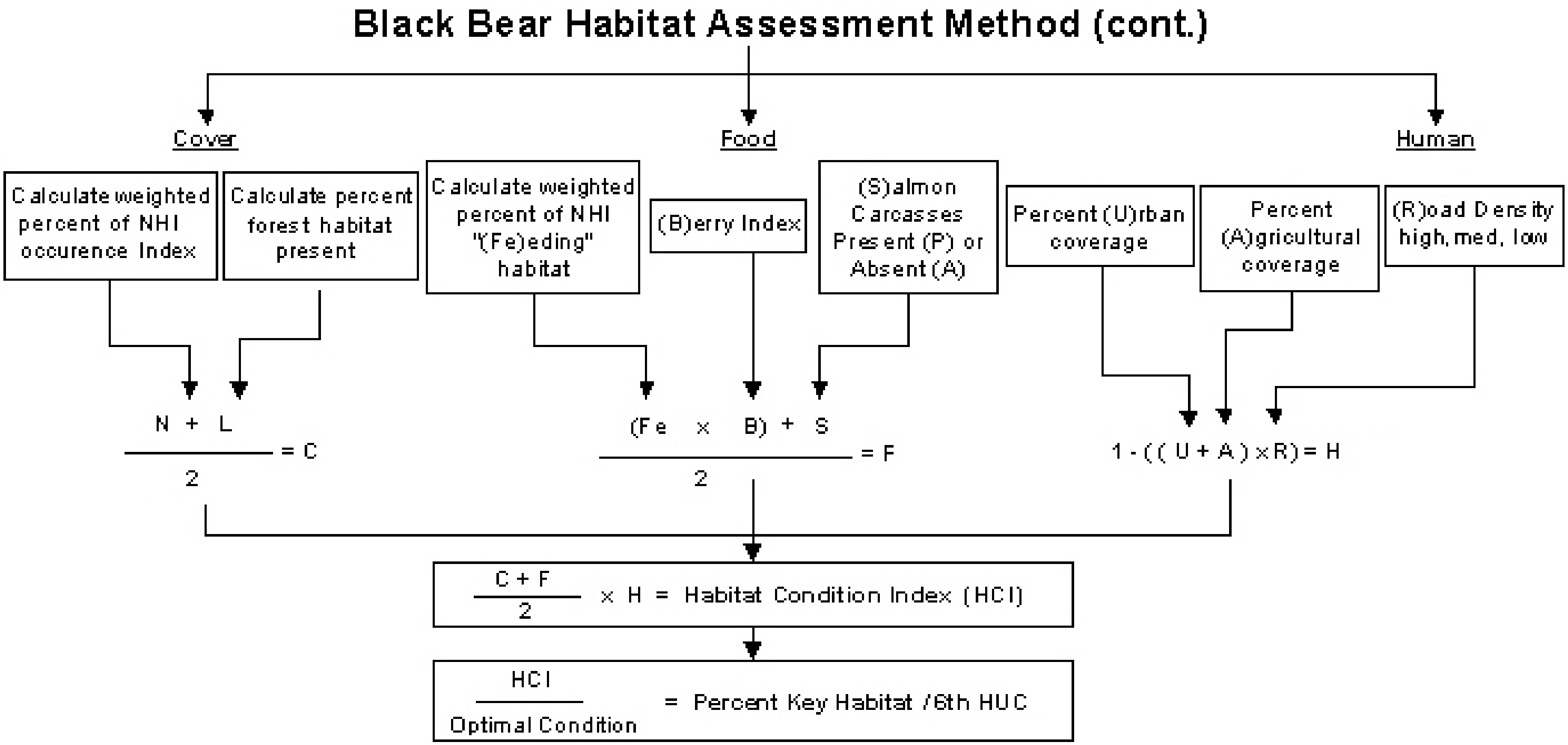


Figure III.B.2b (continued from a) A Habitat Condition Index (HCI) for black bear was calculated for all HUC-6s in the Columbia River Basin. The HCI assessment method integrated a number of conditions for three components of black bear habitat: cover, food and human disturbance.

rank (1.0 = high, 0.5 = medium, 0.0 = low). Human disturbance was assessed with three variables: (1) Percent urban coverage in the HUC, (2) percent agricultural coverage, and (3) Road density. Results from these analyses were aggregated to determine the Habitat Condition Index (HCI) for each 6-HUC. HCI values where then aggregated up to ecological province and the entire basin. The detailed steps taken in the GIS portion of the HCI analysis are presented in Appendix F.

Bald Eagle

Legal Economic, and Abundance Status

Throughout the Columbia River Basin, the bald eagle (*Haliaeetus leucocephalus*) is federally listed as a threatened species under the Endangered Species Act in all seven states. Nonetheless, because of recovery efforts lead by the U.S. Fish and Wildlife Service in partnership with other federal, state, tribes, and local governments, conservation organizations, and private entities, the bald eagle is being considered for removal from this federal designation. The delisting, a U.S. Fish and Wildlife proposal in 1999, is related to the increase in eagle numbers throughout their range. For example, in 1960 only 417 nesting pairs were found in lower 48 states and today the estimate is over 5,700. Hence, many resource biologists and managers are assessing whether or not the bald eagle warrants special protection afforded by the Endangered Species Act. This eagle is also protected by the federal law, Migratory Bird Treaty Act, as well as, under individual state's non-game laws. The bald eagle has no legal economic value.

Life History Characteristics

The bald eagle is a year-round resident in the Columbia River Basin and can be found along most major river courses and ranges from sea level to 8,000 feet (2438 m) (Garrett et al. 1993; Stalmaster 1987). Adults weigh seven to 10 pounds (2.6 to 3.7 kg) with a wingspan of 6 ½ feet (2 m). They have been known to live more than 20 years in the wild, and the age at first breeding is usually five years. The bald eagle builds its nest in the tops of large live trees usually near water and nests can be up to 20 feet wide (6 m) and weigh up to 4,000 pounds (1492 kg) (Knight et al. 1983, Hermata 1989). Food habits vary with seasons and locations, and they do take advantage of fish (suckers, trout, and whitefish), birds (particularly waterfowl), salmon carcasses (especially in the fall and winter), and mammal carrion (Stalmaster 1984 and 1994).

Bald eagles begin laying eggs from early March to early April with mean hatching dates from mid-April to mid-May. Incubation of eggs usually lasts 34-36 days and they fledge one to two young per year but can fledge three on occasion (Stalmaster 1987). Fledging occurs 10 to 14 weeks after hatching or generally in early August. Bald eagles usually have some fidelity with the nest sites and even though they can travel great distances (Gerrard et al. 1978), most nest within 100 miles of where they were originally raised (Jenkins and Jackman 1993). Bald eagles are known to use a communal roost especially in the winter when salmon are spawning. Up to 300 bald eagles may use a single roost site (Knight et al. 1983).

Human disturbance can affect perching, roosting, and feeding (Fraser 1985, Knight and Knight 1986). Bald eagles are more sensitive to human activities on the river (boating or fishing) than to vehicle traffic or airplane flight (Stalmaster and Newman 1978, Knight and Knight 1984, and Department of Interior 1986). However, bald eagles can tolerate some human activity where there is an abundant food supply and adequate habitat (Stalmaster and Newman 1978; Steenhof 1978). Human activity that occurs beyond 1/3 of a mile (or 500m) from a bald eagle use area seldom disturbs the birds (Stalmaster and Newman 1978).

Habitats Relationships

The bald eagle is associated with 23 of the 32 wildlife-habitat types (Table III.B.1) listed for the region. Associations with wildlife habitat types in Table III.B.1 indicate the bald eagle is "Closely Associated" with one habitat type, open water; "Generally Associated" with 16; and "Present" in another eight. Feeding and breeding activities in Table III.B.2 indicate the eagle just breeds in nine, breeds and feeds in an additional five, and just feeds in another 11. Confidence levels with making these determinations are mostly high with the exception of one wildlife-habitat type, feeding in westside grasslands, which is low.

Association with Salmon

The bald eagle has a strong and consistent relationship with salmon as a predator on salmon. This relationship extends to three salmon life stages: saltwater residence (when they are smolts, immature, and adults), spawning, and carcasses. The eagle also has an indirect relationship with salmon because they are known to feed on birds that also feed on salmon (Cederholm et al. 2000).

Habitat Model Input

The bald eagle model, similar to the black bear model, was developed to assess habitat quality (i.e., Habitat Condition Index) for three time periods: historic, current and future. Input variables selected for the

Habitat Type	Association	Activities	Confidence	Comments
Westside Lowlands Conifer-Hardwood Forest	Generally Associated	Reproduces	High	Could breed in this habitat where near open water habitats.
Alpine Grasslands and Shrublands	Present	Feeds	Low	Known to occur in sub-alpine and alpine areas on Vancouver island, B.C.
Westside Grasslands	Present	Feeds	Low	None noted
Shrub-steppe	Present	Reproduces	High	Could breed in this habitat where near open water hapbitats, and if suitable nest
Dwarf Shrub-steppe	Present	Reproduces	High	Could breed in this habitat where near open water habitats.
Desert Playa and Salt Scrub Shrublands	Present	Feeds	High	Wintering.
Agricutulre, pastures, and Mixed Environs	Generally Associated	Feeds	High	None noted
Westside Oak and Dry Douglas-fir Forest and woodlands	Generally Associated	Reproduces	High	Could breed in this habitat where near open water habitats.
urban and Mixed Environs	Generally Associated	Feeds and Breeds	High	could breed in this habitat where near open water habitats, and if suitable nest structures are available.
Open Water - lakes, Rovers, and streams	Closely Assocaited	Feeds	High	None noted
Herbaceous Wetland	Generally Associated	Feeds	High	None noted
Westside Riparian - Wetlands	Generally Associated	Feeds and Breeds	High	None noted
Eastside (Interior) Riparian - Wetlands	Generally Associated	Feeds and Breeds	High	None noted
Coastal Dunes and Beaches	Present	Feeds	High	None noted
Coastal Headlands and Islets	Generally Associated	Feeds and Breeds	High	None noted
Bays and Estuaries	Generally Associated	Feeds and Breeds	High	Requires some sort of structure to place nest on, such as old pilings, if breeding is to occur in this habitat.
Inland Marine Deeper waters	Generally Associated	Feeds	High	None noted
Southwest Oregon Mixed Conifer-Hardwood Forest	Generally Associated	Reproduces	High	Could breed in this habitat where near open water habitats.
Marine Nearshire	Generally Associated	Feeds	High	None noted
Marine shelf	Present	Feeds	Moderate	None noted
Montane Mixed conifer Forest	Generally Associated	Reproduces	High	Could breed in this habitat where near open water habitats.
Eastside (Interior) Mixed Confier Forest	Generally Associated	Reproduces	High	Could breed in this habitat where near open water habitats.
Lodgepole Pine Forest and Woodlands	Generally Associated	Reproduces	High	Could breed in this habitat where near open water habitats.
Ponderosa Pine Forest and Wooldlands	Generally Associated	Reproduces	High	Could breed in this habitat where near open water habitats.
Subalpine Parkland	Present	Feeds	Low	Known to occur in sub-alpine and alpine areas on Vancouver island, B.C.

Table III.B.1 Wildlife habitat types associated with the bald eagle along with their activity, association, and confidence levels.

model were based on: (1) availability of a consistent data set for all 6-HUCs in the basin, (2) importance to bald eagle nesting, roosting, and foraging and (3) likelihood that proposed management activities would influence the variables. Our review of the literature (summarized above) indicated that consistent information on nesting and roosting sites was not available for all 6-HUCs in the basin. Consequently, nesting and roosting sites and the influence of human disturbance on them was not included in the model. Analyses at the subbasin level are more likely to have access to local databases and professionals who are familiar with nest and roost sites and human use areas.

The Habitat Condition Index for the bald eagle was developed by evaluating generalized foraging and breeding information for the various wildlife-habitat types in the SHP database. Habitat associations (Closely and Generally Associated in Table III.B.1) and habitat activities (feeds, breeds and feeds, and breeds in Table III.B.1) for the various wildlife habitat types in the SHP database were the main input variables we used to evaluate food and cover, as outlined in Figure III.B.3. The detailed steps taken in the GIS portion of the HCI analysis are presented in Appendix F.

American Beaver

The American beaver was selected as a species to assess in the Multi-Species Framework because of the association with aquatic ecosystems and with fish diversity and abundance (Schlosser and Kallemeyn 2000). Our HCI assessment of the American beaver included three components: physical condition, cover, and food, similar to our assessment of black bear and the bald eagle. The first step of the of analysis steps, data collection, was problematic for this species. The scale of the habitat data was too coarse and the assessment method met with failure as discussed in the Results.

Legal, Economic, and Abundance Status

The American beaver (*Castor canadensis)* is widely distributed within the Columbia River Basin and is govern by the furbearer regulations that are in place in all seven states. The legitimate economic value of the beaver comes to individuals who trap them and in turn sell their pelts. Sometimes, the beaver is considered a nuisance because it can cause erosion, blockages or flooding. Hence, landowners can have beaver removed or relocated depending on the amount of damage being sustained. The American beaver occurs in all 50 states (Hill 1982), and the estimated population in the early development of North America is 60,000,000.

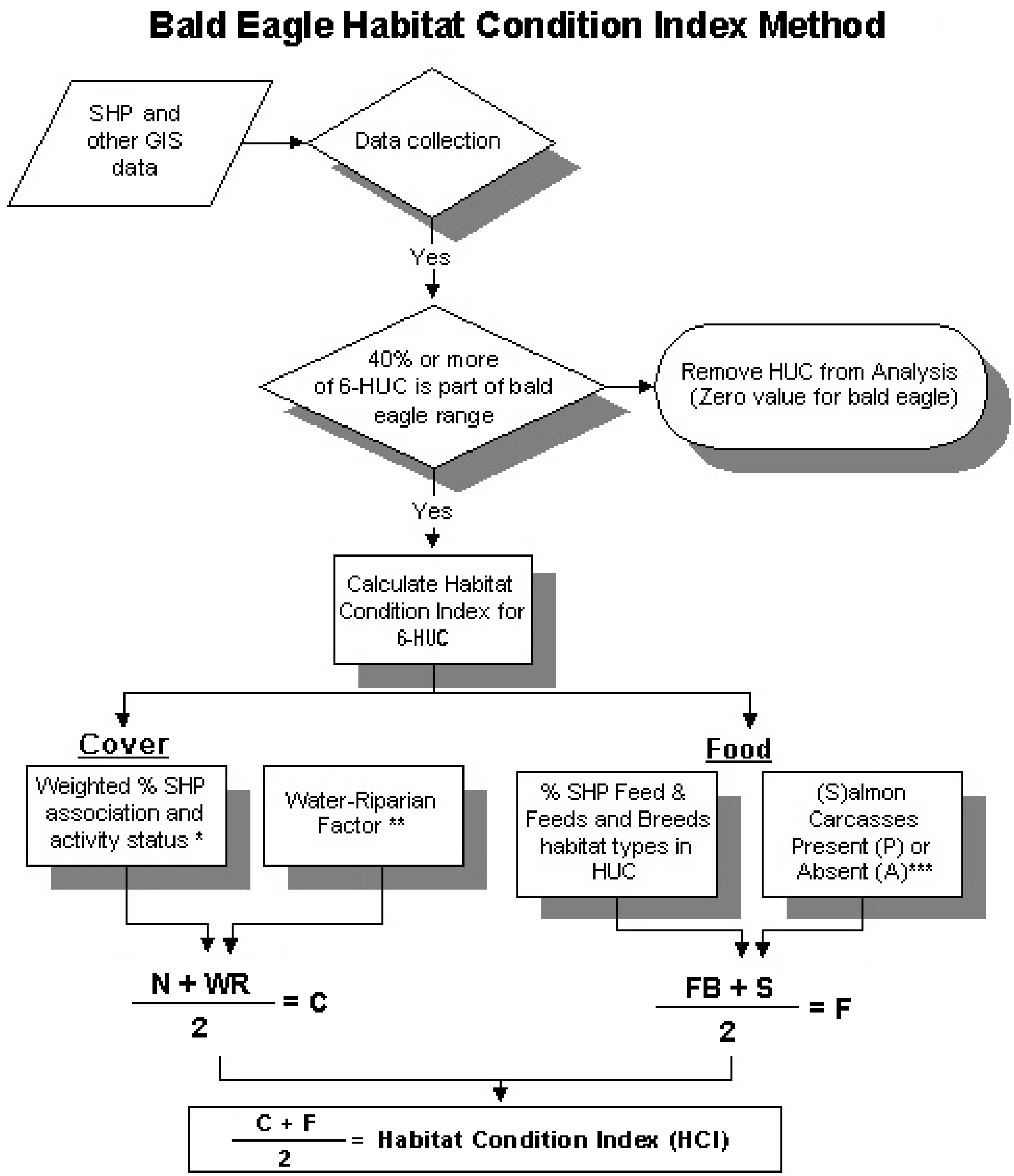


Figure III.B.3 A Habitat Condition index (HCI) for the bald eagle was calculated for all HUC-6s in the Columbia River Basin. The HCI assessment method integrated conditions for food and cover. The influence of human disturbance was not assessed because consistent information on nest locations was not available across the basin.

Life History Characteristics

The beaver is associated primarily with forested and aquatic habitats from sea level to 7,500 feet (2286 m) elevation (Verts and Carraway 1998). Beavers' size and weight show high variability depending on food availability. Adult beavers are up to 47 inches (120 cm) long and weigh from 47 to 83 pounds (16 to 31 kg). The lifespan of beavers in the wild can be greater than 20 years, however few live beyond 10 years (Jenkins 1979).

Most female beavers breed at three years of age, the average number of offspring per litter is three, and they only have one litter per year. Mating occurs mostly in January through February and the gestation period takes 105 - 107 days. Most of the offspring are born in May and June, and the young are weaned at two to three months and leave the natal lodge at the end of their first or second year (Verts and Carraway 1998). Typically, beavers build lodges on banks of streams or ponds, or burrow in banks.

Beavers usually form colonies consisting of a mated pair, their yearlings, and offspring of the year. They have variable dispersal distances from 1.8 – 13.8 miles (2.9 - 22.2 km) and dispersers of various ages averaged 5.6 miles (9.0 km) in a straight line distance (Leege 1968). Beavers are active all year long.

A beaver colony is a single group of four to eight animals per stream reach. A colony uses a common food supply, and maintains common dams. An average of one to two colonies / mile of stream occur in good habitat (Lawrence 1954; Aleksiuk 1968). Naiman et al. (1986) suggested that beavers are "keystone" species because of their relationship to salmonids and ability to "affect ecosystem structure and dynamics far beyond their immediate requirement for food and space." Removal of beavers has been shown to fundamentally alter aquatic ecosystem functions (Spence et al. 1996).

Habitats Relationships

The American beaver is associated with 16 of the 32 wildlife-habitat types in the SHP database (Table III.B.3). As an aquatic specialist it is "Closely Associated" with four open water, wetland and riparian habitat types (Table III.B.3). It is "Generally Associated" with eight habitat types and "Present" in another five habitat types. The beaver is identified to feed and breed in four wetland habitats and in subalpine parkland where wet meadows occur (Table III.B.3). Confidence in these associations and activities is mostly high. However, moderate confidence levels were noted for agriculture, urban, and subapline parklands, along with one low level of confidence for western juniper and mountain mahogany woodlands).

Habitat Type	Association	Activities	Confidence	Comments
Westside Lowlands Conifer-Hardwood Forest	Generally Associated	Feeds	High	none noted
Western Juniper and Mountain Mahogany Woodlands	Present	Feeds	Low	none noted
Agriculture, Pastures, and Mixed Environs	Present	Feeds	Moderate	none noted
Westside Oak and Dry Douglas-fir Forest and Woodlands	Generally Associated	Feeds	High	none noted
Urban and Mixed Environs	Present	Feeds	Moderate	none noted
Open Water - Lakes, Rivers, and Streams	Closely Associated	Reproduces	High	none noted
Herbaceous Wetlands	Closely Associated	Feeds and Breeds	High	none noted
Westside Riparian-Wetlands	Closely Associated	Feeds and Breeds	High	none noted
Montane Coniferous Wetlands	Generally Associated	Feeds and Breeds	High	none noted
Eastside (Interior) Riparian-Wetlands	Closely Associated	Feeds and Breeds	High	none noted
Southwest Oregon Mixed Conifer-Hardwood Forest	Generally Associated	Feeds	High	none noted
Montane Mixed Conifer Forest	Generally Associated	Feeds	High	none noted
Eastside (Interior) Mixed Conifer Forest	Generally Associated	Feeds	High	none noted
Lodgepole Pine Forest and Woodlands	Generally Associated	Feeds	High	none noted
Ponderosa Pine Forest and Woodlands	Generally Associated	Feeds	High	none noted
Upland Aspen Forest	Present	Feeds	High	May use this habitat if not too far from water.
Subalpine Parkland	Present	Feeds and Breeds	Moderate	Known from subalpine meadows in Mt. Rainier National Park.

Table III.B.3 Wildlife habitat types associated with the American beaver along with their activity, association and confidence levels.

Association with Salmon

The beaver is not known to eat or prey on salmon. However, from a habitat standpoint, the beaver does have a close association with salmon because of its ability to create ponds and enhance functional processes that are favorable for salmon (Hill 1982; Schlosser and Kallemeyn 2000).

Habitat Model Input

Input variables to the beaver HCI model included stream hydrology, wildlife-habitat types, food, and breeding. Habitat types, food, and breeding were assessed using information from the SHP database (Table III.B.3). Also, the value of the agriculture habitat type was discounted in the model even though beaver can occur in this habitat type. The stream hydrology conditions that were assessed included monthly flow and amount of sinuosity (meandering in a stream). A diagram of the model outlining the steps of the analysis process is not presented for the beaver because the site-specific stream hydrology data and fine-scale wildlife habitat data were not available on a consistent basis across the basin. Details of the proposed analytical method to assess beaver HCI are summarized in Appendix F.

Major Assumptions

Basin-wide Wildlife Habitat Type Maps

Two wildlife-habitat type maps were developed for the Multi-Species Framework process to depict historic (potential) and current conditions. These maps served as a base for making assessments between the historic and current conditions (Vail, Appendix L). Future (year 2100) conditions under each alternative were also developed. Collectively, we used these two maps and the future habitat type projection to evaluate black bear, bald eagle, beaver, and key ecological functions of wildlife species under historic, current, and future conditions.

Two wildlife-habitat type maps were developed for the Multi-Species Framework process to depict historic and current conditions. These maps served as a base for making assessments between the historic, current, and alternative conditions for evaluating black bear, bald eagle, beaver, and key ecological functions. Wildlife-habitat type maps are useful for integrating concepts so that the outputs can be visually displayed. However, there are some limitations in their use as discussed below. Comparing two maps can show how vegetation communities can change through time. The Interior Columbia Basin Ecosystem Management Project and related assessments also address vegetation changes since early historic times, as reported by Everett et al. (1994), Hann et al. (1998), Hessburg et al. (2000), and Huff et al. (1995).

Current Conditions

The Northwest Habitat Institute (NHI) developed a map depicting the current distribution of the 32 wildlife habitats types, described by the SHP project, for the Columbia River Basin in the United States. This map was compiled from existing vegetation maps that were created for each state as part of the National Gap Analysis Program sponsored by US Geological Survey, Biological Resource Division (USGS/BRD). Each state's map is based on interpreting vegetation cover data from satellite imagery. Vegetation maps from all or parts of seven states (Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming) in the Columbia River Basin were used by NHI to develop the wildlife habitat types map depicting current conditions.

The primary purpose for developing the vegetation maps for the National Gap Analysis Program was for USGS/BRD to conduct statewide biodiversity assessments. Hence, the resolution of their vegetation maps reflects a statewide, regional, or coarse resolution for planning. That is, their maps can serve as an initial basis for large-scale mapping or database investigations but they are more accurately interpreted at the statewide or province scales, and only for some of the largest subbasins.

Hence, the current wildlife-habitat type map provides only an initial depiction of the amounts of wildlife habitats that may exist within watersheds, but is not of sufficient resolution for depicting the site-specific location of habitats within each watershed. The minimum mapping unit for the basin-wide map is 250 acres (100 ha), whereas a more appropriate scale for within watershed assessments would be 10-75 acres (4-30 ha) depending on land ownership and habitat patch sizes. Thus, wildlife habitats that occur in patch sizes less than 250 acres, e.g. linear riparian habitat, are likely underrepresented in the current map.

Further, there has been no formal validation of the basin-wide current wildlife habitat map. Because maps are only a representation of reality and cannot depict all the detail represented in nature, some generalization is unavoidable. Remotely sensed maps developed from photo interpretation or satellite imagery also contain some errors. Conducting an accuracy assessment allows the user to know at a glance what the overall reliability is, so that when decisions are made the accuracy of the map can be taken into account. Because of the size of the mapping area, time frame, and costs, no formal accuracy assessment was done. However, the National Biodiversity Gap Analysis Program had a goal of 80 percent overall accuracy for each state's vegetation map, and NHI accepted their stated validity of their map products.

Finally, because there is a desire to move towards subbasin information, which would entail maps produced at finer resolutions than presented in this report, accuracy assessments may be less critical or a lower priority for the current array of map products than for later map products produced at the subbasin scale. We do recognize the importance of conducting accuracy assessments and that they would be critical to the utility and acceptance of subbasin-scale maps as a tool for resource managers. In general, accuracy assessments would entail determining the classification error in maps by using an *a priori* target level of thematic map accuracy (for subbasin mapping we would propose a per class accuracy of 75 percent and overall map accuracy of 80 percent) and designing the empirical assessment (number of sampling points, etc.) based on statistical sampling procedures (Stehman, 1992).

Historic (Potential) Conditions

A historic (potential) map was developed by NHI by combining products from two previous works: Interior Columbia Basin Ecosystem Management Project (ICBEMP; USDA Forest Service 1997), and the Oregon Biodiversity Project (Defenders of Wildlife 1998). These two mapping efforts used very different methods. The ICBEMP historic data were mostly derived from a model, whereas at least a portion of the Oregon Biodiversity Project map was created by using surveyors' notes from the 1850 land survey.

NHI combined these efforts to create a wildlife habitat map that depicts historic (potential) conditions of the Columbia River Basin in the U.S. The result is a historic map that is a theoretical construct with a coarse (1-km square pixel size) level of resolution designed to give a regional perspective. This map can provide only initial approximations of the presence and distribution of wildlife habitat types within specific subbasins and watersheds because of the need for more detailed information at these levels.

Because of the limitations with the historic map, no validation of this map was done. We are unaware of any previously collected detailed information for all the subbasins and watersheds throughout the specific geographic areas of basin addressed in this project. Further, because there are no recognized historical data sets that would give such a basin perspective, validation would be difficult. Hence, the historic map best depicts gross generalizations of gains or loses of specific wildlife habitat types. Additionally, it can give a user an idea of what the potential may have existed within provinces and within larger subbasins.

Structural Conditions

Many species of wildlife are affected by both the general macrohabitat conditions, depicted in our maps as wildlife habitat types, and by the specific structure of vegetation. However, to accurately depict distribution and abundance of vegetation structure would require spatially explicit data sets at both coarse and fine levels of resolution. A coarse level map typically has a minimum mapping unit (mmu) of about 250 acres, whereas a finer level map shows details at about a 10-acre mmu.

Because fine-level data are either not available or have not been synthesized for all lands basin-wide, the outcomes presented here should be used to interpret wildlife-habitat type information only at a coarse scale. Vegetation structural conditions are best depicted at a finer level of resolution, that is, at a stand level with a 10-to-40 acre mmu, and should be included in future subbasin mapping efforts.

Consideration of vegetation structure can greatly influence analysis and interpretation of wildlife-habitat relationships. We selected a few subwatersheds (6^{th} HUC) for which vegetation structure information was available, and found that consideration of structural condition influenced results of projecting wildlife species and their key ecological functions within the area. Thus, we concluded that, at such finer scales of mapping resolution, vegetation structure likely influences the presence and distribution of wildlife species and thus overall ecosystem biodiversity, productivity, and sustainability.

Key Ecological Functions of Fish and Wildlife Species

The ecological approach we adopted for the Multi-Species Framework supplements the emphasis on coldwater fish with tools that address ecological functions of all wildlife and eventually all fish in the Columbia Basin. The ability to address and describe in a repeatable way ecological functions of all vertebrates (including humans), using a common database, is a new approach to broad-scale resource assessment presented by the Multi-Species Framework.

The term key ecological functions (KEFs) of wildlife refers to the principal set of ecological roles performed by each species in its ecosystem (Marcot and Vander Heyden, 2001). KEFs refer to the main ways organisms use, influence, and alter their biotic and abiotic environments. “Key” refers to the main roles played by each species. Categories of KEFs can be depicted for each species and used in multiple-species analyses of alternatives for land management in the Columbia River Basin.

One major assumption on this analysis is that wildlife KEFs contribute to and affect ecosystem biodiversity, productivity, and resource-use sustainability (BPS). Another assumption is that the parameters of BPS describe ecosystem integrity, the maintenance or restoration of which, we presume, can be one prime goal of ecosystem management. The purpose of tracking wildlife KEFs, including their patterns and changes, therefore, is to determine how management actions might affect wildlife, the biotic functioning of ecosystems, and ecosystem BPS. It serves as a way to measure the degree to which ecosystem management goals are met for maintaining or restoring at least some facets of ecosystem integrity.

We measure changes in wildlife KEFs in several ways, including historic and current patterns of, and future potential changes in: (1) the distribution and abundance of species, based on their habitat associations, that perform particular ecological roles (that is, that are coded for particular KEF categories); (2) Functional redundancy of KEF categories; and (3) The richness and diversity of KEF categories that ecological communities can support. Functional redundancy refers to the number of species performing a particular KEF category. As stated by Marcot and Vander Heyden (2001), the basic premise is that functionally redundant, rich, and diverse communities may be more resistant or resilient to adverse disturbances (MacNally 1995, Naeem 1998, Rastetter et al. 1999) and can more consistently support greater levels of biodiversity (Jaksic et al., 1996 Walker 1992) than can less functionally redundant, rich, or diverse communities.

Marcot and Vander Heyden (2001) noted that ecological implications of functional patterns of species and communities, and their influence on BPS, can be taken as testable hypotheses about the roles of wildlife and how ecosystems work. They listed several key such hypotheses, with perhaps the most important ones for the current work being:

1. Functional redundancy imparts community resilience: for a particular function, the higher the functional redundancy, the greater ability of the community to resist stresses put on that function.
2. The greater the functional redundancy, the more sustainable is the set of resources that the function provides.
3. The more functionally rich and diverse a community, the greater is its natural productivity and its native biodiversity.

Over time, such hypotheses could be tested in the context of adaptive management by comparing performance of BPS over time or among areas managed differently.

Collectively, the methods we used provide a means of determining the degree to which an ecosystem is “fully functional,” by comparing historic, current, and potential future KEF conditions. Fully functional ecosystems are those that have the full set of historic KEF categories, and the historic patterns of functional redundancy for each KEF category.

Other functional aspects include determining: (1) *Functional richness*, which is the number of KEF categories performed by species in a community, (2*) Total functional diversity*, which is functional richness weighted by functional redundancy (Brown 1995), analogous to species diversity, and (3) *Functional web*, which is the full array of all KEFs associated with a set of species that may be specified by some habitat element or structure (Marcot and Vander Heyden 2001). Because many functions can extend beyond a habitat element or structure, functions that are supported in part by specific KECs can influence parts of the ecosystem well beyond those KECs. For example, the ecological functions provided by beaver extend well beyond the confines of the KEC of water depth (Schlosser and Kallemeyn 2000).

Validation Steps

Scientific and common names and species occurrence status, by state, were reviewed by Dick Johnson (Washington State University), B. J. Verts (Oregon State University), Tom O'Neil (Northwest Habitat Institute), Rolf Johnson (Washington Department of Fish and Wildlife [WDFW]), Derek Stinson (WDFW), Kelly Bettinger (WDFW), Charlie Bruce (Oregon Department of Fish and Wildlife [ODFW]), Kelly McAllister (WDFW), Bruce Mate (Oregon State University Marine Science Lab), Steven Jeffries (WDFW), and Robin Brown (ODFW). Taxonomic order follows regional publications or commonly accepted national books to facilitate cross-referencing.

The Species Habitat Project (SHP) assigned five occurrence status categories to each wildlife species in the SHP database: *occurs*, *accidental*, *introduced*, *reintroduced*, and *extirpated*; the species could be listed as any one of these categories in any state within the basin (Johnson and O'Neil 2001). *Occurs* means $\geq$15 documented observations, that is, they are considered to be common species for the area. Some species listed as "occurs" do not have 15 records in recent decades, so there are species listed that were formerly more abundant, but now may be considered rare (like the short-tailed albatross). This figure of 15 documented observations was derived from its use in the states' ornithological groups, such as the Oregon Field Ornithologists. *Accidental* denotes those species with <15 documented occurrences, or >15 records but the Columbia Basin is not a regular part of the species' range. *Introduced* denotes species that are not native (that is, that likely did not occur before European settlement) but that now breed in the Columbia Basin. *Reintroduced* denotes native species that were eliminated from the Columbia Basin or reduced to such low population levels that additional individuals were required to supplement or re-establish the species. *Extirpated* refers to a native species whose originally native populations have been completely extirpated from the Columbia Basin.

Three categories were used to describe the breeding status of the species. *Breeds* is for those species with ≥5 documented breeding records by separate pairs unless professionals familiar with the species believed that breeding is probable but has not yet been documented. *Non-breeder* refers to those species that occur in the state(s) but do not breed, or have <5 documented breeding records. *Bred-Historically* refers to those species that used to breed in the state(s) but currently do not.

NHI did the alternative strategies analysis for the black bear and bald eagle using basin-wide species distribution maps. NHI used data from previous inventories or studies to validate these basin range maps. For example, 29 years of bald eagle inventory data helped determine which 6th HUCs should be a part of the bald eagle's basin-wide range. With black bear, the radio locations from a 3-year study in the Central Cascades of Oregon helped clarify the Habitat Condition Index by comparing NHI's black bear distribution map with that from the study. Additionally, species range information from Idaho, Oregon, Western Montana, and Washington further helped with the validation of NHI's distribution maps of bald eagle and black bear by comparing the maps with the Habitat Condition Index model's ranges. Our last review for accuracy compares differences between species ranges in the literature with known occurrence of suitable habitat. The databases and analyses of wildlife KEFs were not validated; nor were the patterns of community function resulting from our Ecological Functions Analysis. Clearly, work remains to better quantify the ecological roles of wildlife, how those roles affect BPS, and how management actions affect the functioning of communities.

METHODS - ECOLOGICAL INTEGRATION

The summary is organized as follows:

Integrating Assessments of Fish and Wildlife Populations and Ecological Functions

The scientific principals of the Multi-Species Framework assessment process call for an analysis of fish, wildlife, and their ecological functions for evaluating alternative strategies for managing natural resources in the Columbia Basin. The following sections present methods of the assessments of what we are calling the Ecological Functions Analysis. The Ecological Functions Analysis provides a method by which ecological functions of fish and wildlife can be assessed individually and jointly.

There are many possible means by which fish and wildlife populations can interact, and how such interactions can vary geographically and over time. The purpose of the integrated fish-wildlife analysis is to provide a basis for determining if and how management activities associated with basin-wide planning alternatives significantly influence ecological interactions between fish and wildlife, and the implications of such interactions on ecosystem biodiversity, productivity, and sustainability.

The components of the Ecological Functions Analysis are shown in a diagram depicting the major categories of fish-wildlife interactions that we considered (Figure III.C.1). This figure lists the following section headings representing each type of interaction.

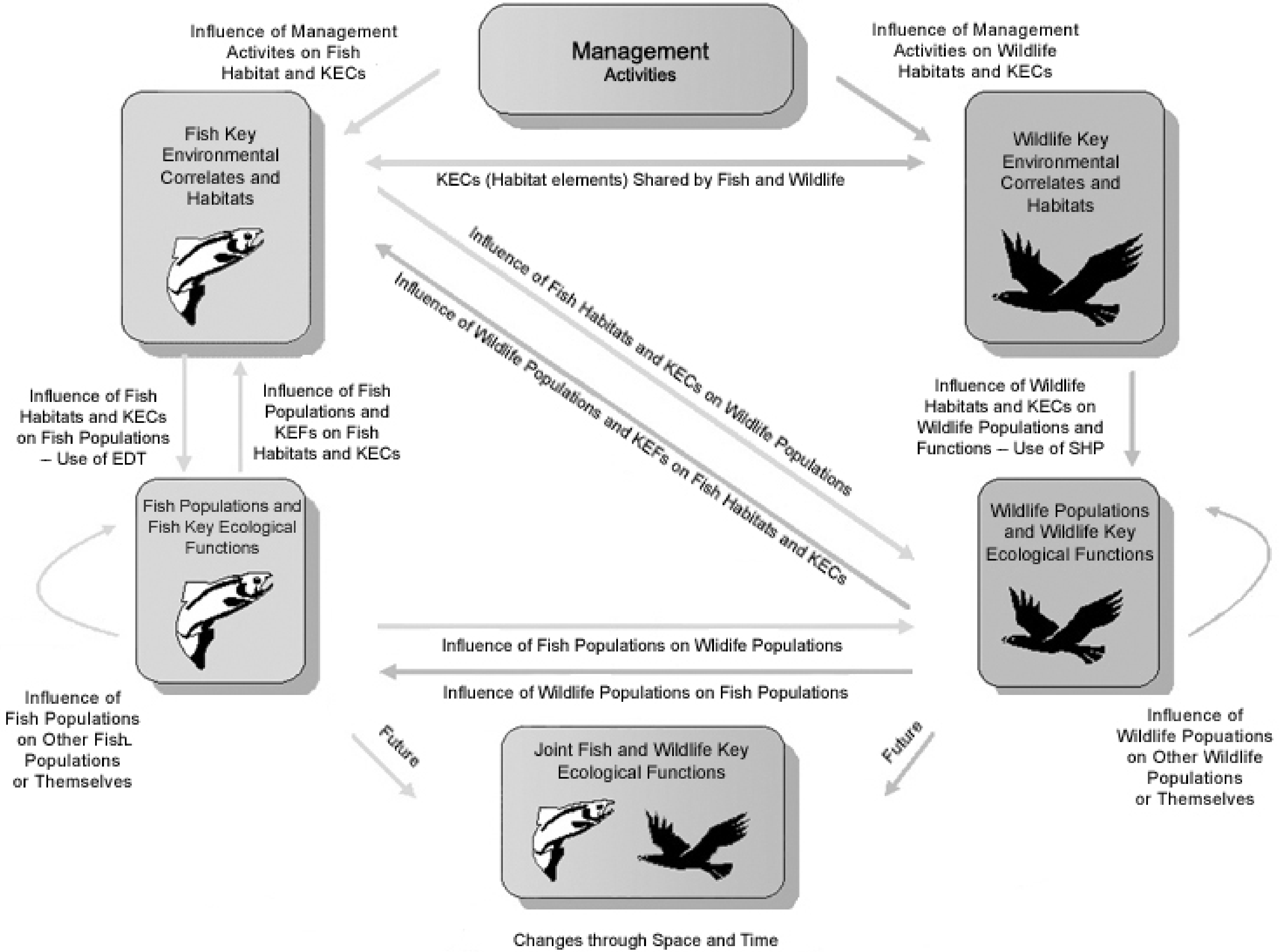


Figure III.C.1 Generalized process for evaluating fish and wildlife interactions.

Influence of Habitats on Populations and Functions

Integrating fish and wildlife information requires coordination of methods, data sets, and terminology used to evaluate fish species, wildlife species, and their ecological functions. The first step to relate terminology used by fish and wildlife biologists is to describe habitat. Table III.C.1 lists the KECs (habitat elements) that are used in the SHP database to define wildlife habitat elements. Table III.C.2 lists EDT Level 2 Habitat Attributes for fish and shows how the fish habitat attributes relate (i.e., crosswalk) to wildlife KECs. This fundamental coordination of habitat language allows fish and wildlife biologists to describe, in a common language, how management alternatives can influence habitat.

In addition, the common language helps both wildlife and fish managers use the SHP database that depicts which KECs are potentially influenced by categories of strategies that collectively capture alternatives assessed in this report. A Management Activities database in the SHP can, in future analyses, be used by managers to help do impact assessments of management activities on KECs for wildlife and on EDT Level 2 habitat attributes for fish. For example, strategies that are described by a suite of standardized management activities (in the SHP database) can be associated with changes in all KECs ("habitat elements" in the SHP database) as depicted, to be influenced by those activities. Then, cross-referencing which fish and wildlife species are associated with the changed KECs and EDT habitat attributes, and knowing the key ecological functions these species provide in the ecosystem, provides a basis for linking alternative management strategies with ecological functions of both fish and wildlife species.

The most fundamental interactions we assessed were the influence of habitats and key environmental correlates (KECs) on populations of fish and wildlife separately, that is, how fish habitats and KECs influence fish populations, and how wildlife habitats and KECs influence wildlife populations.

Influence of Fish Habitats and KECs on Fish Populations – Use of EDT

For fish, analyzing the influence of fish habitats and KECs on fish populations entailed use of the EDT model. This methodology is discussed more fully in the section on Fish-Methods of this report.

Influence of Wildlife Habitats and KECs on Wildlife Populations and Functions – Use of SHP

For wildlife, analyzing the influence of wildlife habitats and KECs on wildlife populations entailed use of the Species Habitat Project (SHP) database to evaluate potential presence by 6^{th} HUC of wildlife species given the presence of wildlife habitats and KECs. The broad-scale, basin-wide nature of the current work, however, focused on the wildlife-habitat types, but neither

Table III.C.1

Number	KEC	Definition
1.1.1.2	down wood	in riparian areas direct use during overbank floods; recruitment from riparian to channel over time; role of wood in shaping channel structure
2.1.2.1	predation	introduced fishes prey on juvenile salmon in freshwater (e.g., walleye, smallmouth bass)
2.1.2.2	direct displacement	competitive exclusion from foraging or reproductive habitat (e.g., smallmouth bass in tributaries)
2.1.2.4	other	disease originating from introduced fishes
2.2.1	mountain pine beetle	positive relation--down wood recruitment
2.2.2	spruce budworm recruitment	positive relation--direct food source and down wood
2.2.3	gypsy moth recruitment	positive relation--direct food source and down wood
2.3	beaver/muskrat activity	positive provides habitat structure short & long term
2.4	burrows	positive provides habitat structure short & long term
4.1.1	dissolved oxygen	positive relation--strict requirements
4.1.2	water depth	positive association with deeper waters
4.1.3	dissolved solids	association with high-to-intermediate values
4.1.4	water pH	association with intermediate values
4.1.5	water temperature	negative--requirement & association with coldest available waters
4.1.6	water velocity	association with intermediate values
4.1.7	water turbidity	negative--growth and survival decline as function of concentration and duration
4.1.8	free water (derived from any source)	positive
4.1.9	salinity and alkalinity	association with high-to-intermediate values
4.2.1	oxbows	positive--preferred habitat for rearing stages
4.2.2.1	intermittent	occasional use but overall negative association
4.2.2.2	upper perennial	positive--frequent use
4.2.2.3	lower perennial	positive--heaviest use
4.2.3.1	open water zone	positive seasonal heavy use
4.2.3.2	submerged/benthic	positive seasonal heavy use
4.2.3.3	splash zone/periodically flooded	positive seasonal heavy use (during peak flows)
4.2.4.1	rocks	positive association
4.2.4.2	cobble/grave	strong positive association all life stages
4.2.4.3	sand/mud	generally negative association most life stages
4.2.5.1	submergent vegetation	occasional positive association
4.2.5.2	emergent vegetation	occasional positive association
4.2.6	coarse woody debris in streams and rivers	positive association (cover, food supply, habitat-shaping element)
4.2.7	pools	positive association (cover, etc)
4.2.8	riffles	generally negative association
4.2.9	runs/glides	positive association
4.2.10	overhanging vegetation	positive: cover, food source, indicator for complex, stable channels
4.2.11	waterfalls	negative -- movement barriers
4.2.13	seeps or springs	strong positive association in most life stages
4.6	lakes/ponds/reservoirs weak	positive association
4.6.1.1	open water zone	use by some life stages
4.6.1.2	submerged/benthic	use by some life stages
4.6.1.3	splash zone/periodically flooded	use by some life stages

4.6.2.1	rocks	use by some life stages
4.6.2.2	cobble/gravel	use by some life stages
4.6.4.1	ponds (<2 ha)	use by juvenile rearing life stages
4.6.4.1	lakes (>2 ha)	use by juvenile rearing life stages
4.7.1	riverine wetlands	use by juvenile rearing life stages
4.7.2.1	forest	use by juvenile rearing life stages
4.7.2.2	non-forest	use by juvenile rearing life stages
4.9	seasonal flooding	use by juvenile rearing life stages
5.1.3	nearshore subtidal	use by all marine life stages
5.1.4	pelagic	use by all marine life stages
5.3.1	protected	use by all marine life stages
5.3.2	semi-protected	use by all marine life stages
5.3.3	partially exposed	use by all marine life stages
5.4.2	kelp	use by all marine life stages
5.5.1.1	fronts (e.g. tide rips and confluence zones)	use by all marine life stages
5.5.2	euphotic zone	use by all marine life stages (visual foragers)
5.6	water temperature	negative (prosper in coldest conditions)
5.8.4	delta	positive association (food supply, physiological transition zone)
5.8.6	lagoon	positive association (food supply, physiological transition zone)
5.8.7	salt marsh	positive association (food supply, physiological transition zone)
5.8.8	reef	positive association (food supply, physiological transition zone)
5.8.9	tidal flat	positive association (food supply, physiological transition zone)
8.5	diseases transmitted by domestic animals	negative effect of hatchery-origin fish and aquaculture facilities
8.12.1	herbicides/fungicides	negative effect-high sensitivity to low exposures (lethal and sublethal effects documented)
8.12.2	insecticides	negative effect-high sensitivity to low exposures (lethal and sublethal effects documented)
8.12.3	pesticides	negative effect-high sensitivity to low exposures (lethal and sublethal effects documented)
8.12.4	fertilizer	negative effect through toxicity or through eutrophication
8.16	culverts	negative -- partial or complete migration barriers
8.17	irrigation ditches	negative -- movement barriers, mortality sinks
8.19.3	water pollution	negative -- manifold effects on survival/growth/behavior
8.22	bulkheads, seawalls, revetment	generally negative, simplifies habitat structure
8.23	jetties, groins, breakwaters	generally negative, simplifies habitat structure
8.24	water diversion structures	negative, movement barrier population sinks
8.28	hatchery fish releases	generally negative, adverse effects on growth, survival, behavior, and genetic basis for local adaptation, and often stimulates predation pressure

* Number codes refer to the classification system for KEFs or key ecological functions, as shown in Table 1 - Section 3.3
** Source: C. Frissell, pers. Comm.

Table III.C.1

Table III.C.2 Management Activities linked to KECs.

I. FIRE MANAGEMENT
- A. Suppressing wildfire
- B. Low to moderate intensity burns
- C. High intensity burns
- D. Fire (in general)

II. FRESHWATER WETLAND, RIPARIAN, AND AQUATIC RESOURCE MANAGEMENT
- A. Creating and maintaining impoundments
- B. Controlling water levels
- C. Creating/maintaining islands or rafts within impoundments
- D. Draining wetlands, marshes, ponds, lakes
- E. Increasing water supply
- F. Decreasing water supply
- G. Burning wetlands to maintain successional stages
- H. Restoration of wetlands
- I. Wetland management techniques
- J. Flooding fields and wetlands
- K. Removing riparian vegetation
- L. Livestock grazing of riparian areas
- M. Adding coarse woody debris and boulders to streams and rivers
- N. Removing coarse woody debris from streams and rivers
- O. Restoring/maintaining beaver populations
- P. Retaining riparian buffer strips
- Q. Armoring banks for erosion control
- R. Controlling sedimentation by revegetation of banks with grass-sedge-forb mixtures
- S. Controlling water pollution
- T. Disposing/assimilating wastewater
- U. Dredging
- V. Locating/constructing stream crossings
- W. Controlling aquatic plants
- X. Chanelization

III. ROAD MANAGEMENT
- A. Road construction and obliteration
- B. Operational aspects of road maintenance and use
- C. Road closures
- D. Bridges (in general)
- E. Roads (in general)

IV. AGRICULTURAL ACTIVITIES
- A. Applying fertilizers
- B. Applying pesticides
- C. Applying herbicides
- D. Applying fungicides
- E. Haying/mowing
- F. Maintaining grasses and forbs within orchards, Christmas tree farms vineyards etc.
- G. providing/maintaining vegetation along field and ditch margins
- H. Retaining crop residue
- I. Implementing farmland conservation programs
- J. Irrigating

K. Altering drainage
L. Decreasing water supply - flow withdrawal
M. No-till farming/minimum till farming
N. Clean farming
O. Strip intercropping
P. Conversion of native habitats
Q. Control of vertebrates considered to be agricultural pests
R. Providing artificial nesting sites
S. Agriculture (in general)

V. SHRUBLAND AND GRASSLAND MANAGEMENT
A. Mechanical vegetation management
B. Burning
C. Using herbicides
D. Restoration
E. Conversion of shrubland to native or non-native grassland
F. Livestock grazing
G. Shrubland management (in general)
H. Grassland management (in general)

VI. LIVESTOCK MANAGEMENT
A. Livestock grazing
B. conversion of shrubland to native or non-native grassland
C. Creating or providing stockponds
D. Excluding livestock from riparian areas

VII. FENCING
A. Fencing to control or direct wildlife access
B. Fencing to product or restore habitat
C. Fencing to excluding livestock from riparian areas

VIII. MINING ACTIVITIES
A. Site reclamation
B. Surface/strip mining and processing
C. Underground mining and processing
D. Maintaining access to abandoned subsurface mines and tunnels
E. Placer prospecting and mining
F. Mineral exploration
G. Sand/gravel (aggregate) and peat mining
H. Mining (in general)
I. Mining activities involving blasting
J. Oil and gas extraction

IX. FOREST MANAGEMENT
A. Harvest Operation Activities:
1. Clearcutting
2. Shelterwood cuts
3. Seed tree cuts
4. Group selection
5. Selective harvest across all tree sizes
6. Selective harvest of specific sizes or conditions or species
B. Silvicultura/Stand Improvement Activities:

1. Pre-commercial thinning
2. Commercial thinning
3. Pruning
4. Simplifying species composition and/or structure
5. Type conversion
6. Prescribed burning
7. Applying insecticides
8. Forest management (in general)

C. Site prep/Tree Establishment Activities
1. Applying herbicides
2. Fertilizing plantation
3. Removing slash
4. Planting or seeding for reforestation
5. Tilling prior to planting

D. Habitat Management Activities
1. Maintaining mature/old growth
2. Grazing livestock
3. Retaining medium-sized green trees
4. Retaining large green trees
5. Retaining trees with defects
6. Creating/maintaining edges
7. Retaining mast trees
8. Retaining forest openings
9. Developing/maintaining brush/slash piles
10. Retaining/providing dead/down wood
11. Retaining/creating snags
12. Retaining riparian buffers
13. Providing artificial nest sites
14. Creating/maintaining corridors

E. Incidental Activities:
1. Introducing exotic vegetation
2. Creating water sources
3. Removing hazard tries
4. Building skid roads and landings
5. rest vertebrate pest control

F. Special Forest Products
1. Firewood cutting
2. Harvesting wild mushrooms
3. Bough collection
4. Special forest products (in general)

X. MARINE ACTIVITIES

A. Marine dredging and filling
B. Harbor, marina, and ferry terminal development
C. Residential docks in marine and freshwaters
D. Toxic spills in fresh and saltwater
E. Marine shoreline armoring
F. Developing underwater marine structures
G. Marine fisheries
H. Aquaculture

XI. URBAN DEVELOPMENT

A. Paving
B. Building houses and businesses
C. Owning domestic animals
D. Urban aquatic habitat management
E. Landscaping and vegetation management
F. Water quality and stormwater management
G. Establishing/maintaining greenways/greenbelts

XII. RECREATIONAL ACTIVITIES
A. Trail use and camping
B. Snowshoeing/snow skiing/sledding
C. Mountain/rock climbing
D. Motorized boating
E. Non-motorized boating
F. Swimming
G. Off-road driving
H. Snowmobiling
I. Aircraft use
J. Recreational developments

XIII. RIGHT-of-WAY MANAGEMENT
A. Utility Corridors

Table III.C.2 Management Activities linked to KECs.

their structural conditions nor the presence of specific KECs. Such refinement is left to the next step in which more spatially-refined subbasin analyses are conducted.

To evaluate potential occurrence of ecological functions by 6^{th} HUC, we linked wildlife species (predicted present based on their wildlife habitat associations) to their KEF categories to determine which functions could be provided. This database query listed the number of wildlife species (functional redundancy) for each combination of KEF category and wildlife habitat type, occurring within each 6^{th} HUC. We used the percent of each 6^{th} HUC occurring in each wildlife habitat type as a weighting factor for functional redundancy, for each KEF category, thereby calculating a 6^{th} HUC-wide weighted estimate of functional redundancy for each KEF category. It was this weighted value of KEF functional redundancy that we then used for mapping KEF functional redundancy conditions for historic, current, and future states, and for mapping changes in such conditions among time periods.

Although the resolution of these maps was the 6^{th} HUC level, we strongly suggest viewing results at larger geographic areas, such as province and basin-wide levels. Also, at the finer, subbasin scale, incorporation of KECs and structural conditions of wildlife habitats would greatly help refine this functional analysis by providing a more precise description of environmental conditions by which to predict species presence.

Influence of Fish Habitats and KECs on Wildlife Populations

A number of wildlife species are associated with aquatic and riparian habitats and KECs that influence fish. Examples include most amphibian species, marine and freshwater aquatic and semi-aquatic mammals (such as whales, mink, and river otter), and many aquatic and semi-aquatic birds (such as many shorebirds, ducks, geese, and others) that feed on aquatic macroinvertebrates. For instance, the SHP database, in fact, lists 135 wildlife species that associate with some type of freshwater riparian or aquatic body, and that feed on freshwater aquatic macroinvertebrates. Other wildlife species also influenced by fish KECs include wildlife species associated with flowing streams, stream temperature, stream and lake substrates, macrophytes and submergent vegetation, and other environmental factors.

The main purpose of highlighting this type of interaction is to be able to list wildlife species potentially benefited when providing for fish habitat conditions. Ultimately, we propose depicting habitat types, habitat structures, and key environmental correlates jointly for fish and wildlife under a combined classification system.

KECs (Habitat Elements) Shared by Fish and Wildlife

Managers of natural resources in the Columbia Basin have recently been discussing the need to incorporate fish and wildlife habitat components into a common format for evaluation or assessment. We address this need by using the KECs (habitat elements) as a basis to integrate our depiction of fish and wildlife habitat components. The process of combining fish habitat attributes into the list of wildlife KECs has been started for Chinook salmon and bull trout. Fisheries ecologists in the EWG identified 74 KECs used by various life history stages (Table III.C.1). This was a pilot effort to demonstrate the feasibility of bringing fish and wildlife habitat information together. Proposed Framework efforts include efforts to expand this work by identifying KECs of all resident and anadromous fish species in the Columbia Basin by various life stages.

Once the list of KECs is expanded to include additional species of fish, then managers will be able to evaluate management strategies using a common set of variables for fish and wildlife. While this is seemingly a small step forward, it allows managers to determine how proposed land management activities, under a specific planning alternative, can affect the KECs listed in Table III.C.1 and thereby influence both salmon and wildlife associated with those elements. We demonstrated this assessment approach by querying databases listing management activities (Table III.C.2) associated with a given management activities or alternative strategy. We then listed KECs influenced by those management activities, and then we identified which species of fish and wildlife are associated with those KECs. Once knowing which species are involved, the key ecological functions (KEFs) for fish and wildlife can be jointly assessed. In this way, ecosystem functional diversity and functional redundancy can be described for all vertebrate species in the basin in a common assessment.

Influence of Populations on Themselves

In some cases, fish or wildlife populations can have an influence on themselves. Such influence can take the form of density-dependent demographic relations as are depicted in traditional Ricker recruitment curves or Beverton-Holt functions. The wildlife analogue to this is found in population models represented by logistic equations, in which changes in population size occur as a function of population carrying capacity. Other influences may manifest through the effects of functional roles (KEFs) on habitat attributes and conditions, such as salmon changing the substrate structure of spawning gravel and thereby altering the capacity of the environment for spawning. Although we have not specifically modeled such within-species effects, they nonetheless might prove salient in some cases, and are worth noting.

Influence of Populations on Other Populations

Another class of interactions between fish and wildlife populations is how organisms can affect other species directly. Examples include predator-prey relations and competition for resources or space.

Influence of Fish Populations on Wildlife Populations

One of the major ways that fish populations can directly influence wildlife populations is through wildlife predation on fish, that is, as fish serving as prey for wildlife. We analyzed this in two ways: general patterns of wildlife predation on salmon, and wildlife species-specific use of salmon carcasses as an example of a more in-depth type of wildlife population analysis that can be done. The focus here is on affects on (benefits to) wildlife.

We analyzed how each of five salmon life stages serves as potential food for wildlife species. The SHP database depicts use of salmon life stages according to combinations of the six degrees of association (strong and consistent, recurrent, indirect, rare, unknown, and no relationship) and the five salmon live stages. We tallied number of wildlife species according to combinations of association and stage. Some wildlife species may have different degrees of association with different salmon life stages, and feed on more than one salmon life stage.

Influence of Wildlife Populations on Fish Populations

In some cases, wildlife populations might directly affect fish (salmon) populations through predation. Examples may include predation on rearing and saltwater stages of salmon by Caspian terns. In many cases, actual effect on fish population size, trends, and vital rates from such predation is unknown and unstudied, although such effects are sometimes viewed as important.

Recently, a comprehensive effort was undertaken to determine what wildlife species in Oregon and Washington have a relationship with salmon. A literature review conducted on this topic indicated a general lack of information on the relationship between the 605 species of wildlife that occur in the region and their use of salmon. Wildlife and fish species experts were contacted to address this lack of published knowledge about salmon use by wildlife. These experts were asked to address use of the five life stages of salmon as providing direct or indirect forage for wildlife species occurring in terrestrial, freshwater, estuarine, or marine environments. The life stages include incubation (eggs and alevin), freshwater rearing (fry, fingerling, parr), saltwater (smolts, immature adults, adults), spawning (adults), and carcasses. The strength of the relationships were also identified and classified as: strong and consistent, recurrent, indirect, rare, unknown, and no relationship. The results from the comprehensive effort are reported in Cederholm et al. (2000).

Future evaluation of fish and wildlife interactions will build on the relationships documented in Cederholm et al. (2000). We anticipate that future reports will discuss: disease transmission between fish and wildlife; fish-fish interactions (e.g., salmon subject to predation by small mouth bass) that could influence wildlife; fish habitat influences on wildlife; wildlife functions that influence habitat of fish; and wildlife functions that are affected by salmon predation.

Influence of Populations on Habitats and KECs

Another type of interaction influence is that of how the ecological roles of organisms might alter KECs and habitat elements of other species. This includes how fish can alter KECs for other fish, and how wildlife can alter KECs for fish. Other combinations are also possible, but we considered these as the most salient for broad-scale interpretation.

Influence of Fish Populations and KEFs on Fish Habitats and KECs

The behavior of some fish might influence the habitats and KECs of other fish species. One example is how bottom-dwelling and –feeding fish such as carp can roil the substrate, reducing capability of the environment to support other organisms such as rooted submergent vegetation along with the attendant aquatic macroinvertebrates such vegetation can support. In turn, other invertebrate-feeding fish species may become reduced as well. Bottom roiling can also directly change the physical texture, potentially reducing spawning or feeding substrates for other species. Other fish-KEC interactions also likely occur.

Influence of Wildlife Populations and KEFs on Fish Habitats and KECs

In some cases, the ecological roles of wildlife organisms can influence habitat elements and KECs for fish. We are exploring this type of relation in greater detail, as it may provide to be a salient basis for an integrated approach to fish and wildlife habitat management.

One example is how some wildlife species might change the riparian and aquatic environments, altering specific KECs for fish such as salmon. For instance, American beaver, nutria, and several other wildlife species have the ecological role of creating aquatic structures, such as dams and lodges, which can alter stream flow and change stream morphology and stream substrates. In particular such changes might serve to alter several KECs of importance to salmon, notably degree of gravel embeddedness, temperature spatial variation, variation in channel width, and daily variation in stream flow rates. These are fish KECs recognized in the EDT model as of particular importance to salmon. A number of other wildlife KEFs and relations to fish KECs can be identified using the SHP database.

Although our broad-scale modeling does not yet quantitatively integrate such wildlife influences on fish KECs, our analysis sets the stage for such consideration and analysis at finer levels of spatial resolution. To this end, we have crafted an operational prototype of a Bayesian belief network to exemplify how such effects can be modeled, using the example discussed above (Figure III.C.2).

Influence of Planning Alternatives and Management Activities on Habitats

The major way in which management activities can influence fish and wildlife, as considered in this report, is through their effects on fish and wildlife habitats and KECs. Such effects can be depicted by using the SHP databases and EDT models. For example, we listed the wildlife KECs pertaining to species that can have major influence on fish KECs, and then determined the set of management activity categories that could influence such wildlife KECs. In this way, we can provide general information on which categories of management activities might have the greatest influence on the largest number of wildlife and fish KECs that, in turn, can have various interaction influences.

Changes through Space and Time

Finally, all the above influences and interactions should be viewed as potentially changing through space and time. Changes through space entails knowing how conditions in one location directly or indirectly cause changes in other locations, such as downstream effects of upstream changes in upland and riparian vegetation cover. At present, our Framework analysis deals with such effects either not at all, as with our wildlife habitat and functional analyses, or only indirectly, as with the EDT modeling analyses.

Modeling time-dynamic changes is difficult and for this broad-scale Framework we have focused on three time periods: the historic condition (roughly indicating potential historic conditions), the current condition, and future potential conditions under each of the three scenarios we explored. As the Framework is applied to more local scales, analyses should be run to determine some transition periods among these three major conditions as well.

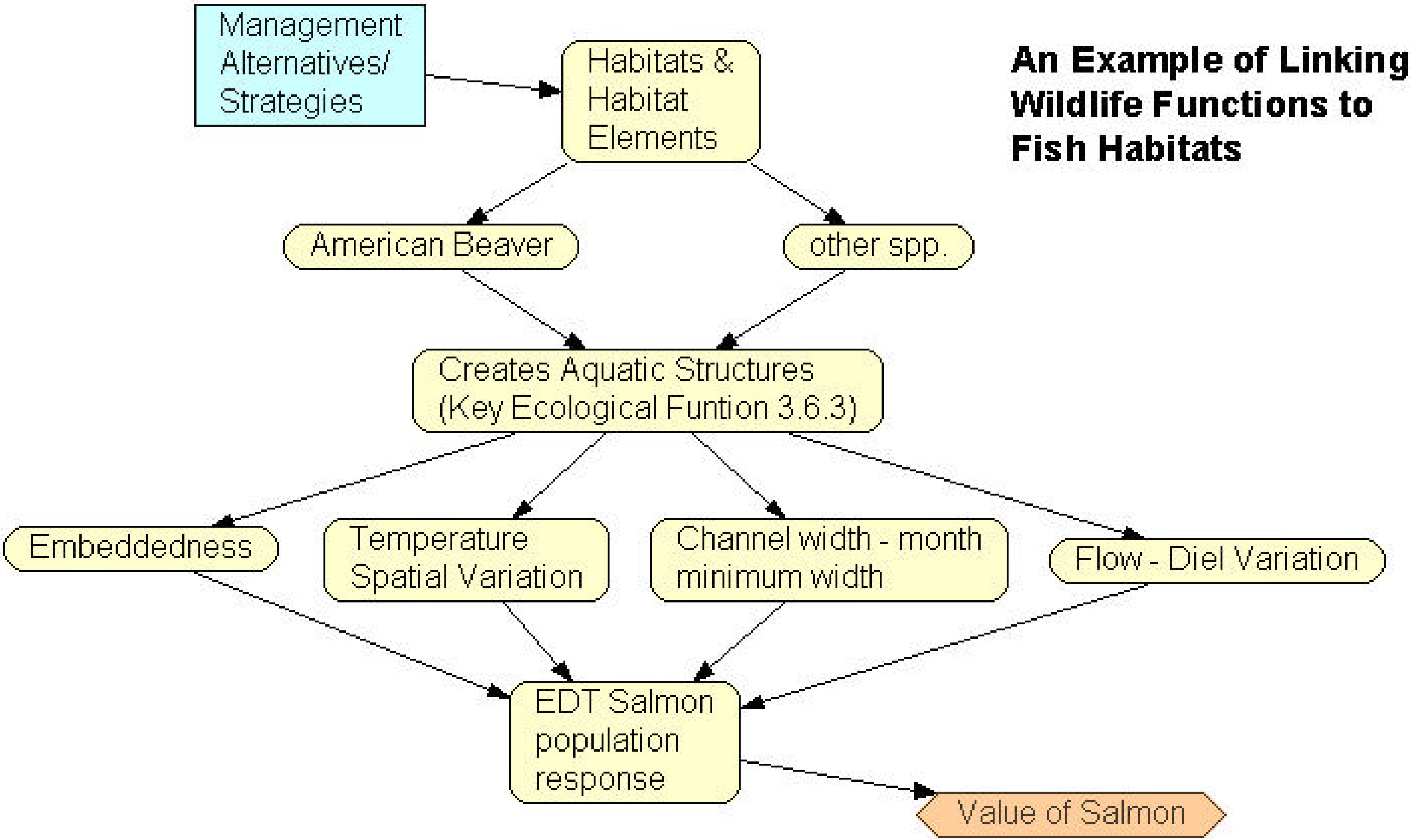


Figure III.C.2 An example of linking wildlife functions to fish habitats.

METHODS - ADDRESSING UNCERTAINTY

This section of the Methods addresses uncertainty; it is organized as follows:

Uncertainty and Use of a Scientific Approach

Uncertainty as Handled in this Report

Worldviews

Uncertainty and use of a Scientific Approach

The Framework utilizes two streams of science (sensu Holling 1996). The first stream (reductionist) is a science of parts whereby specific experiments are conducted to assess specific questions and processes that effect specific variables and to address null hypotheses with "either/or" outcomes. Information from this level is used (when data are available) to describe the ecological attributes (i.e., key environmental correlates) and change/trends in the Columbia Basin. The goal of this level of science is to narrow (e.g., using brief time frames and small areas) the focus of the experiments and resulting information to the point that uncertainty is reduced to an acceptable level and that most peers will agree on the resulting conclusions. A problem with using this focused approach within an ecological context is that once a piece (i.e., small area within the basin) is pulled out and studied and null hypotheses accepted or rejected, there is a tendency to extrapolate the findings to the entire basin without integrating findings from adjacent small areas.

The second stream of science used in the Framework is the integration of parts (Holling 1996). Scientific evaluation at this level occurs not by conducting specific experiments but by synthesizing information from unplanned as well as planned interventions in the whole system or by comparing and contrasting extreme examples. Challenges by peers are important at each step of the process (agreement among peers is probably the exception rather than the rule). These challenges are based on multiple lines of evidence (versus experimental results).

The purpose for using the second stream of science in the Framework process is to gain a basic understanding of how the ecological system functions and how it might respond to proposed alternatives. These are difficult to impossible to fully analyze for the entire array of environments in the Columbia Basin using only traditional experimental approaches.

These two streams of science relate across spatial scales (Figure III.D.1). The reductionist approach to science is practiced at the 6-HUC or smaller area. At this scale, environmental attribute data are most often described with a variance term using conventional statistical tools. Due to an initial lack of data (much less variance of data) across the basin, analyses are (at first) deterministic. The holistic approach of the second stream of science integrates information across landscapes, land ownerships, and subbasins, up to the basin or province, and synthesizes information from different sources, experts, and studies, where available. The second stream of science addresses questions and hypotheses that are related to patterns across the basin or province (e.g., how much habitat enhancement is required to improve chinook productivity at the province level by 10 percent?).

The Framework does not solely follow either stream of science. It is conceived and designed to address questions across the hierarchical levels simultaneously, so that knowledge of, and actions pertaining to, each level in the hierarchy is used in context of other levels. Thus data collection and analysis methods are coordinated with levels above and below. The process of coordinating data, analysis rules and language across levels is difficult. Resolving these difficulties takes time and effort to communicate. There are many possible benefits for addressing these difficulties. The benefits of taking an adaptive assessment approach to solve these difficulties (as illustrated in Figure III.D.1) are: (1) Increased system understanding passing through to the lower levels of the hierarchy and (2) Increased statistical rigor (i.e., attention to bias when estimating environmental attributes and to experimental error, sensu Karl et al. 2000) when collecting data at specific sites for testing basin-scale questions and hypotheses.

As the Framework is implemented, uncertainty associated with environmental parameters can be quantified and estimated as variances in their values in specific geographic and ecological contexts. Such estimates can be aggregated (i.e., step up the spatial hierarchy) to address hypotheses formulated during the Framework analyses presented in this report. Understanding of the whole system gained from the first Framework analysis will step down to provide an understanding of how the fuller system might function at the scale of smaller areas (6-HUCs) of the basin. This process of increasing statistical rigor at the basin and province scales, and increasing understanding of the system at the

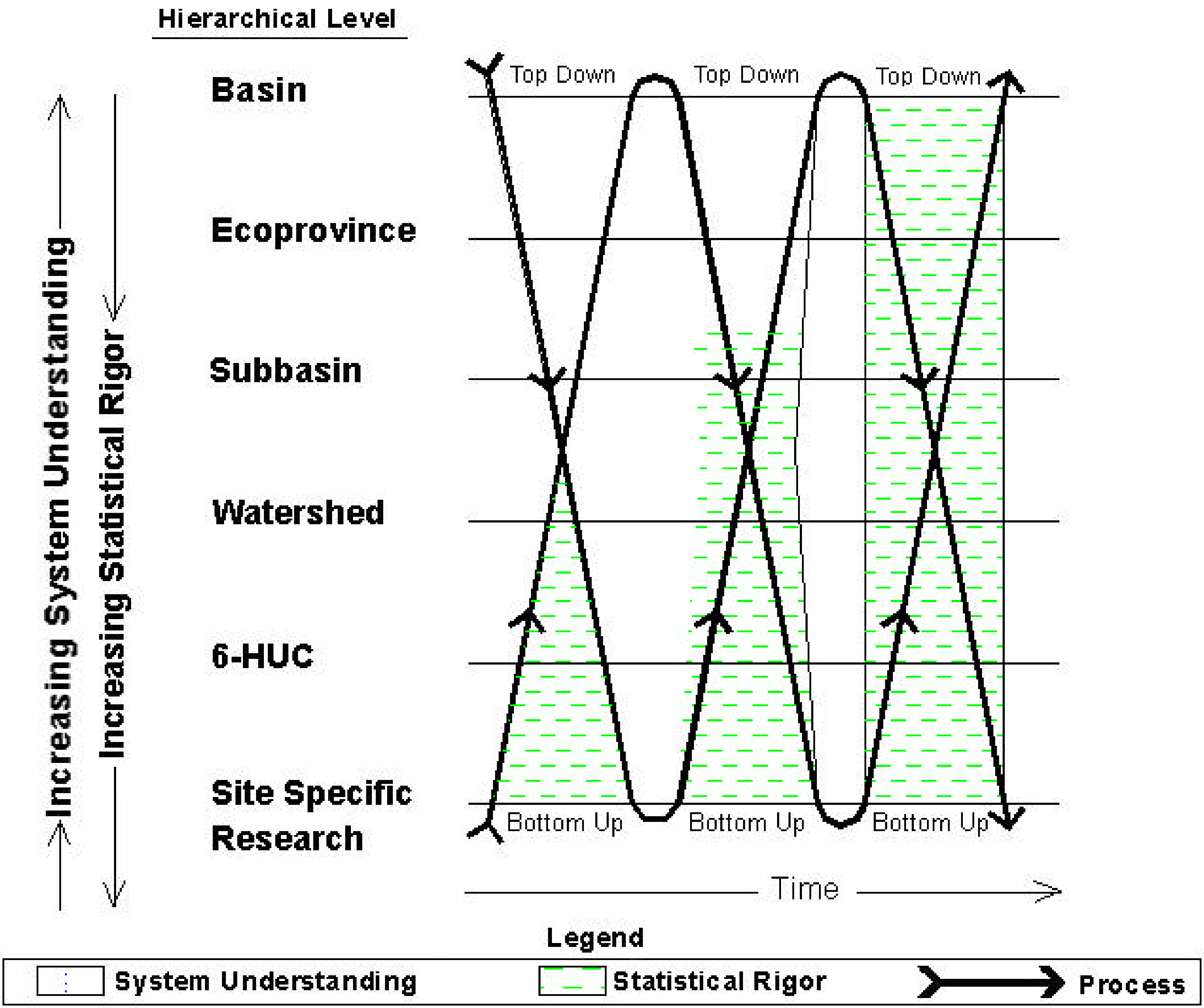


Figure III.D.1 The Framework is both top down and bottom up. It is conceived and designed to address questions across the hierarchical levels simultaneously, with information gained at each level in the hierarchy used at the other levels, and the coordinating of data collection and analysis methods across levels. The process of coordinating data, analysis rules, and language across levels is difficult. Resolving these difficulties takes time and effort to communicate. There are many possible benefits for addressing these difficulties. The benefits illustrated in this figure increase through time and are: 1) Increased understanding of how the system works at the lower levels, by passing through to the lower levels of the hierarchy and 2) Increased use and inference from traditional statistical tools applied at lower levels, allowing analysis of data and rules from specific sites to be applied at the top levels.

subbasin and 6-HUC scales, actually pertains to many activities that improve learning through time. This is part of adaptive management in the sense of Holling (1978) and Walters (1997).

Adaptive management in the Framework process addresses uncertainty for both levels of science by: (1) Defining questions and goals, (2) Stating working hypotheses via working models that clearly articulate assumptions and predictions, (3) Implementing management actions and research to address uncertainty, by devising management as science experiments, and (4) Monitoring and interpreting the results of management actions (Figure III.D.2). If this process determines that assumptions are met or addressed and world view analyses provide the explicit comparisons that contribute to the decision making process, the process ends with using the answers to the questions to reaffirm or revise current management direction. If monitoring cannot or does not allow assumptions to be adequately addressed or if worldview analyses are not explicit, re-evaluation will be necessary and one should enter the adaptive management evaluation process again (Figure III.D.2). Re-evaluation might involve collection of data to address uncertainty associated with environmental attributes and Bio-rules, reformulating questions or modifying worldviews or alternatives. As the Framework process started we, as others (Karieva et al. 2000), realized data was lacking by which to parameterize a stochastic model for the whole basin. As a consequence, our model runs are designed to be deterministic. Results from our deterministic analysis are not meant to appear certain. They are meant to be the basis for formulating hypotheses about how the information from small 6-HUCs can be integrated to answer holistic questions.

In summary, we propose, in this Framework, that scientific uncertainty be addressed by using an adaptive assessment and management process. Uncertainty for both streams of science will be addressed as the Framework is applied so that when change is detected at the local level, it can be related to and understood in the context of the whole, evaluated, and turned into action to evaluate management guidelines designed to maintain or restore desirable ecosystem functions.

Uncertainty as Handled in this Report

The Ecological Work Group of the Framework determined that data were not available by which to parameterize a stochastic model to assess the proposed alternatives at the basin and province levels. The EDT and HCI models were run in a deterministic mode and as such do not explicitly address uncertainty (variability) for the first stream of science (that

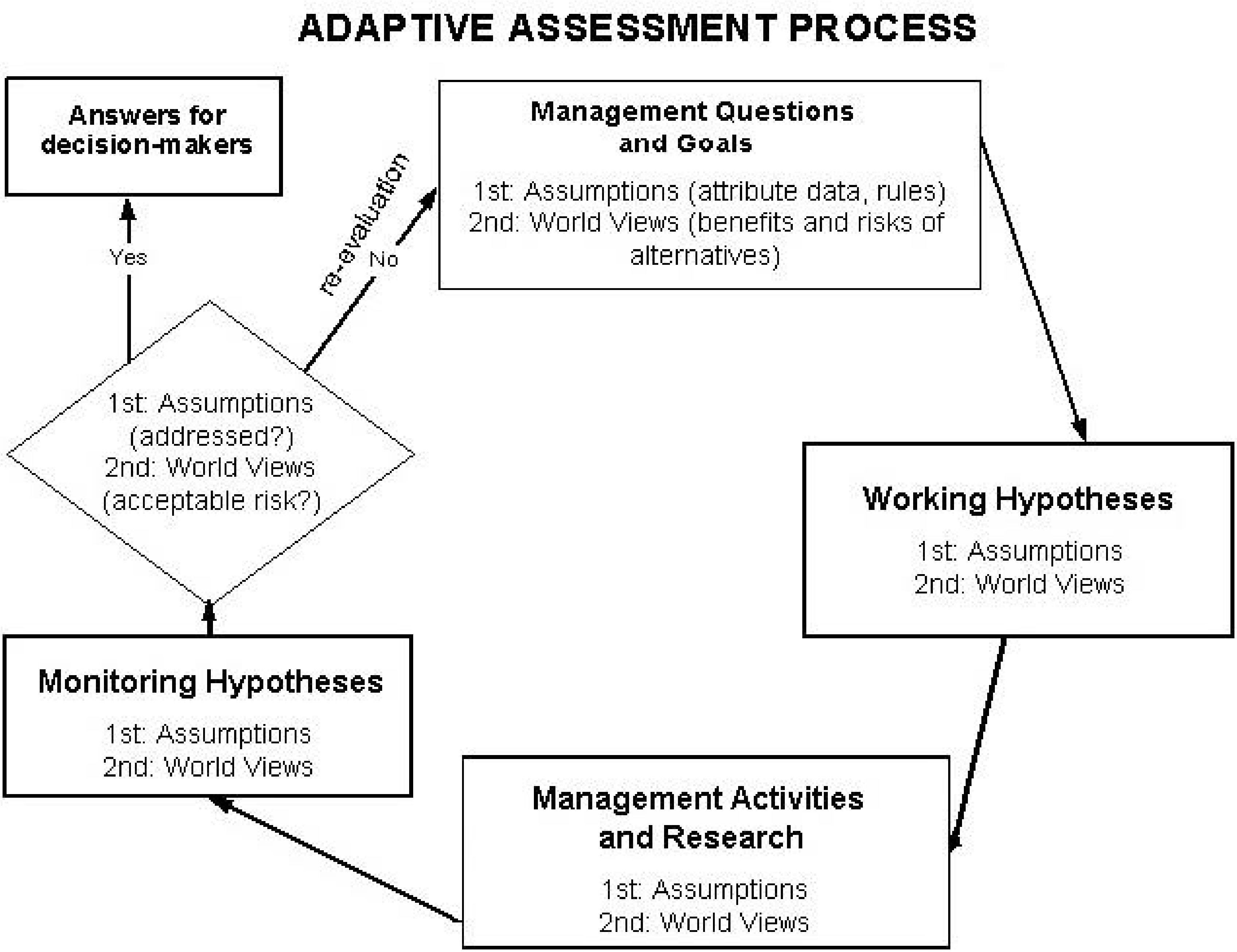


Figure III.D.2 The Framework proposes to address the uncertainty of the 1st and 2nd streams (sensu Holling 1996) of science via an adaptive assessment process that will integrate information across scales through time. Each step of the adaptive assessment process address the assumptions (e.g., EDT rules) associated with the 1st stream, and the World Views associated with the 2nd stream of science.

addresses local conditions. Uncertainty for the first stream of science will be addressed by incorporating more attention to variance and explicitly uncertainty as the Framework process moves forward. Uncertainty associated with the second stream of science – that is, uncertainty over how the entire system as a whole is thought to function – is addressed for each of three Framework alternatives by use of the concept of world views. The three Framework alternatives examined in this report describe three different future visions (based on three different world views) for fish and wildlife management in the Columbia River Basin. The analyses of world views pertain to chinook issues and as such do not address wildlife and fish / wildlife analyses conducted for the alternative analyses. The wildlife analyses at this phase of the Framework are intended to be illustrative of how populations and functions could be addressed at the subbasin level.

Inherent in each of the world views is a set of assumptions about the way the world works. Because our knowledge of these assumptions is imperfect, there is uncertainty as to the overall fish and wildlife benefits each alternative may provide.

Our analyses examine the elements of uncertainty and risk by evaluating each alternative and determining the maximum benefit and risk resulting from its implementation. Benefits and risks vary by world view. Maximum benefit is achieved when all of the critical assumptions inherent in the world view represent correct guesses about how the biological systems truly operate and respond to human activities. The maximum risk is the outcome when these same assumptions are all wrong. The purpose of this section is to present an assessment of the uncertainty and risks inherent in the three alternatives. We describe how the alternatives perform under two opposing worldviews, which we refer to as Technology Optimistic and Technology Pessimistic. We present a third worldview, Moderate, which shows an intermediate position that reflects likely outcomes when only a portion of the assumptions inherent in the Technology Optimistic and Technology Pessimistic worldviews actually represent the true State of Nature (Table III.D.1).

In Table III.D.2 we show how each of the alternatives should perform in relation to the worldviews based on the assumptions inherent in each alternative. Each of the three alternatives were analyzed under each of these three world views, resulting in nine analysis outcomes. The range of analysis outcomes represents, in a sense, the spread of expected results under the various world views they represent, that is, the uncertainty of how the world and its biological systems operate.

	Alternative 2	Alternative 5	Alternative 6
If *Technology Optimistic* worldview is true	Outcome for Alt 2 if “TO” is true	Outcome for Alt 5 if “TO” is true	Outcome for Alt 6 if “TO” is true
If *Moderate* worldview is true	Outcome for Alt 2 if “M” is true	Outcome for Alt 5 if “M” is true	Outcome for Alt 6 if “M” is true
If *Technology Pessimistic* worldview is true	Outcome for Alt 2 if “TP” is true	Outcome for Alt 5 if “TP” is true	Outcome for Alt 6 if “TP” is true

Table III.D.1 Analysis matrix for the three worldviews.

	Alternative 2	Alternative 5	Alternative 6
If *Technology Optimistic* Worldview is true	Worst Case	Worst Case	Best Case
If *Moderate Worldview* is true	Intermediate	Intermediate	Intermediate
If *Technology Pessimistic* Worldview is true	Best Case	Best Case	Worst Case

Table III.D.2 Analysis performance matrix for the three alternatives by worldview.

Alternative 2 and 5 should perform best under the Technology Pessimistic worldview because they depend least on technology for successful performance, and Alternative 6 should perform best under the Technology Optimistic worldview because it depends most on technology for successful performance, where performance refers to future size and trend of chinook salmon populations.

However, our real interest in how we deal with uncertainty lies in how the alternatives perform when we guess incorrectly about how the world and its biological systems operate. For Alternatives 2 and 5, this occurs when we implement either alternative and discover later that the Technology Optimistic worldview was more accurate. For Alternative 6, the worst-case scenario results when we implement the alternative and eventually determine that the Technology Pessimistic view of the world was more accurate. As in life, we would like to choose an option that performs well even when we are wrong about a number of key assumptions.

In the following subsection we present the results of the worldview analysis.

Worldviews

The results of the worldview analysis presented in this section show chinook production potential (abundance) by alternative and worldview, at the basin scale (Figure III.D.3).

- The data presented in III.D.3 show that at the basin level Alternative 2 might be expected to outperform the other alternatives.
- As expected, Alternative 2 performs best under the Technology Pessimistic worldview and poorest under the Technology Optimistic view. However, even under the worst case condition (Technology Optimistic) Alternative 2 produces a larger increase in chinook abundance than any other alternative (within worldviews).
- Alternative 2 produces the highest benefits when it is assumed that juvenile transportation is ineffective, in-river survival rates are low, ocean nearshore survival is high, and hatchery fish fitness and post-release survival are low.
- Because the increase in chinook abundance for Alternative 2, under the worst case scenario is greater than the best-case scenario for the other alternatives, there is less risk and uncertainty associated with the selection of this alternative (at least with regard to producing more

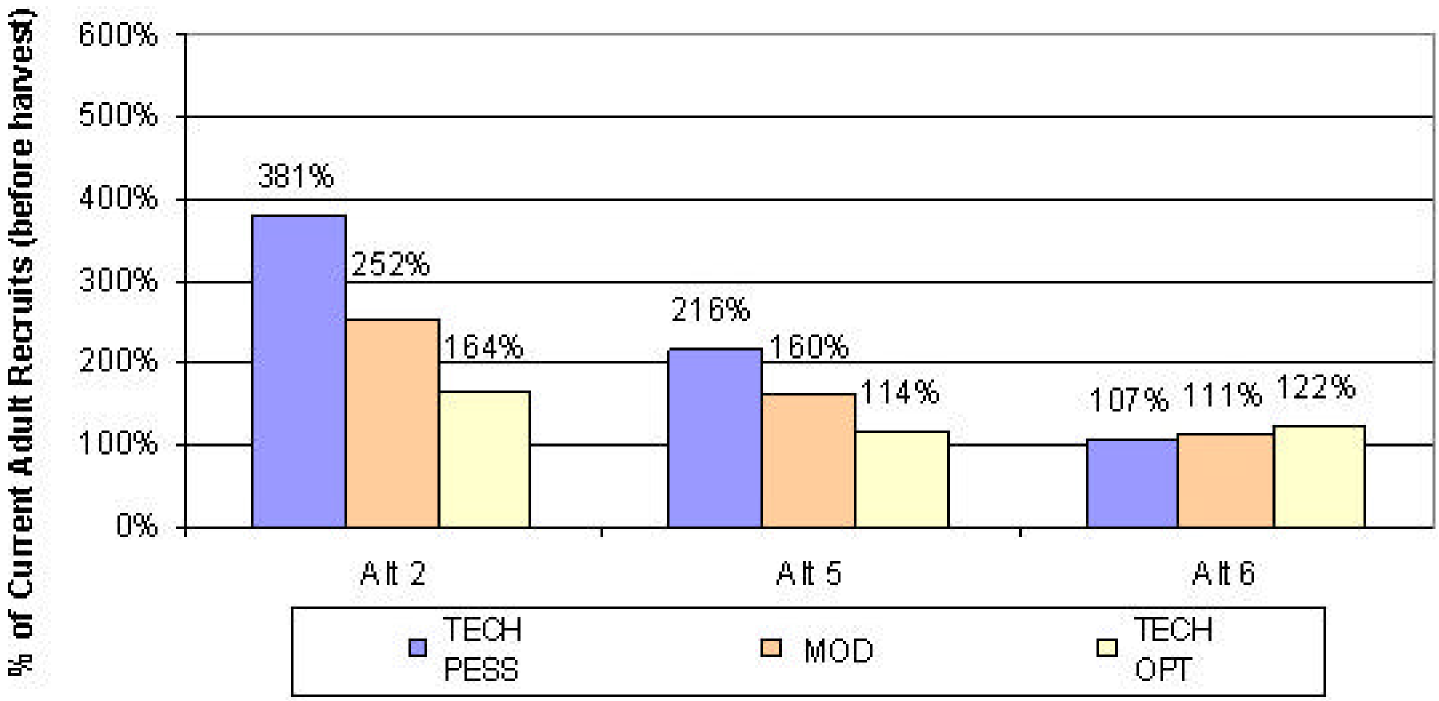


Figure III.D.3 Total chinook production potential by alternative expressed as a percentage of the Current Potential, under the three world views.

chinook). Under the best-case scenario (all assumptions are true) chinook abundance may increase by as much as 381 percent; under the worst case, 164 percent.

- The cost of implementing Alternative 2 has been estimated at ~$765 million a year. In contrast, the cost of implementing Alternative 5 and Alternative 6 has been estimated at $390 million and $210 million, respectively. Thus, to reduce uncertainty to the level shown for Alternative 2, the region must pay an additional $375–$555 million a year (CH2Mhill 2000).
- Note that all of the alternatives, regardless of worldview, increase overall chinook abundance by more than ~107 percent. Therefore, the implementation of any of the alternatives should result in a significant increase in chinook production over current. In the figures below we show that some alternatives achieve the increase through actions that emphasize natural production (Alternative 2); others through the use of hatcheries (Alternatives 5 and 6).
- Alternative 5 improves chinook production potential from 114 percent (Technology Optimistic) to 216 percent (Technology Pessimistic). This alternative performs best when it is assumed that transportation is relatively ineffective, in-river juvenile survival is low, nearshore ocean survival rates are high, and habitat restoration actions in the tributaries are effective. In fact, Alternative 5 requires the largest increase in freshwater habitat productivity of all the alternatives to produce the number of chinook shown in Figure III.D.3.
- Because dams are not removed in Alternative 5, the juvenile transportation program eliminated during the early spring and summer could be revived if research confirmed transportation survival benefits. This flexibility reduces the risk associated with guessing wrong about the transportation assumption (i.e. ineffective).
- Alternative 6 improves chinook performance by 107 percent (Technology Pessimistic) to 122 percent (Technology Optimistic). Alternative 6 is therefore relatively insensitive to the assumptions included in the worldviews. Most of the chinook production increase in this alternative is a result of improvements made in tributary habitat and hatchery fish fitness.
- Alternative 6 performs best when it is assumed that transportation is effective, ocean nearshore survival is low, hatchery fish fitness is high and habitat actions focused on the tributaries are effective in increasing freshwater productivity. In short, Alternative 6 assumes that we have, for the most part, mitigated for hydro impacts through transportation

and juvenile bypass facilities, and therefore efforts should now be focused on improving tributary habitat.

- Alternative 6 relies on the least amount of improvement in freshwater habitat productivity to achieve its objectives. Thus, there is less risk associated with Alternative 6 in regards to meeting the habitat goals embedded in the alternative in comparison to the others.
- The transportation program could be eliminated in Alternative 6 if research shows this program to be ineffective. This flexibility reduces the risk of guessing incorrectly about the effectiveness of the transportation program.
- It should be noted that in all of the alternatives it is assumed that the actions were implemented as designed. This means that dams can be removed and habitat can be improved, in some cases dramatically on both public and private lands. There is considerable risk that in the non-modeling world (i.e. real world) that some actions may be politically impossible to implement or, over time, become socially unacceptable. Thus, attempting to implement an alternative that requires significant social change may pose greater risk than one that does not.

The data in Figure III.D.3 show the percent increase over current in chinook production potential for each of the alternatives. For clarity sake, we also present the estimated number of adult chinook produced by alternative and worldview in Figure III.D.4. From the data in Figure III.D.3 we conclude:

- Total chinook production potential is less than 1,000,000 adults for all alternatives under all worldviews.
- Under their respective best case scenarios Alternatives 2, 5, and 6 produce 992,000 728,000, and 755,000 chinook adults, respectively. In the worst case scenarios, Alternative 2, 5 and 6 chinook production decreases to 898,000, 652,000 and 428,000 chinook, respectively. The point to be made is that the difference between the best case (Alternative 2) and worst case (Alternative 6) is approximately 564,000 adults. This defines the maximum reward possible for choosing the right alternative and State of Nature. Because there is good deal of uncertainty around this estimate, it is up to resource managers to decide whether doubling or halving the number would have any impact on the selection of one approach over another.

Although total chinook production may weigh heavily in the selection of a preferred alternative, a second, and probably just as important criterion, in the selection process is each alternative's reliance on natural versus

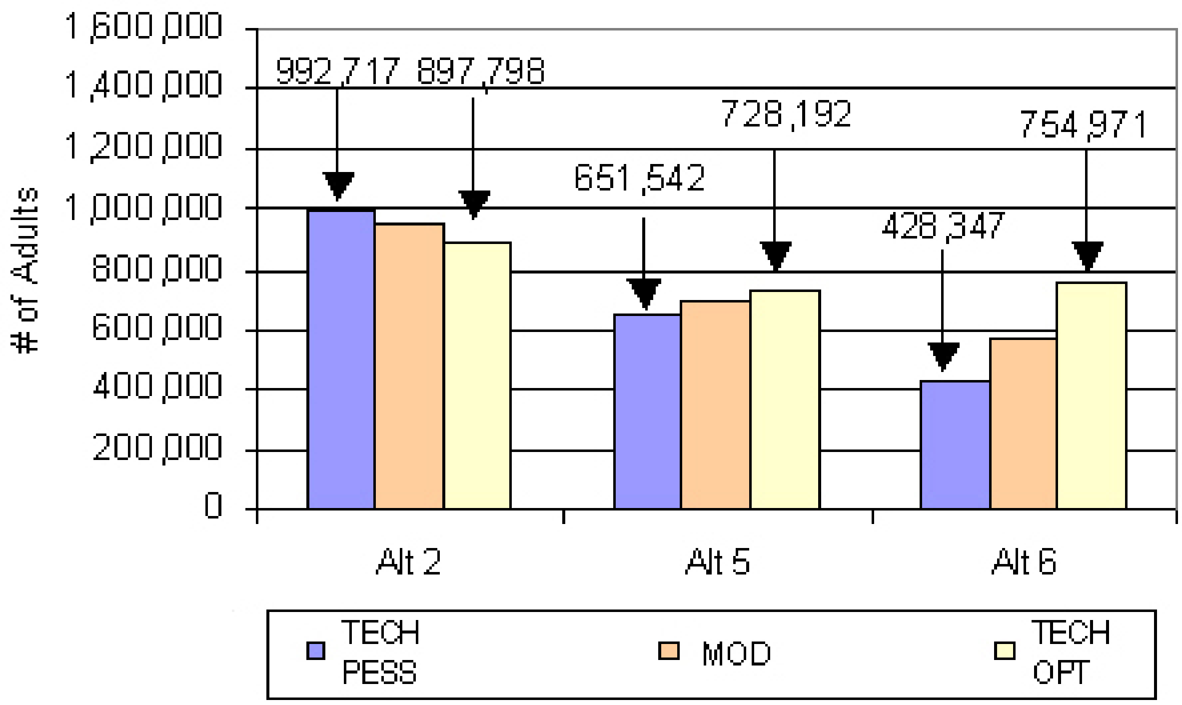


Figure III.D.4 The total number of chinook (hatchery + natural) produced under each of the three analysis alternatives and worldviews.

hatchery production to achieve its objectives. The percent of the total chinook production that natural fish make up for each alternative is shown in Figure III.D.5.

The key points the reader should come away with from the data presented in Figure III.D.5 include:

- Alternative 2 actions result in a Columbia River system that emphasizes natural over hatchery production. The emphasis on natural production poses some risk however as it means that assumptions regarding our ability to improve and recover habitat become more critical. As habitat actions will require many decades to both implement and derive fish survival benefits, the pay-off of as to when the region could see the run sizes depicted for the alternative may be longer than the other alternatives which rely more heavily on hatcheries.
- The approach taken in Alternative 2 (e.g. recover mainstem habitat, increase habitat connectivity, restore ecosystem function) is more consistent with the Council's Scientific Principles (Appendix I). If our assumption is that by following these principles the region is much more likely to improve chinook performance, then there is less risk in selecting an approach like Alternative 2 in comparison to the others.
- Some of the actions included in Alternative 2 may not be internally consistent. The alternative emphasizes natural production yet still allows for the continuation of a large hatchery production program. Because there is still considerable debate (uncertainty) as to the impact hatchery fish have on wild stocks, either eliminating or severely curtailing the hatchery program could reduce this risk.
- The implementation of Alternatives 5 and 6 result in a Columbia River system heavily dependent on hatchery production to achieve their respective chinook performance objectives. This is especially true if the Technology Optimistic worldview best represents the correct State of Nature. A decision to place a large emphasis on hatchery production poses significant risk to natural (wild) fish through the mechanisms of competition, disease, genetic introgression and harvest. A major assumption, and therefore risk, inherent in both Alternative 5 and 6 is that the region can maintain a large-scale hatchery program and increase natural chinook abundance through aggressive habitat measures directed at the tributaries.

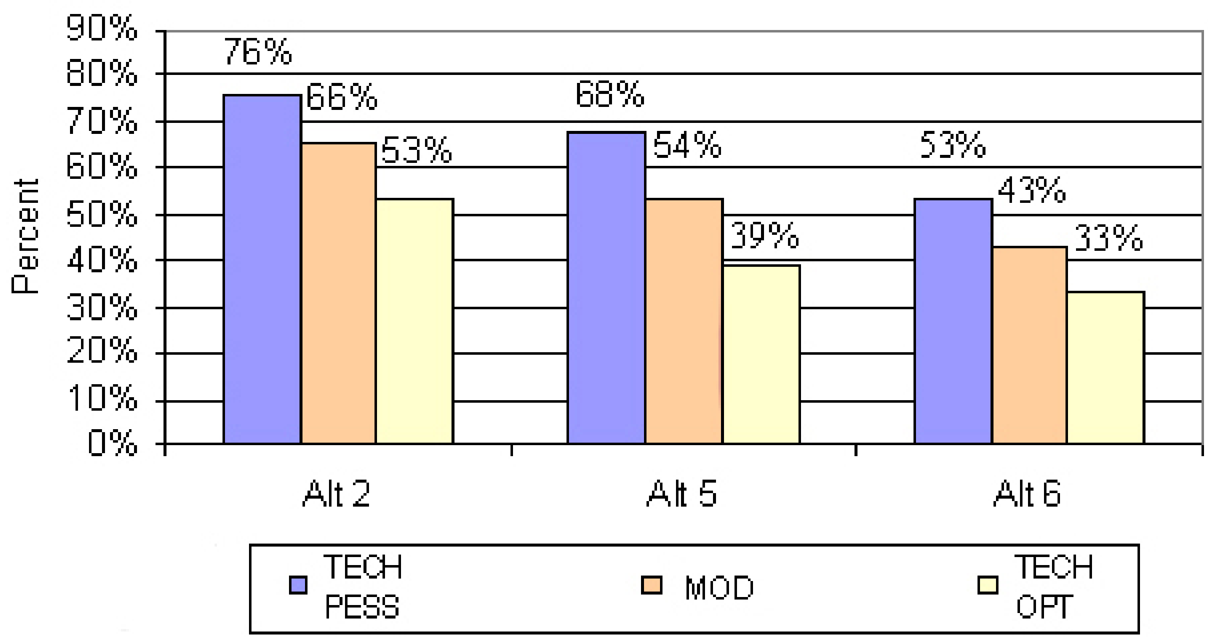


Figure III.D.5 Percent natural chinook production under each of the three analysis alternatives and worldviews.

The level of natural production resulting from each alternative is also important for it has a direct effect on the regions ability to meet ESA requirements. These effects are best seen by looking at the impacts each alternative has on the listed ESU’s (Figure III.D.6). It should be noted that the data shown in Figure III.D.6 are for the Moderate worldview only. These results are sufficient to make the key points presented below.

- Alternative 2 substantially increases chinook abundance, productivity and life-history diversity in all ESU’s. Thus, there is less risk associated with this alternative in regards to recovering listed chinook stocks.
- It is evident from the data in Figure III.D.6 that each of the alternatives provides the least amount of benefit to upper-Columbia River ESU’s (12 and 13). This is especially true for the productivity parameter, which for ESU 12 is actually reduced under Alternatives 5 and 6. These data point to the fact that actions in all of the alternatives have been focused primarily on improving chinook performance in the Snake River (ESU’s 14 and 15). To reduce the extinction risk for stocks originating in the Upper-Columbia River, consideration should be given to implementing more actions in these ESU’s.
- The difference in chinook performance in Alternatives 5 and 6 indicate that performance in some ESU’s (e.g 12 and 13) could be improved by simply shifting habitat actions from public to private land or vice-versa. The poor response for ESU 13 under Alternative 6 is in a large part the result of implementing less effective (lower intensity) habitat actions on private lands in comparison to Alternative 5. To reduce the risk that Alternative 6 may actually reduce productivity in some ESU’s, more thought needs to be given to where habitat actions are implemented (public or private) and at what scale (intensity).
- The large improvement in chinook abundance for ESU 14 under Alternative 2 comes primarily from new spawning habitat created in the Snake River and John Day pool. In contrast, the majority of the chinook production for ESU 14 under Alternatives 5 and 6 results from increased production in the John Day, Deschutes and Umatilla Rivers. Alternative 2 basically assumes that dam removal will create two populations with greater abundance than the Hanford Reach fall chinook population. It will be difficult, if not impossible to test the validity of this assumption without actually removing a project. Removing a smaller dam on a tributary could possibly test this assumption.

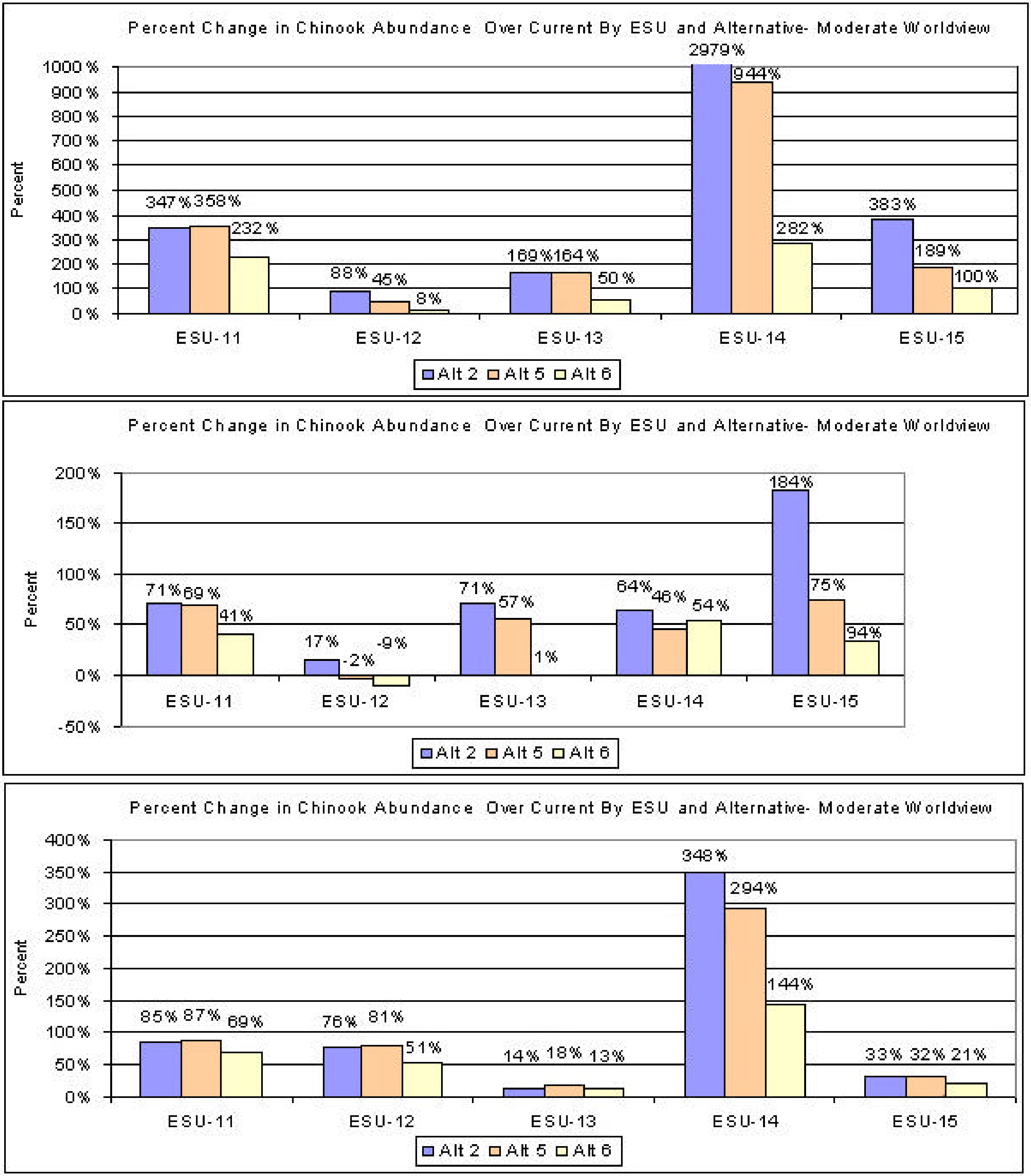
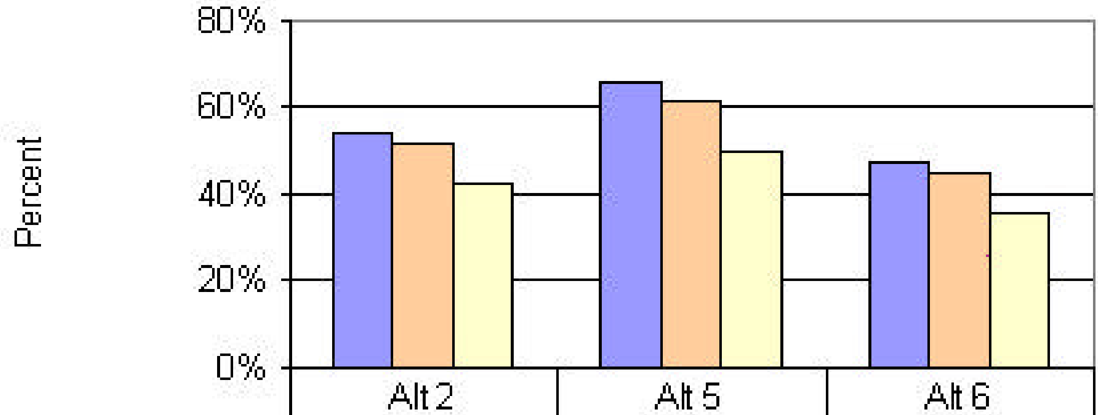


Figure III.D.6 Percent change in natural chinook abundance, productivity and life-history diversity for each analysis alternative under the Moderate worldview.

To increase the performance of natural fish, each of the alternatives includes actions that improve freshwater habitat conditions. The amount of habitat improvement expected from each alternative is shown in Figure III.D.7.

Key points for Figure III.D.7 include:

- All of the alternatives require a substantial increase in freshwater productivity in order to increase chinook performance throughout the Columbia River Basin. Alternative 5 requires the most improvement in freshwater habitat, while Alternative 6 requires the least. At a minimum the alternatives assume that freshwater habitat productivity can be improved by 35 percent. This is a relatively large improvement that may not be achievable either as a result of social constraints or due to the ineffectiveness of habitat actions.
- The data in Figure III.D.7 should not be interpreted as requiring a 35 percent-66 percent improvement in freshwater habitat in all reaches of the Columbia River Basin. Instead, the correct interpretation is that the alternatives require that we eliminate 35 percent-66 percent of the identified habitat problems. These problems may be as simple as removing a small blockage or as complex as restoring late summer stream flows in a tributary dewatered as a result of agricultural practices. Regardless, under either interpretation there is still considerable risk that this range of improvement in freshwater habitat cannot be achieved. However, the exact scale of the effort, and thus probable success, will not be known until after a Diagnosis has been completed for all of the subbasins. It is envisioned that the Diagnosis would be performed as part of the Assessment and Subbasin Planning phases of the Council's Framework program.
- Each of the alternatives assume a different level of habitat restoration effort (intensity) dependent on whether this habitat is located on private or public lands. Alternative 2 places equal effort in improving habitat on private (2) and public lands (2). Alternative 5 emphasizes habitat actions on public land (3) over private (2), while Alternative 6 requires the same amount of effort as Alternative 5 does for public lands (3) but significantly less on public lands (1). It is assumed that there is more risk associated with an alternative that requires substantial improvement in habitat on private lands in comparison to an alternative that relies on actions on public lands.
- The Technology Optimistic worldview assumes that less habitat improvement is needed because the quality of the habitat is better than assumed under the other worldviews. The risk in making such an



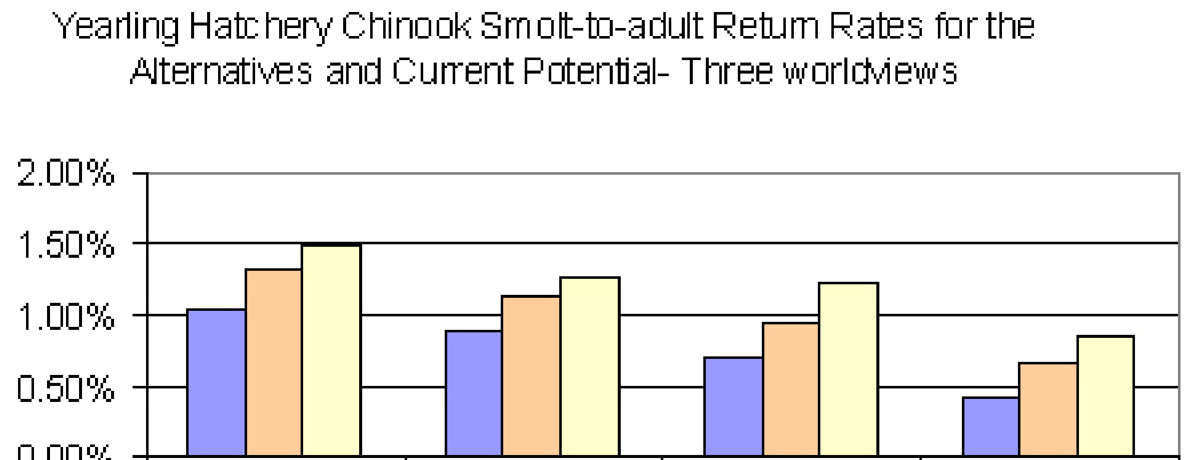
	Alt 2	Alt 5	Alt 6
TECH PESS	54%	66%	48%
MOD	52%	61%	44%
TECH OPT	42%	49%	35%

Figure III.D.7 The percent change in freshwater productivity over the Current Potential for each of the three analysis alternatives and worldviews. The productivity value is a simple average of all five province productivity values.

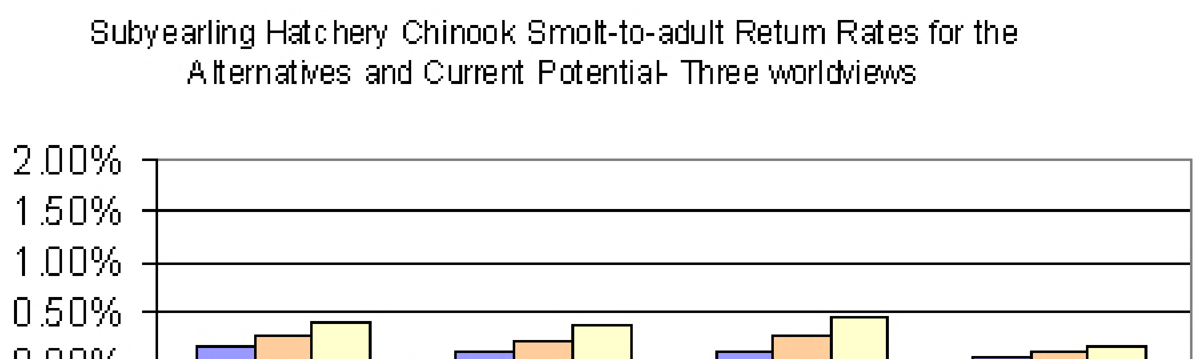
assumption is that regional managers may underestimate the amount of effort (and costs) required to achieve habitat objectives.

In regards to hatcheries, the data in Figure III.D.8 show the overall expected adult return rate for hatchery fish by alternative and worldview. The main points from Figure III.D.8 include:

- The adult return rates in this figure should be considered a long-term average. There will be years when the adult return rate is higher and years when it is lower. Thus, resource managers should not expect to see these adult return rates in every year for every stock.
- All alternatives assume that hatchery fish survival can be improved through the use of innovative culture practices (NATURES, etc.) and that this improvement would result in a ~50 percent increase in hatchery fish survival. Studies underway in the Yakima and other basins should help determine the validity of this assumption in the next three years. For now then, there is considerable risk that these survival benefits cannot be achieved.
- The adult-return rates shown for yearlings under each of the worldviews appear to be very high in relation to the adult return rates observed for chinook juveniles originating from hatcheries located higher in the Columbia River system (Berggren and Basham 2000). There is therefore considerable risk that the adult return rates presented for each worldview may not be achieved on a long-term basis for upper basin stocks. It should be noted that we anticipate that these values will decrease significantly during the Assessment Phase of the Framework process as more information on the Pathogen attribute is developed.
- The smolt-to-adult return rates for Alternative 2 are considerably higher than those estimated for the other alternatives under all worldviews. This results primarily from improvements to mainstem Columbia and Snake River habitat that reduces mortality and decreases the amount of time required for juveniles to migrate from natal streams to the estuary. While the direct survival benefits from actions such as dam removal are relatively certain, increased survival from a decrease in travel-time is not. A major assumption (risk) in Alternative 2 is that there exists a strong flow survival relationship for juvenile migrants.
- Although smolt-to-adult return rates appear high for the Technology Optimistic viewpoint they are consistent with this worldview assumption that the low hatchery fish survival rates observed over the



	Alt 2	Alt 5	Alt 6	Current
TECH PESS	1.05%	0.89%	0.70%	0.41%
MOD	1.32%	1.13%	0.94%	0.67%
TECH OPT	1.48%	1.26%	1.23%	0.86%



	Alt 2	Alt 5	Alt 6	Current
TECH PESS	0.16%	0.13%	0.13%	0.05%
MOD	0.26%	0.22%	0.26%	0.11%
TECH OPT	0.42%	0.36%	0.45%	0.18%

Figure III.D.8 Smolt-to-adult return rates for yearling and subyearling hatchery chinook for each analysis alternative and Current Potential-three worldviews. The return rates presented are before harvest (i.e. harvest is eliminated).

last 10 years reflect poor nearshore ocean survival conditions and that these conditions though cyclical, would improve over time. To realize the best-case scenario for Alternatives 6 requires this assumption to be true.

- The increase in subyearling hatchery fish survival under Alternative 6 in comparison to Alternative 5 for the Moderate and Technology Optimistic worldviews reflect the effect juvenile transportation assumptions have on model results. Alternative 6 maximizes transportation, while in Alternative 5 it is used only when river conditions deteriorate (high temperature, low flow). A major assumption inherent in Alternative 6 is that for subyearling chinook, transportation would provide significant survival benefits in comparison to in-river migration.
- For yearling hatchery chinook, Alternative 5 produces higher smolt-to-adult return rates than Alternative 6. This is due primarily to the transportation assumptions included in Alternative 6. Transportation survival for yearlings is less than ~50 percent for both the Technology Pessimistic and Moderate worldviews. In-river survival under Alternative 5 for juveniles migrating from Lower Granite Dam to below Bonneville Dam can be as high ~55 percent, dependent on time of year. Thus, in-river migration provides a significant survival advantage for upper river hatchery stocks in Alternative 5. If transport survival is high (Technology Optimistic) then the difference in the smolt-to-adult return rates for these alternatives narrows, but for hatchery stocks as a whole, Alternative 5 still has a higher return rate than Alternative 6. The point being that this uncertainty can be reduced significantly for yearling hatchery fish by simply placing production facilities lower in the basin where they would be less affected by the transportation and in-river survival assumptions.
- Placing hatchery facilities lower in the basin would also allow the region to more effectively separate hatchery fish from natural fish, thereby reducing the uncertainty associated with hatchery fish impacts on natural (wild) stocks originating from ESUs 13-15. Such an approach would require defining the purpose of each hatchery (i.e. mitigation, harvest, supplementation) and then defining the areas (provinces) where each type of facility would be allowed.

RESULTS - FISH

This section of the Results addresses fish; it is organized as follows::

Columbia Basin Scale Analysis

Province Scale Analysis

ESU Scale Analysis

In the Framework section, we show how proposed actions affect environmental attributes and discuss the resulting change in biological performance. In the section on Validation, we present data to confirm our assumption that the EDT model results for the Current Potential provide a reasonable estimate of fish abundance in the basin. We also present a summary of chinook model results for the Historic Potential, the Current Potential, and each of the three alternatives.

Framework

The Framework process was designed to help the region develop a collective vision and approach for fish and wildlife recovery in the Columbia River Basin. The Framework is based on the following premise:

> Actions are designed to affect environmental attributes in a manner that changes biological performance to better meet basin goals.

In short, the Framework provides an explicit linkage between the basin vision, biological performance, and actions needed for achieving the performance (Figure IV.A.1).

In this section, we use the results of the analysis to demonstrate how we filled in the linkages connecting actions, environmental attributes, and biological performance, with data.

The Effect of Actions on Environmental Attributes

The actions included in the analysis alternatives can be classified roughly into what is referred to in the region as the All-Hs: habitat, hydrology, harvest, and hatcheries. We included three of the Hs in each of the alternatives – the amount and intensity of application for each of these actions, however, varied by alternative. For example, Alternative 2 emphasized hydrology actions and habitat work, while Alternatives 5 and 6 relied heavily on habitat actions focused in the tributaries. The fourth H, harvest, was set at zero for all alternatives in order to more clearly highlight effects of the other three Hs. The change in the environmental

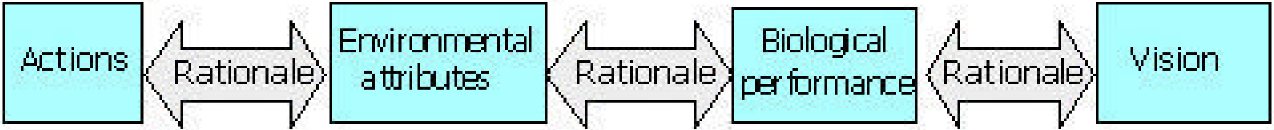


Figure IV.A.1 Framework logic.

attributes described below is heavily influenced by the actions inherent in each alternative.

The change in each of the 45 environmental attributes resulting from implementation of the alternatives is shown in Figure IV.A.2. The values in Figure IV.A.2 represent the amount of change expected from the Current Potential. The values apply only to the freshwater rearing phase of the chinook life cycle and, thus, emphasize spawning egg incubation and juvenile rearing conditions in the tributaries. We present model results incorporating the marine component of the species life cycle later in the report.

In Figure IV.A.2, data are presented in a consumer report type format where ○ indicates less than 20 percent improvement, ◐ is 20 percent to < 40 percent improvement, and ● is 40 percent or higher improvement. A close examination of the data presented in Figure IV.A.2 shows that there was little change (<20 percent) in the majority of the environmental attributes modeled.

The lack of significant change could be the result of any of the following conditions:

- The alternative did not include strategies designed to affect the attribute.
- The strategy was ineffective or had little effect on the attribute.
- A problem did not exist with this attribute (i.e., no impact on fish survival).
- The quality of the data was too coarse to detect a change (especially true for the habitat type data).

In the EDT methodology, the exact cause for a lack of change observed in some of the environmental attributes would be determined during the diagnosis phase of the analysis. However, we did not complete a diagnosis for this analysis, as it was not needed for meeting the study objectives and was not applicable for the particular analytical process employed. We discuss this issue in more detail at the end of this section.

Of the 45 environmental attributes modeled, seven generally showed a change of greater than 40 percent for most alternatives. These seven attributes are:

1. bed scour
2. fine sediment

	BLUE_MOUNTAIN			COLUMBIA_CASCADE			COLUMBIA_GORGE			COLUMBIA_PLATEAU			MOUNTAIN_SNAKE		
	A2	A5	A6	A2	A5	A6	A2	A5	A6	A2	A5	A6	A2	A5	A6
Alkalinity	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Bed scour	●	●	◐	●	●	◐	●	●	●	●	●	◐	●	●	●
Benthos diversity and production	◐	◐	○	◐	○	●	◐	◐	○	◐	◐	○	◐	●	◐
CONFINE	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
ConfineHydro	○	○	○	○	○	○	○	○	○	○	○	○	◐	◐	◐
Dissolved oxygen	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Embeddedness	●	●	◐	●	●	●	●	●	●	●	●	◐	●	●	●
Flow - interannual variability in high flows	○	○	○	○	○	○	○	○	○	○	○	○	○	◐	◐
Flow - intra-annual flow pattern-monthly variation	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Flow - Intra daily (diel) variation	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Flow - interannual variability in low flows	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	○	○	◐	◐
Fine sediment	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Fish community richness	○	○	○	○	○	◐	○	○	○	○	○	○	○	○	○
Fish pathogens	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Fish species introductions	○	○	○	○	○	◐	○	○	○	○	○	○	○	○	○
Gradient	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Harvest and harassment	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Hatchery fish outplants	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Habitat type - backwater pools	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Habitat type - beaver ponds/dammed pools	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Habitat type - large cobble/boulder riffles	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Habitat type - off-channel habitat factor	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Habitat type - pools	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Habitat type - pool tailouts/glides	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Habitat type - small cobble/gravel riffles	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Hydrologic regime (natural)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
SumOfHydroRegimeReg	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Icing	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Metals - in sediments/soils	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Metals - in water column	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Miscellaneous toxic pollutants - water column	○	○	○	○	○	○	○	○	○	○	○	○	○	◐	◐
Nutrient enrichment	◐	◐	○	◐	○	◐	◐	◐	○	◐	◐	○	◐	◐	◐
Obstructions to fish migration	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Predation risk	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Riparian function	●	●	◐	●	●	●	●	●	◐	●	●	◐	●	●	●
Salmon Carcasses	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○
Temperature - daily maximum (by month)	◐	●	◐	◐	◐	◐	◐	●	◐	◐	●	◐	◐	●	●
Temperature - daily minimum (by month)	○	○	○	○	○	○	●	●	●	○	○	○	○	○	○
Temperature - spatial variation	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Turbidity	●	●	◐	●	●	●	●	●	●	●	●	◐	●	●	●
Wood debris	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Water withdrawals	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

○ = < 20% improvement ◐ = 20 - 39% improvement ● = 40% or greater improvement

Figure IV.A.2 Percent of the difference between Historic and Current Potential recovered for each of 45 environmental attributes by province and by alternative (width and length variables not included).

3. riparian function
4. temperature monthly maximum
5. embeddedness
6. turbidity
7. woody debris

The exact percent change in the attributes from the Current Potential is shown by alternative and province in Table IV.A.1. It should be noted that local biologists reviewed the first four attributes listed above as part of the coarse screening process. Thus, the quality of the data is substantially improved for these four environmental attributes and may explain why these attributes had the greatest effect on model results.

The data presented in Table IV.A.1 and Figure IV.A.2 demonstrate that the actions did indeed have a large effect on many of the environmental attributes given the assumptions (rules) inherent in the analysis. Later in this report we will show how these changes can be used in setting biological objectives for the basin and individual provinces.

In summary, the rationale linking actions to environmental attributes is established and documented in this step of the analysis. What is yet to be demonstrated is whether the change in the environmental attributes resulted in increased biological performance.

This question is answered in the paragraphs below.

Biological Performance

The goal of changing the landscape is to increase the productivity of the species dependent upon that landscape. In the Framework, it is assumed that as the landscape changes, productivity also changes. In other words, an improvement in fish habitat should result in an increase in fish survival and eventually abundance. In the previous section we showed how the landscape, as represented by the environmental attributes, changed under each alternative. We now show how this change affected biological performance.

The data in Figure IV.A.3 summarize the change in freshwater habitat productivity assumed to occur in the Columbia River Basin with the implementation of the three analysis alternatives[1]. As noted previously, freshwater productivity consists primarily of the egg incubation and

[1] The data for the Current and three alternatives are based on the Moderate set of analysis assumptions.

Province	BLUE MOUNTAIN			COLUMBIA CASCADE			COLUMBIA GORGE			COLUMBIA PLATEAU			MOUNTAIN SNAKE		
Alternative	**A2**	**A5**	**A6**	**A2**	**A5**	**A6**	**A2**	**A5**	**A6**	**A2**	**A5**	**A6**	**A2**	**A5**	**A6**
Bed Scour	42	54	36	48	69	60	59	75	53	44	55	34	43	71	65
Riparian Function	48	58	38	47	64	57	47	60	45	48	58	39	47	66	59
Wood Debris	55	65	47	57	74	70	58	72	62	56	66	46	54	76	71
Embeddedness	44	50	22	46	64	54	45	60	44	46	56	33	46	65	42
Fine Sediment	57	68	46	65	83	70	59	75	59	57	68	46	54	76	67
Turbidity	49	52	27	50	64	52	50	61	44	48	55	32	45	59	40
Temperature - daily Maximum (by month)	38	46	28	34	47	38	33	41	25	39	47	26	34	48	40

Table IV.A.1 Percent improvement in the key environmental attributes by province and alternative.

	BLUE_MOUNTAIN			COLUMBIA_CASCADE			COLUMBIA_GORGE			COLUMBIA_PLATEAU			MOUNTAIN_SNAKE		
	A2	A5	A6	A2	A5	A6	A2	A5	A6	A2	A5	A6	A2	A5	A6
Alkalinity	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Bed scour	●	●	◐	●	●	◐	●	●	●	●	●	◐	●	●	●
Benthos diversity and production	◐	◐	○	◐	○	●	◐	◐	○	◐	◐	○	◐	●	◐
CONFINE	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
ConfineHydro	○	○	○	○	○	○	○	○	○	○	○	○	◐	◐	◐
Dissolved oxygen	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Embeddedness	●	●	◐	●	●	●	●	●	●	●	●	◐	●	●	●
Flow - interannual variability in high flows	○	○	○	○	○	○	○	○	○	○	○	○	○	◐	◐
Flow - intra-annual flow pattern-monthly variation	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Flow - Intra daily (diel) variation	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Flow - interannual variability in low flows	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	○	○	◐	◐
Fine sediment	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Fish community richness	○	○	○	○	○	◐	○	○	○	○	○	○	○	○	○
Fish pathogens	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Fish species introductions	○	○	○	○	○	◐	○	○	○	○	○	○	○	○	○
Gradient	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Harvest and harassment	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Hatchery fish outplants	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Habitat type - backwater pools	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Habitat type - beaver ponds/dammed pools	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Habitat type - large cobble/boulder riffles	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Habitat type - off-channel habitat factor	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Habitat type - pools	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Habitat type - pool tailouts/glides	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Habitat type - small cobble/gravel riffles	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Hydrologic regime (natural)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
SumOfHydroRegimeReg	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Icing	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Metals - in sediments/soils	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Metals - in water column	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Miscellaneous toxic pollutants - water column	○	○	○	○	○	○	○	○	○	○	○	○	○	◐	◐
Nutrient enrichment	◐	◐	○	◐	○	◐	◐	◐	○	◐	◐	○	◐	◐	◐
Obstructions to fish migration	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Predation risk	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Riparian function	●	●	◐	●	●	●	●	●	◐	●	●	◐	●	●	●
Salmon Carcasses	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○
Temperature - daily maximum (by month)	◐	●	◐	◐	◐	◐	◐	●	◐	◐	●	◐	◐	●	●
Temperature - daily minimum (by month)	○	○	○	○	○	○	●	●	●	○	○	○	○	○	○
Temperature - spatial variation	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Turbidity	●	●	◐	●	●	●	●	●	●	●	●	◐	●	●	●
Wood debris	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Water withdrawals	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

○ = < 20% improvement ◐ = 20 - 39% improvement ● = 40% or greater improvement

Figure IV.A.2 Percent of the difference between Historic and Current Potential recovered for each of 45 environmental attributes by province and by alternative (width and length variables not included).

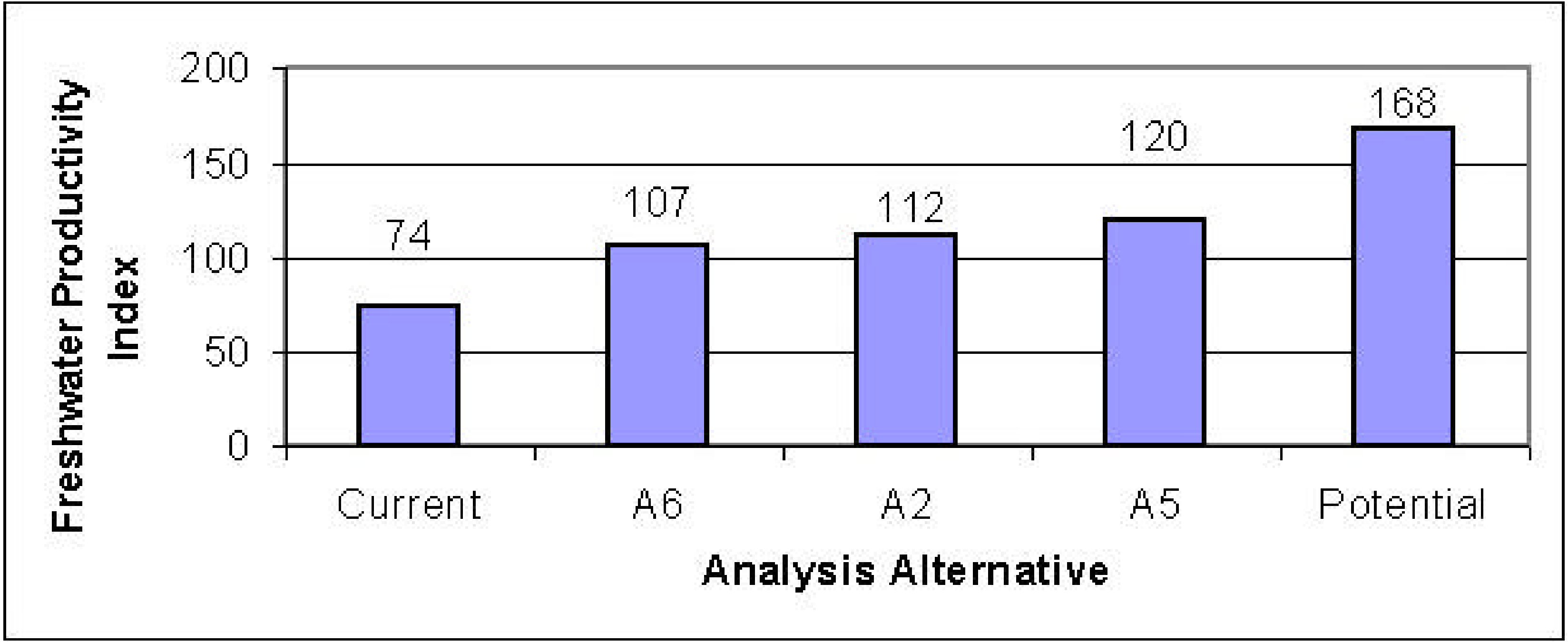


Figure IV.A.3 Freshwater productivity index for each condition and the three analysis alternatives (juveniles per 1,000 eggs).

juvenile rearing life stages. Therefore, the productivity term in Figure IV.A.3 represents the average number of juveniles (per 1,000 eggs) that would survive to the smolt stage with the *removal of all density dependent survival factors*.

With the completion of this step of the analysis we have filled in the linkages connecting actions, environmental attributes and biological performance (Figure IV.A.4). Whether the biological performance is sufficient to meet the vision described for each alternative can only be determined by looking at the overall increase in chinook performance resulting from the implementation of each.

In the EDT method fish performance is described in terms of productivity, abundance, and life history diversity. Obtaining estimates for these three parameters requires that the complete life cycle of the species be modeled. The results of the chinook life cycle analyses are presented in Sections C through G.

Before we describe how chinook performance has changed in the basin over time, and could change in the future with the implementation of each alternative, we finish this section with a discussion regarding the diagnosis phase of EDT.

EDT Diagnosis

The steps in a standard EDT analysis are depicted in Figure IV.A.5. In this typical approach, the diagnosis step is completed prior to the identification of treatments (actions)—the logic in EDT is that you cannot identify and prioritize effective treatments until after you determine (diagnosed) what the problems are!

In the Multi-Species Framework analysis, treatments (actions) were constructed without the benefit of a completed diagnosis. We assumed that the stakeholder groups submitting the alternatives had sufficient knowledge of the basin to develop a suite of actions, or at least an approach, that would be relatively effective at addressing basin ills—thereby achieving their identified basin goals. This assumption is likely correct for actions dealing with the hydroelectric system and hatcheries, but probably less so for habitat. To be effective, habitat actions must be precisely located on the landscape. The scale (how much) of the habitat action is also very important in determining overall biological and cost effectiveness.

Modeled habitat treatments were constructed at the 6-HUC scale, with the only location criteria being whether the land was in public or private hands. Habitat treatments were, therefore, based more on policy concerns than on biological effectiveness. This may explain why some

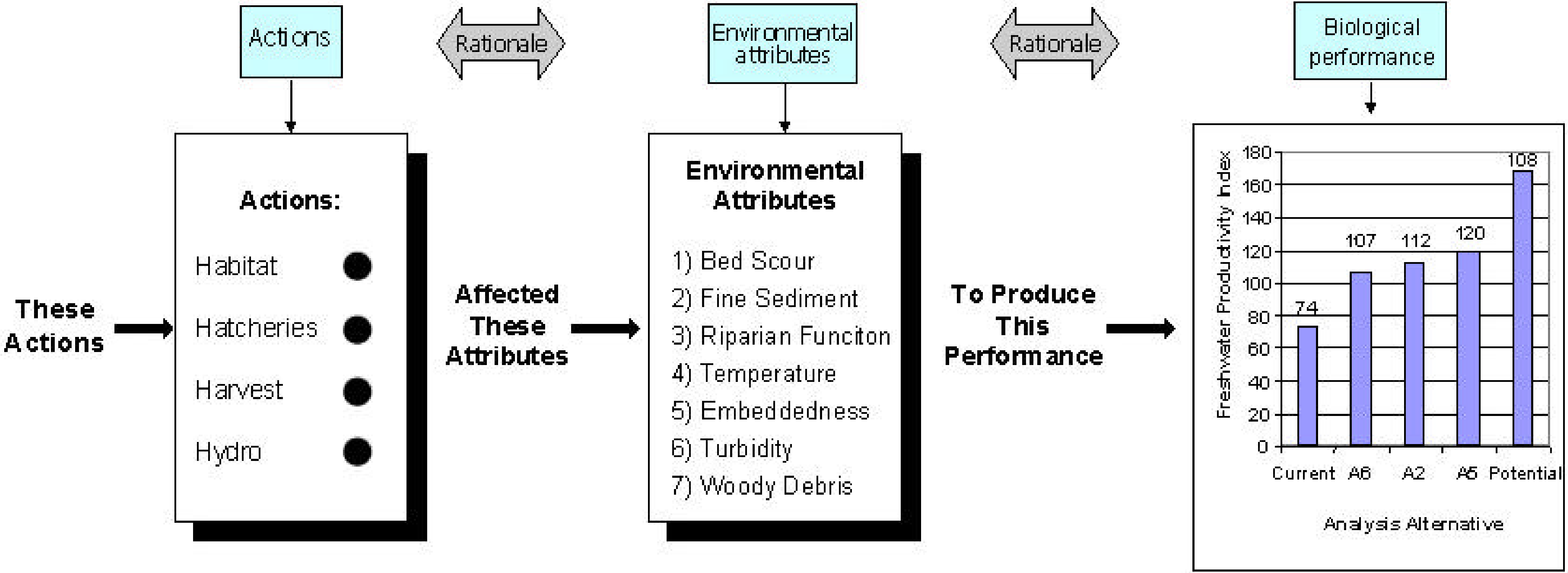


Figure IV.A.4 The Framework logic linking actions to environmental attributes to biological performance.

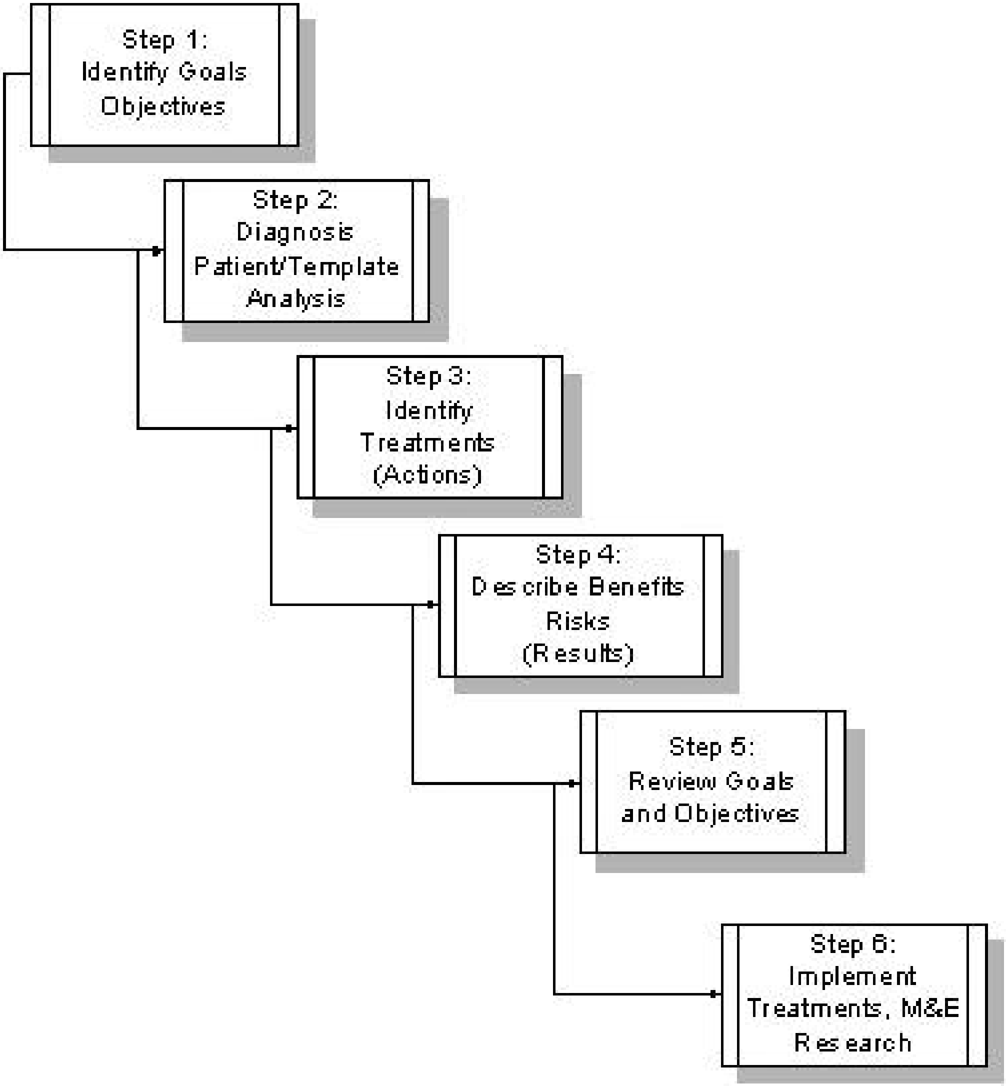


Figure IV.A.5 Steps in the EDT process.

environmental attributes showed little difference between the Current Potential and the three analysis alternatives. Habitat actions could have been selected to address problems identified if a detailed diagnosis similar to the one shown below for the Deschutes River, Oregon (Figure IV.A.6) had been done first.

The data in Figure IV.A.6 show the relative change in attribute effects on salmonid (spring chinook) survival in stream reaches of the Deschutes River (Mobrand 1999). The data is presented in a consumer report type format for easy interpretation. The larger and darker the circle, the bigger the impact the attribute has on salmon survival. For example, the attribute having the largest effect on chinook survival in the Lower Deschutes River mainstem is pathogens.

For the Deschutes analysis, once the major problems were identified, the next step in the diagnosis was to determine precisely where in the Lower Deschutes River mainstem the problems occur.

Locating the problems requires examining the data at a finer scale. Figure IV.A.7 shows the resulting attribute data by river mile for both the lower river and key tributaries. These data indicate that the attributes of habitat diversity, oxygen, pathogens, predation, sediment load, and temperature had the largest effect on salmon productivity.

We can see the size of the effect the key environmental attributes are having on salmon survival in Figure IV.A.8. The data show that overall productivity in this reach has decreased from 60 percent to 39.4 percent dependent on the life stage examined.

Once we have identified the problems and their location, the next step in the diagnosis is to determine the increase in survival that would occur if we could treat the problems successfully. This information is also presented in Figure IV.A.8 and summarized here for convenience:

- Potential percent change in productivity = 2.1 percent
- Potential percent change in NEQ = 9.4 percent
- Potential percent change in diversity = 10.7 percent

In short, the successful treatment of the problems identified would result in about a 10 percent increase in salmon abundance in the basin.

The diagnosis is typically completed for all stream reaches analyzed in the basin of interest. The results of the diagnosis allow us to identify the problem, its location and effect on survival (by life stage), and the resulting increase in survival from the elimination of the problem. In addition, the diagnosis also provides us with the ability to prioritize reaches for treatment. The information needed to prioritize reaches is shown in Figure IV.A.8 under the following headings: Productivity Rank,

Geographic Area	Average change in attribute effect on survival from historic condition															
	Channel stability	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Habitat diversity*	*Harvest*	*Nutrient load*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*% Key habitat (quantity)*
Lower Deschutes River mainstem	•	•	•	•	•	•	•	•			⬤	●	●	●		•
Eastside Tributaries (excluding Trout Cr.)	●	•		●	●	⬤	•	•	⬤	⬤	⬤	•	●	⬤	•	⬤
Warm Springs River system	●	•	•	•	•	•	•	•	•	•	•	•	●	●	•	●
Trout Creek system	⬤	•		•	⬤	⬤	•	•	⬤	●	●	•	⬤	⬤	•	⬤
Shitike Creeke system	●	•		•	•	●	•	•		•	•	•	●	●	•	⬤
Pelton-Round Butte Project Area		•		•	⬤	●	•	•	⬤	⬤	⬤	•	⬤	•		⬤
Metolius River (upstream of Lake BC)		•		●	•	•	•				●	●	•			⬤
Lower Crooked River (upstream of Lake BC)	•	•		●	●	⬤	•	•	⬤	●	⬤	•	●	⬤	•	⬤
Upper Crooked River (including tributaries)	●	•		•	⬤	⬤	•	•	⬤	●	⬤	•	⬤	⬤	•	⬤
Lower Ochoco Creek (including Ochoco Resevior)	●	•		●	⬤	●	•		⬤	●	•	•	⬤	⬤	•	⬤
Upper Ochoco Creek	•	•		•	●	●	•		⬤	●	⬤	•	●	⬤	•	⬤
Middle Deschutes River mainstem				•		•	•				⬤	●				⬤
Squaw Creek	●	•		•	⬤	●	•		⬤	●	⬤	•	•	⬤	●	⬤

Key to Extent of Change in Attribute Effect

	Small	Moderate	High
Condition improved over historic	∘	○	◯
Condition degraded over historic	•	●	⬤

Blank indicates no change

Figure IV.A.6 Pattern of change from historic to current in relative survival conditions attributable to different environmental attributes. Example shown is for chinook salmon in the Dechutes basin.

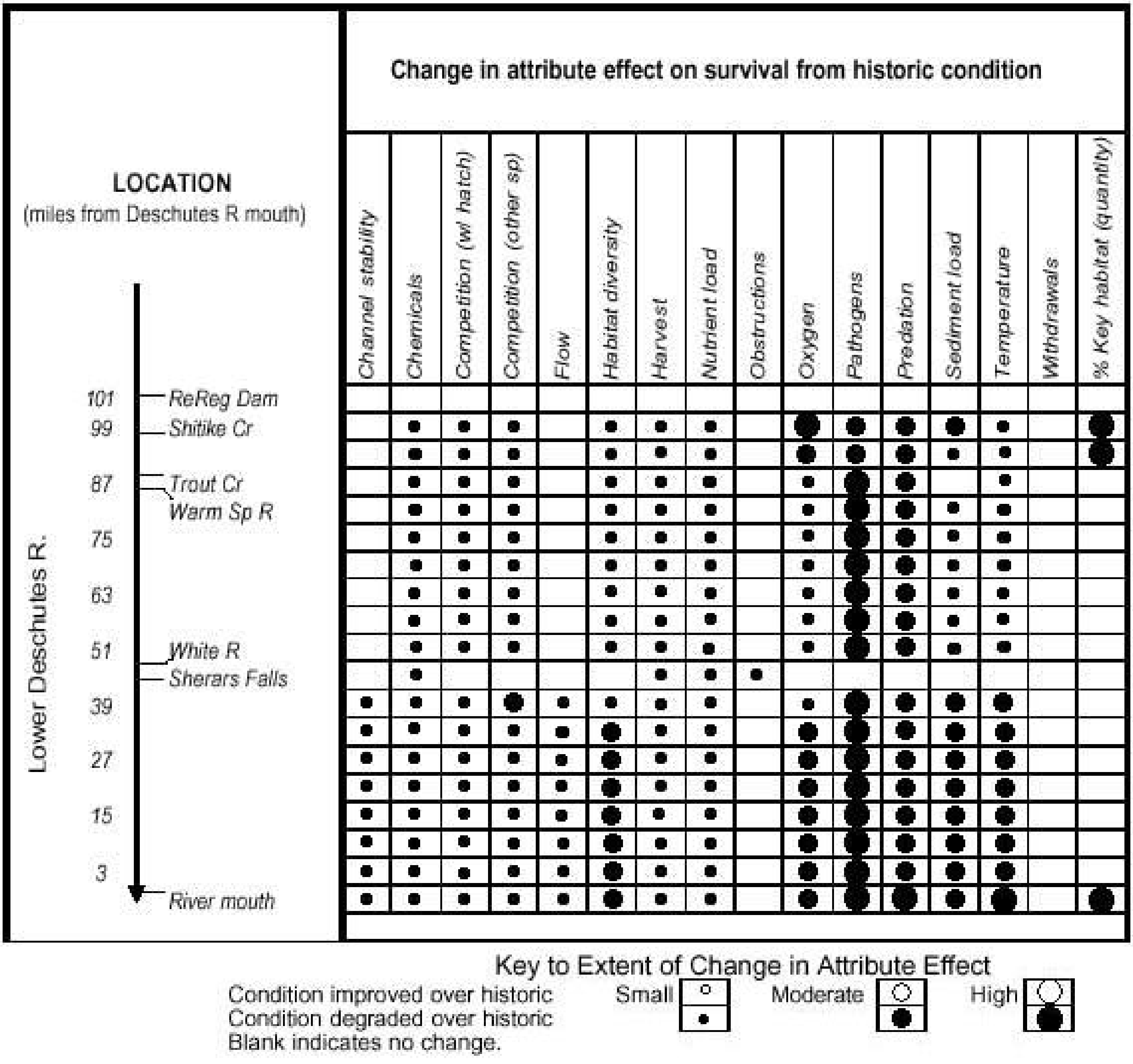


Figure IV.A.7 Change in environmental attribute effect on survival from the Historic Potential. Example shown is for chinook salmon in the Deschutes basin.

Stream(s) / Water(s):	Deschutes R.	Sub-Watershed:	Mainstem downstream of ReReg
Reach:	White R. to Warm Springs R.	Reach Length (mi):	38.5
		Reach Code:	L Deschutes MS-5A

Restoration Benefit Category:	A	Productivity Rank:	13	Potential % change in productivity:1/	2.1%
Combined Performance Rank:	5	Average Abundance (Neq) Rank:	5	Potential % change in Neq:1/	9.4%
% of Life History Trajectories Affected:	100	Life History Diversity Rank:	11	Potential % change in diversity:1/	10.7%

Lifestage	Relevant months	%of life history trajectories affected	Productivity change (%)	Life Stage Rank	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Habitat diversity	Harvest	Nutrient load	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	% Key habitat (quantity)
					Change in attribute impact on survival															
Spawning	Sep																			
Egg incubation	Sep-Apr																			
Fry colonization	Mar-May	0.9	-2.5%	8		Small loss		Small gain		Small loss		Small loss			Small loss	Small loss	Small loss			
0-age active rearing	Mar-Oct	1.0	-39.4%	5			Small loss	Small loss		Small loss					Moderate loss	Small loss	Small loss	Small loss		
0-age migrant	Oct-Nov	7.3	-5.1%	6		Small loss	Small loss			Small loss	Small loss				Small loss	Small loss				
0,1-age inactive	Oct-Mar	7.3	-11.7%	4		Small loss				Moderate loss		Small loss			Small loss		Small loss			
1-age migrant	Mar-Jun	99.9	-0.8%	2		Small loss	Moderate loss			Moderate loss	Small loss				Moderate loss	Moderate loss	Small loss			
1-age resident rearing	Mar-May	7.3	-0.6%	7			Small loss			Small loss		Small loss			Small loss	Small loss	Small loss			
1-age transient rearing	Jan-Dec																			
2+-age transient rearing	Jan-Dec																			
Prespawning migrant	Apr-Aug	100.0	-1.0%	1		Small loss					Moderate loss	Small loss			Small loss		Small loss	High loss		
Prespawning holding	May-Sep																			
All Stages Combined		100																		

Species/Component: Spring Chinook (sub-watershed spawners)
Restoration Emphasis: Restoration or maintenance / improvement of historic life histories

1/ 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).

<HP> Indicates highest priority given due to fragmentation of habitat by dam or reservoir

KEY

NA= Not Applicable

	Loss	Gain
None		
Small	• (filled)	○ (open)
Moderate	● (filled)	○ (open)
High	● (filled)	○ (open)
Extreme	● (filled)	○ (open)

Figure IV.A.8 Pattern of change from historic to current in relative survival conditions attributable to different environmental attributes. Example shown is for chinook salmon in the Deschutes basin.

Average Abundance Rank, and Life History Diversity Rank. In this example, the lower river received an abundance rating of 5, a diversity rating of 11, and a productivity rating of 13. In other words, there are only four reaches in the basin where effective treatments result in larger increases in abundancy; 10 that see larger increases in diversity; and 12 for productivity. Any proposed fish enhancement plan for the basin should emphasize and prioritize treatments in the highest ranked reaches. Such an approach would result in a program that is more effective from both a biological and cost perspective.

The major point the reader should come away with from this discussion is that the diagnosis is the key component required for developing effective fish recovery and enhancement strategies in any basin. It is in the diagnosis phase that the environmental problems are identified, ranked according to their impact on salmon survival, and prioritized for treatment. The diagnosis is the tool used for focusing our actions on improving the key environmental attributes driving biological performance in the basin. The change in these key environmental attributes then become the biological objectives to be monitored over time for quantifying the effectiveness of our actions.

Although a diagnosis was not performed as part of this analysis, it is envisioned that it will be completed in the last stage of the Framework process: subbasin planning. In the absence of a detailed diagnosis, the discussion presented in the model results section will focus primarily on outcomes at the basin and province scales and not at the subbasin level.

EDT Model Results Validation

As noted previously, we assumed that the data incorporated into this analysis were sufficient for estimating fish performance at the basin and province levels. To confirm this assumption, we compared EDT model results of chinook production for the Current Potential (Moderate worldview) with chinook counts at Bonneville, Priest Rapids, and Ice Harbor Dams for the years 1988-1997 (ODFW and WDFW 1998). The results of this comparison analysis are shown in Figures IV.A.9, IV.A.10, and IV.A.11.

The comparison analysis shows that EDT chinook estimates for the Current Potential fell within the 10-year range at all three projects. EDT estimates of the number of chinook arriving at Ice Harbor Dam were at the upper end of the dam count data. These results were deemed reasonable given the quality of the data available for the coarse screening analysis, the assumptions inherent in the analysis, and the fact that data

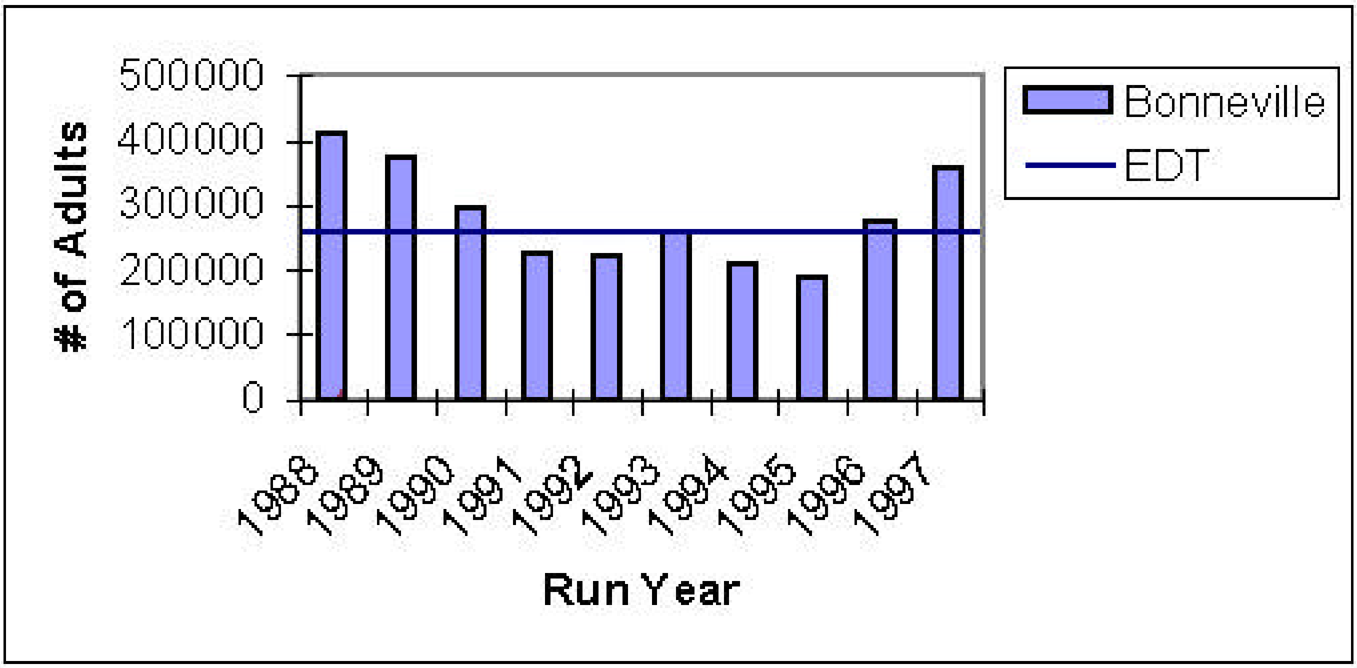


Figure IV.A.9 EDT model estimates of adult chinook arriving at bonneville versus actual dam counts (1988-1997).

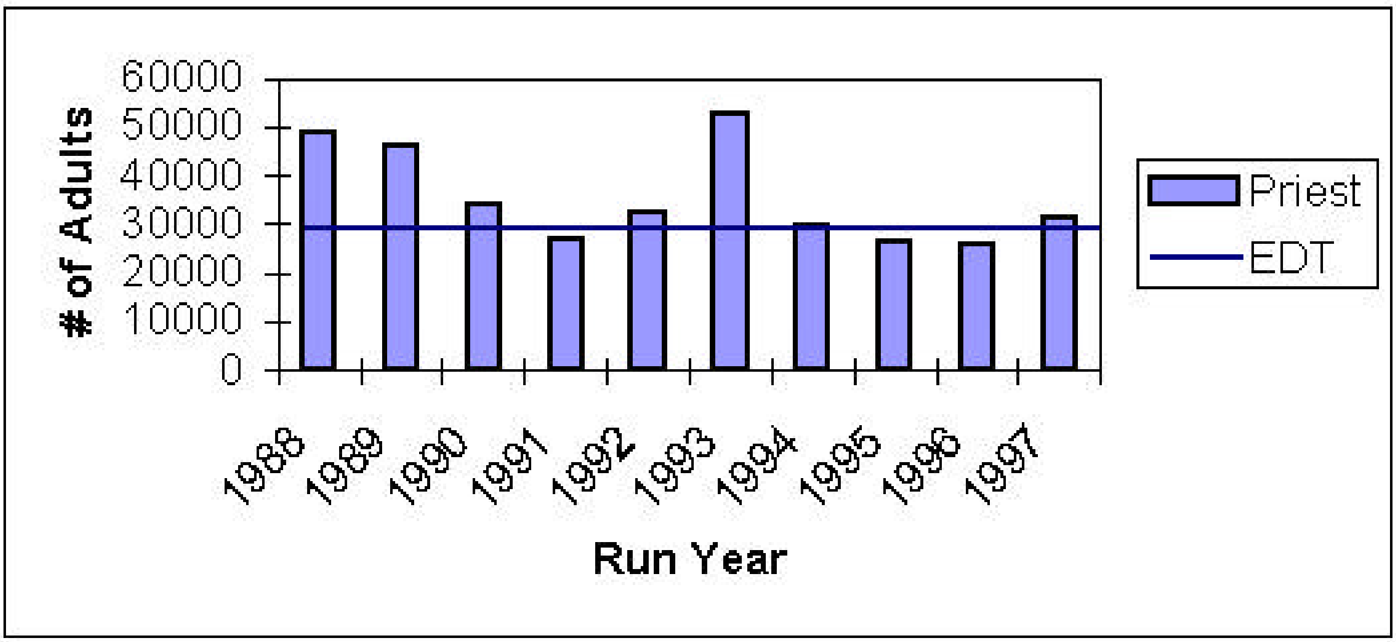


Figure IV.A.10 EDT model estimates of adult chinook arriving at Priest Rapids versus actual dam counts (1988-1997).

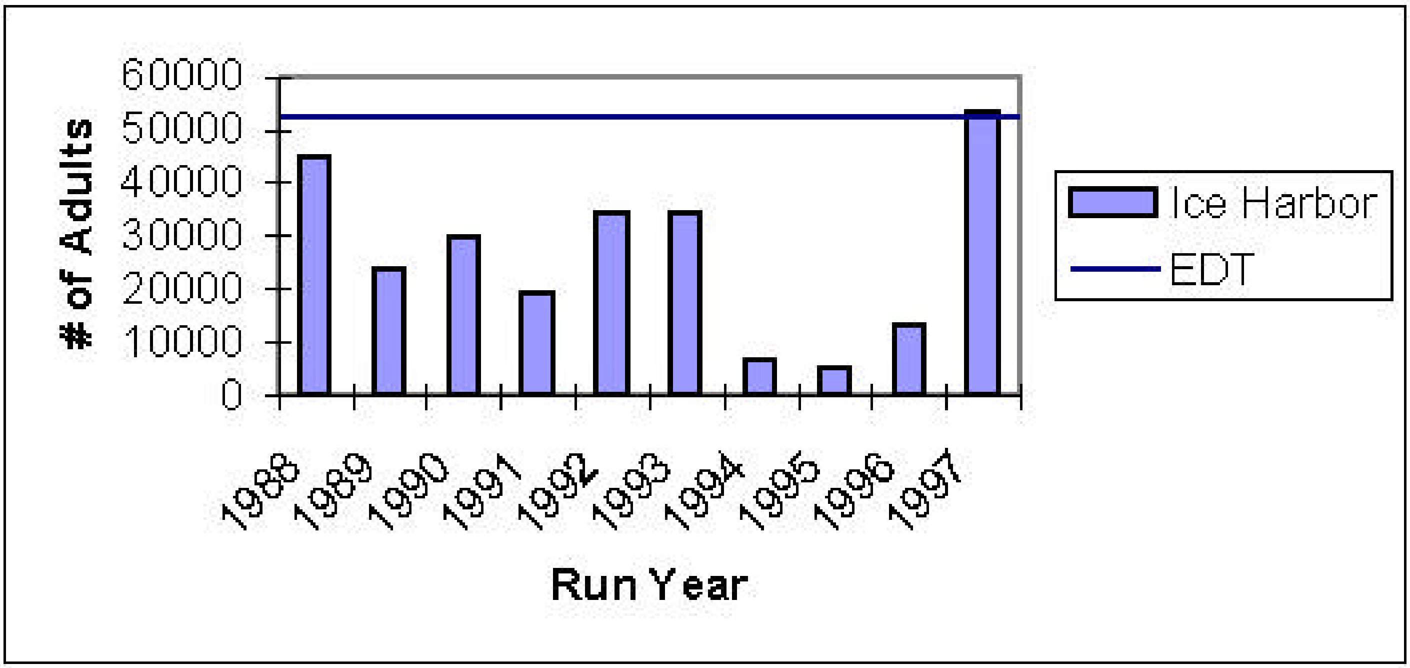


Figure IV.A.11 EDT model estimates of adult chinook arriving at Ice Harbor versus actual dam counts (1988-1997).

quality will be improved as the Framework process proceeds to the next two stages of the analysis: Assessment and Subbasin Planning.

Once we determined that the results obtained for the Current Potential were reasonable, we used these as the basis for developing the alternatives and calibrating the worldview model runs (Methods). It should be emphasized that the EDT model results presented from this point forward will not include ocean or mainstem harvest effects on adult returns unless otherwise noted. This step was required in order to make the results for all conditions (Historic Potential, Current Potential, and Alternatives 2, 5, and 6) comparable. This is especially true when comparing alternatives to the Historic Potential, which represents historical conditions prior to European influence (i.e., no or limited ocean harvest). Again, all model results represent an estimate of chinook production with the elimination of all human harvest effects.

Future Phases of The Framework Process—Assessment and Subbasin Planning

The validation discussion above shows that the accuracy of EDT estimates of chinook production varies dependent on the dam's location in the basin, which corresponds to different provinces (Figure IV.A.9, Figure IV.A.10, Figure IV.A.11).

This outcome was expected and planned for in the Framework process. The developers of the Framework envisioned that the analysis would be undertaken in a series of steps wherein each step the quality of the data would be improved. The steps identified were Step 1–Derived Data, Step 2–Course Screening, Step 3–Assessment, and Step 4-Subbasin Planning (Figure IV.A.12). The results presented in this report are for Step-2 Course Screening and should be treated as if the analysis were 50 percent complete.

In the Assessment phase of the process, we envision that the data used in this analysis will be refined at a finer geographic scale within the subbasins. The improved data quality will provide regional managers with an understanding of the core problems within the subbasins and watersheds. The Assessment phase will therefore provide decision-makers with the ability to prioritize watersheds for more detailed assessments at the watershed scale. These more detailed assessments will be undertaken during the Subbasin Planning phase of the analysis.

We anticipate that data quality will improve substantially during Subbasin Planning, as biologists with local knowledge and expertise fill in missing Level 2 attributes, confirm attribute ratings, and adjust ratings based on site-specific data at the stream reach level. Once the data have

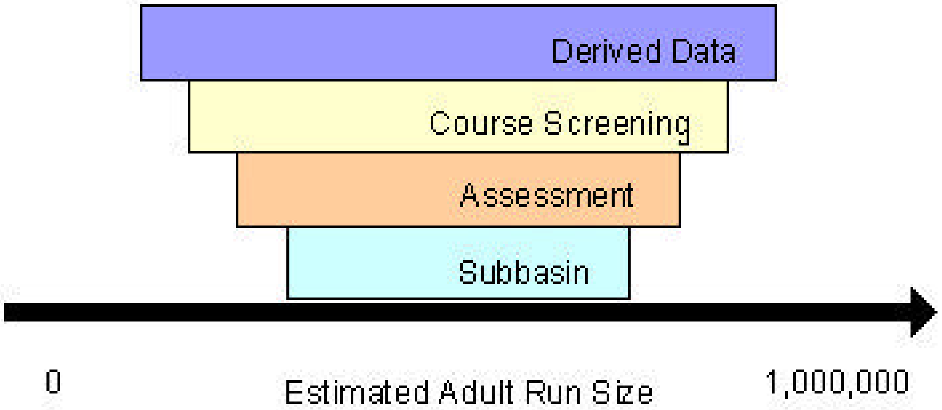


Figure IV.A.12 The four analysis steps in the Framework process.

been updated, biologists would then perform the diagnosis to determine basin ills and develop the treatments needed to effectively cure these ills.

Historic Potential

Columbia Basin Scale Analysis

To determine the level of chinook production possible in the basin, we need an estimate of the Historic Potential—the assumption being that the basin, as a whole, cannot sustain natural production levels higher than what occurred historically. Because there is a great deal of uncertainty inherent in any exercise attempting to estimate fish abundance over 150 years ago, we used the assumptions present in the three worldviews to develop a range of possible historic chinook production levels (Figures IV.A.13 and IV.A.14).

The data in Figure IV.A.13 show that the Historical Potential production of the basin could range from a low of 2.0 million under the Technology Optimistic worldview to 4.6 million for the Technology Pessimistic worldview. In general, under all worldviews total chinook production consisted of approximately 50 percent falls, 33 percent summer/falls, and 17 percent springs.

For the historical analysis, we modeled only those stream reaches downstream of Chief Joseph Dam (Columbia River) and Hells Canyon Dam (Snake River) approximately 5,540 total stream miles.

Thus, the abundance estimates do not include stream reaches above these fish blockages.

The difference between the worldview abundance estimates lies in the assumptions inherent in each. In the Technology Pessimistic view of the world, both freshwater and ocean habitats are assumed to be much more productive than they are in the Technology Optimistic worldview. This difference is important because it defines the overall production potential of the basin, relationship between current and historic run size, and expected improvement in chinook production possible from the implementation of the three analysis alternatives. The Historic Potential defines what is possible to achieve through future actions. The bigger the difference between Historic and Current Potentials, the greater the opportunity for improvement.

Historic Potential chinook productivity and life history diversity under the three worldview assumptions are shown in Table IV.A.2. As you can see from the data presented in this table, productivity is highest under the Technology Pessimistic worldview, and lowest for the Technology

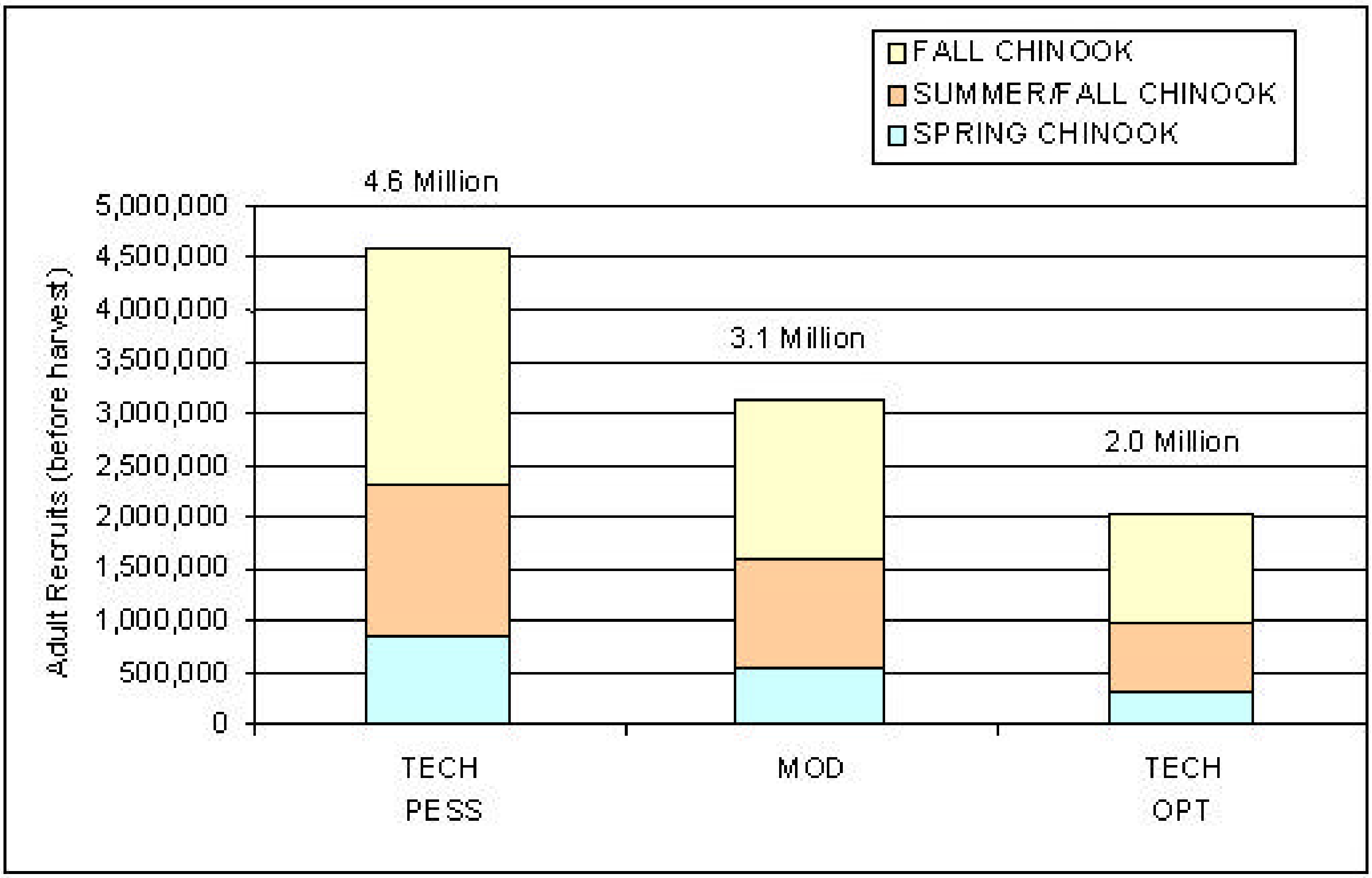


Figure IV.A.13 Historic Potential natural chinook production in the Columbia River Basin (no harvest) under three worldviews.

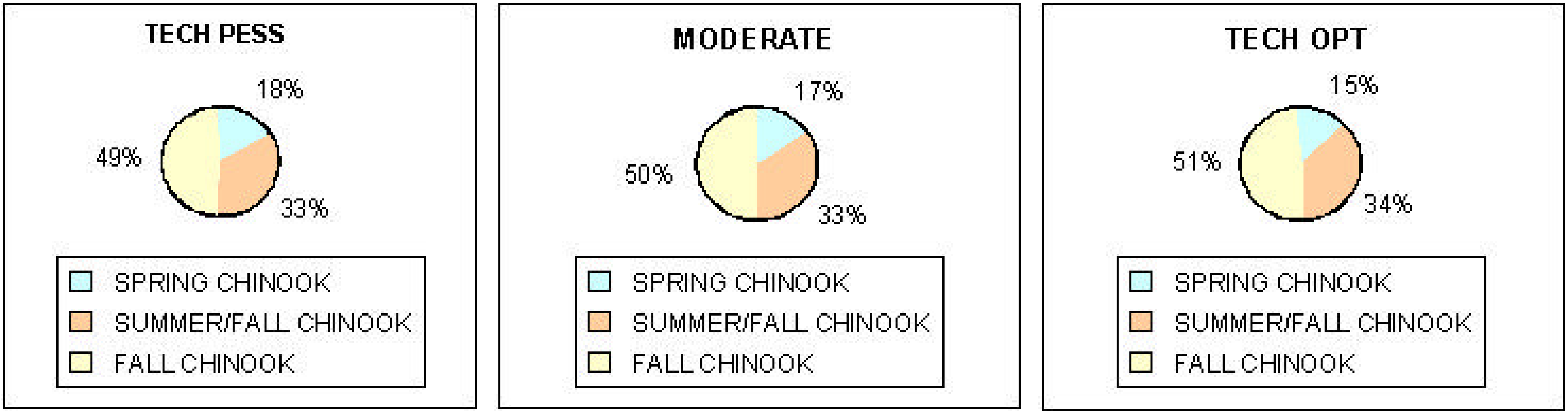


Figure IV.A.14 The percent of total basin chinook production by race, under the three worldviews.

Optimistic. Life history diversity is the same for all worldviews (i.e., 100 percent), meaning that the full range of life history patterns modeled was possible under the Historic Potential.

Productivity is important because it is a measure of the ability of a species to rebound when population size is reduced. The very high productivity values shown for the Technology Pessimistic worldview indicate that chinook populations would respond rapidly as we improve habitat conditions throughout the basin. In contrast, the lower productivity values associated with the Technology Optimistic worldview indicate that fish response to similar actions would be more gradual. The time component is important for determining how many years may be needed to observe or directly measure the effects our actions have on chinook performance. Future research and monitoring programs focused on determining the effectiveness of proposed actions would therefore need to consider the element of time in their design.

Life history diversity is important because it 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 environmental change. Diverse life history patterns dampen the risk of extinction or reduced production in fluctuating environments (den Boer 1968).

The information presented in this section described a possible range of historic chinook performance for the Columbia River Basin under different worldviews. In the next section we describe how historic chinook production varied in the five provinces analyzed.

Province Scale Analysis

We developed estimates of chinook Historic Potential performance for five Columbia River Basin provinces (Figure IV.A.15). The Columbia Gorge, Columbia Plateau, Columbia Cascade, Blue Mountains and Mountain Snake (Figure IV.A.15) Modeling results are summarized by province, race, and worldview in Table IV.A.3. Because the discussion points presented above for the basin level analysis also apply at the province level, they are not repeated here. Instead, we use the data in Table IV.A.3 for the Moderate worldview to quickly summarize the key results.

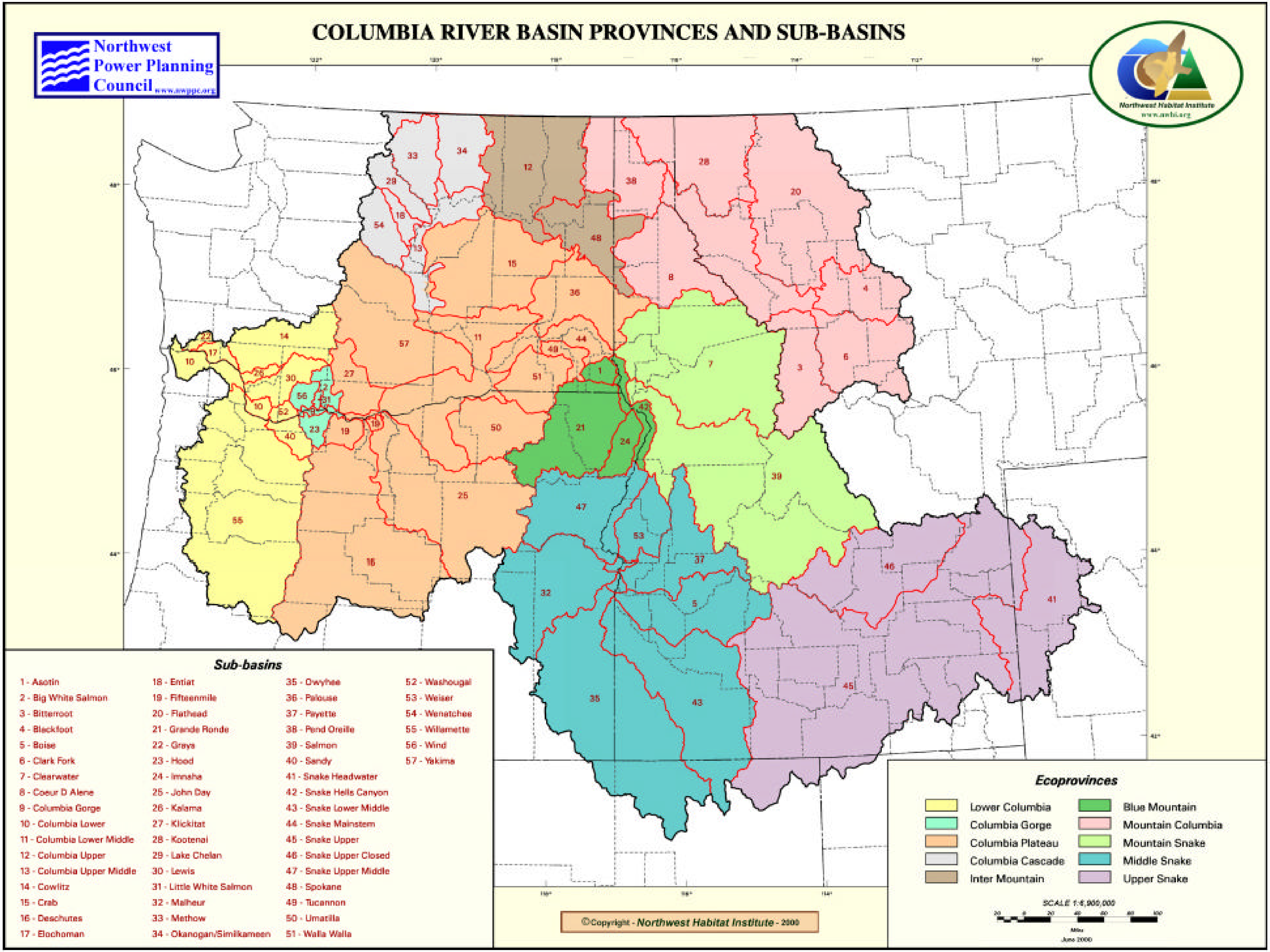


Figure IV.A.15 Provinces of the Columbia River ecosystem.

HISTORIC POTENTIAL

Technology Pessimistic

	Abundance: Natural	% of Total	Hatchery	% of Total	Hatch + Natural	% of Total	Life Hist. Divers. Index	Productivity	Nbr of Sust. Popul.
SPRING									
BLUE_MOUNTAIN	125,726	15%	0	n/a	125,726	15%	100%	44.8	3
COLUMBIA_CASCADE	48,408	6%	0	n/a	48,408	6%	87%	45.1	3
COLUMBIA_GORGE	45,734	6%	0	n/a	45,734	6%	100%	42.8	4
COLUMBIA_PLATEAU	317,419	39%	0	n/a	317,419	39%	100%	49.2	15
MOUNTAIN_SNAKE	277,733	34%	0	n/a	277,733	34%	100%	43.5	10
ALL PROVINCES	815,021	100%	0	n/a	815,021	100%	n/a	n/a	35
SUMMER/FALL CHINOOK									
BLUE_MOUNTAIN	47,819	3%	0	n/a	47,819	3%	100%	49.0	1
COLUMBIA_CASCADE	751,247	50%	0	n/a	751,247	50%	98%	38.7	6
COLUMBIA_PLATEAU	319,083	21%	0	n/a	319,083	21%	100%	49.6	4
MOUNTAIN_SNAKE	384,626	26%	0	n/a	384,626	26%	100%	51.0	7
ALL PROVINCES	1,502,774	100%	0	n/a	1,502,774	100%	n/a	n/a	18
FALL CHINOOK									
BLUE_MOUNTAIN	231,590	10%	0	n/a	231,590	10%	100%	34.9	1
COLUMBIA_GORGE	82,373	4%	0	n/a	82,373	4%	100%	40.5	2
COLUMBIA_PLATEAU	1,965,651	86%	0	n/a	1,965,651	86%	98%	33.4	9
ALL PROVINCES	2,279,614	100%	0	n/a	2,279,614	100%	n/a	n/a	12
TOTAL CHINOOK									
BLUE_MOUNTAIN	405,134	9%	0	n/a	405,134	9%	n/a	n/a	5
COLUMBIA_CASCADE	799,656	17%	0	n/a	799,656	17%	n/a	n/a	9
COLUMBIA_GORGE	128,107	3%	0	n/a	128,107	3%	n/a	n/a	6
COLUMBIA_PLATEAU	2,602,153	57%	0	n/a	2,602,153	57%	n/a	n/a	28
MOUNTAIN_SNAKE	662,359	14%	0	n/a	662,359	14%	n/a	n/a	17
ALL PROVINCES	4,597,409	100%	0	n/a	4,597,410	100%	n/a	n/a	65

Moderate

	Abundance: Natural	% of Total	Hatchery	% of Total	Hatch + Natural	% of Total	Life Hist. Divers. Index	Productivity	Nbr of Sust. Popul.
SPRING									
BLUE_MOUNTAIN	83,948	16%	0	n/a	83,948	16%	100%	26.4	3
COLUMBIA_CASCADE	32,621	6%	0	n/a	32,621	6%	87%	26.8	3
COLUMBIA_GORGE	27,445	5%	0	n/a	27,445	5%	100%	22.3	4
COLUMBIA_PLATEAU	200,051	38%	0	n/a	200,051	38%	100%	27.3	15
MOUNTAIN_SNAKE	184,809	35%	0	n/a	184,809	35%	100%	25.6	10
ALL PROVINCES	528,874	100%	0	n/a	528,875	100%	n/a	n/a	35
SUMMER/FALL CHINOOK									
BLUE_MOUNTAIN	34,106	3%	0	n/a	34,106	3%	100%	29.1	1
COLUMBIA_CASCADE	532,535	51%	0	n/a	532,535	51%	98%	24.7	6
COLUMBIA_PLATEAU	219,493	21%	0	n/a	219,493	21%	100%	28.8	4
MOUNTAIN_SNAKE	263,312	25%	0	n/a	263,312	25%	100%	30.4	7
ALL PROVINCES	1,049,445	100%	0	n/a	1,049,445	100%	n/a	n/a	18
FALL CHINOOK									
BLUE_MOUNTAIN	163,564	10%	0	n/a	163,564	10%	100%	21.5	1
COLUMBIA_GORGE	59,084	4%	0	n/a	59,084	4%	100%	24.3	2
COLUMBIA_PLATEAU	1,343,427	86%	0	n/a	1,343,427	86%	98%	21.6	9
ALL PROVINCES	1,566,075	100%	0	n/a	1,566,075	100%	n/a	n/a	12
TOTAL CHINOOK									
BLUE_MOUNTAIN	281,618	9%	0	n/a	281,618	9%	n/a	n/a	5
COLUMBIA_CASCADE	565,156	18%	0	n/a	565,156	18%	n/a	n/a	9
COLUMBIA_GORGE	86,529	3%	0	n/a	86,529	3%	n/a	n/a	6
COLUMBIA_PLATEAU	1,762,971	56%	0	n/a	1,762,971	56%	n/a	n/a	28
MOUNTAIN_SNAKE	448,121	14%	0	n/a	448,121	14%	n/a	n/a	17
ALL PROVINCES	3,144,393	100%	0	n/a	3,144,394	100%	n/a	n/a	65

Technology Optimistic

	Abundance: Natural	% of Total	Hatchery	% of Total	Hatch + Natural	% of Total	Life Hist. Divers. Index	Productivity	Nbr of Sust. Popul.
SPRING									
BLUE_MOUNTAIN	49,561	16%	0	n/a	49,561	16%	100%	14.7	3
COLUMBIA_CASCADE	21,723	7%	0	n/a	21,723	7%	100%	13.8	3
COLUMBIA_GORGE	14,496	5%	0	n/a	14,496	5%	100%	11.1	4
COLUMBIA_PLATEAU	110,423	36%	0	n/a	110,423	36%	100%	14.2	15
MOUNTAIN_SNAKE	108,915	36%	0	n/a	108,915	36%	100%	14.2	10
ALL PROVINCES	305,117	100%	0	n/a	305,118	100%	n/a	n/a	35
SUMMER/FALL CHINOOK									
BLUE_MOUNTAIN	22,783	3%	0	n/a	22,783	3%	100%	17.1	1
COLUMBIA_CASCADE	354,324	52%	0	n/a	354,324	52%	100%	15.3	6
COLUMBIA_PLATEAU	139,679	21%	0	n/a	139,679	21%	100%	16.5	4
MOUNTAIN_SNAKE	162,632	24%	0	n/a	162,632	24%	100%	17.3	7
ALL PROVINCES	679,417	100%	0	n/a	679,417	100%	n/a	n/a	18
FALL CHINOOK									
BLUE_MOUNTAIN	110,948	11%	0	n/a	110,948	11%	100%	13.3	1
COLUMBIA_GORGE	39,502	4%	0	n/a	39,502	4%	100%	14.4	2
COLUMBIA_PLATEAU	883,078	85%	0	n/a	883,078	85%	100%	13.8	9
ALL PROVINCES	1,033,528	100%	0	n/a	1,033,528	100%	n/a	n/a	12
TOTAL CHINOOK									
BLUE_MOUNTAIN	183,291	9%	0	n/a	183,291	9%	n/a	n/a	5
COLUMBIA_CASCADE	376,046	19%	0	n/a	376,046	19%	n/a	n/a	9
COLUMBIA_GORGE	53,997	3%	0	n/a	53,997	3%	n/a	n/a	6
COLUMBIA_PLATEAU	1,133,180	56%	0	n/a	1,133,180	56%	n/a	n/a	28
MOUNTAIN_SNAKE	271,547	13%	0	n/a	271,547	13%	n/a	n/a	17
ALL PROVINCES	2,018,062	100%	0	n/a	2,018,063	100%	n/a	n/a	65

Table IV.A.3 Biological performance results for the Historic Potential, under the three worldviews.

> The key biological performance results for the Historic Potential province analysis (under the Moderate worldview) are as follows:
>
> - Total historical abundance potential of chinook in the Columbia River Basin is highest in the Columbia Plateau (57 percent) and lowest in the Columbia Gorge (three percent)
> - The Columbia Plateau has the highest level of historical spring chinook abundance at 39 percent, with the least amount of production occurring in the Columbia Gorge (six percent)
> - Summer/fall chinook abundance is greatest in the Columbia Cascade (51 percent) and lowest in the Blue Mountain (three percent).
> - Historical fall chinook abundance is highest in the Columbia Plateau (86 percent) and lowest in the Columbia Gorge (four percent).
> - Similar to the basin analysis, productivity estimates vary by worldview, with Technology Pessimistic producing the highest values.

Now that we have presented what we believe to be the range of possible Historical Potential chinook production for the basin, the next step in the analysis is to describe what the Current Potential production of the basin is today.

Current Potential

As was the case with the Historic Potential analysis, there is considerable uncertainty regarding the Current Potential chinook production of the Columbia River Basin. There are two schools of thought on this topic, which we refer to as the Technology Pessimistic and the Technology Optimistic worldviews. Under the first worldview, current freshwater habitat conditions are poor in comparison to the historic conditions. The degradation in habitat is a direct result of human impacts. The Technology Optimistic worldview on the other hand states that the human effects on habitat is less severe and that Historical Potential chinook production in the basin was much lower (i.e., 2.0 million versus 4.6 million).

To account for this uncertainty, we used the assumptions present in the worldviews to estimate a range for the current production potential (Current Potential) of the basin. In this section the results of this analysis are presented at the basin, province, and ESU levels.

In estimating a range for the Current Potential:

1. Abundance numbers represent the number of adult chinook surviving to the spawning life stage. Thus, any mortality due to mainstem dam passage and pre-spawning mortality has already been subtracted from the totals.
2. The Current Potential represents the number of adults that can be produced under current habitat, hatchery, and hydro conditions and operations.
3. Ocean and Columbia River mainstem fisheries have been eliminated in all model runs. Model results are therefore an estimate of the number of adult chinook expected to return with the elimination of harvest. The removal of harvest was needed in order to make a more valid comparison between Historic Potential (no harvest) and Current Potential.
4. The adult data presented in the tables are classified into two groups: natural and hatchery. The natural group consists of both wild and hatchery fish that spawn in the wild.
5. Life history diversity and productivity values apply only to natural populations.

Figure IV.A.16 shows the impact of eliminating harvest on the number of hatchery chinook adults returning to the basin. As you can see from this figure, eliminating harvest increases the number of adults returning to the basin, and the level of increase is dependent on the worldview. Again, in order to make a fair comparison between the Historic Potential and Current Potential of the basin, harvest has been eliminated from the analysis.

Columbia River Basin Scale Analysis

Estimates of Current Potential chinook hatchery and natural production for the basin under each worldview are summarized in Table IV.A.4 and shown graphically in Figure IV.A.17. The data in Figure IV.A.17 indicate

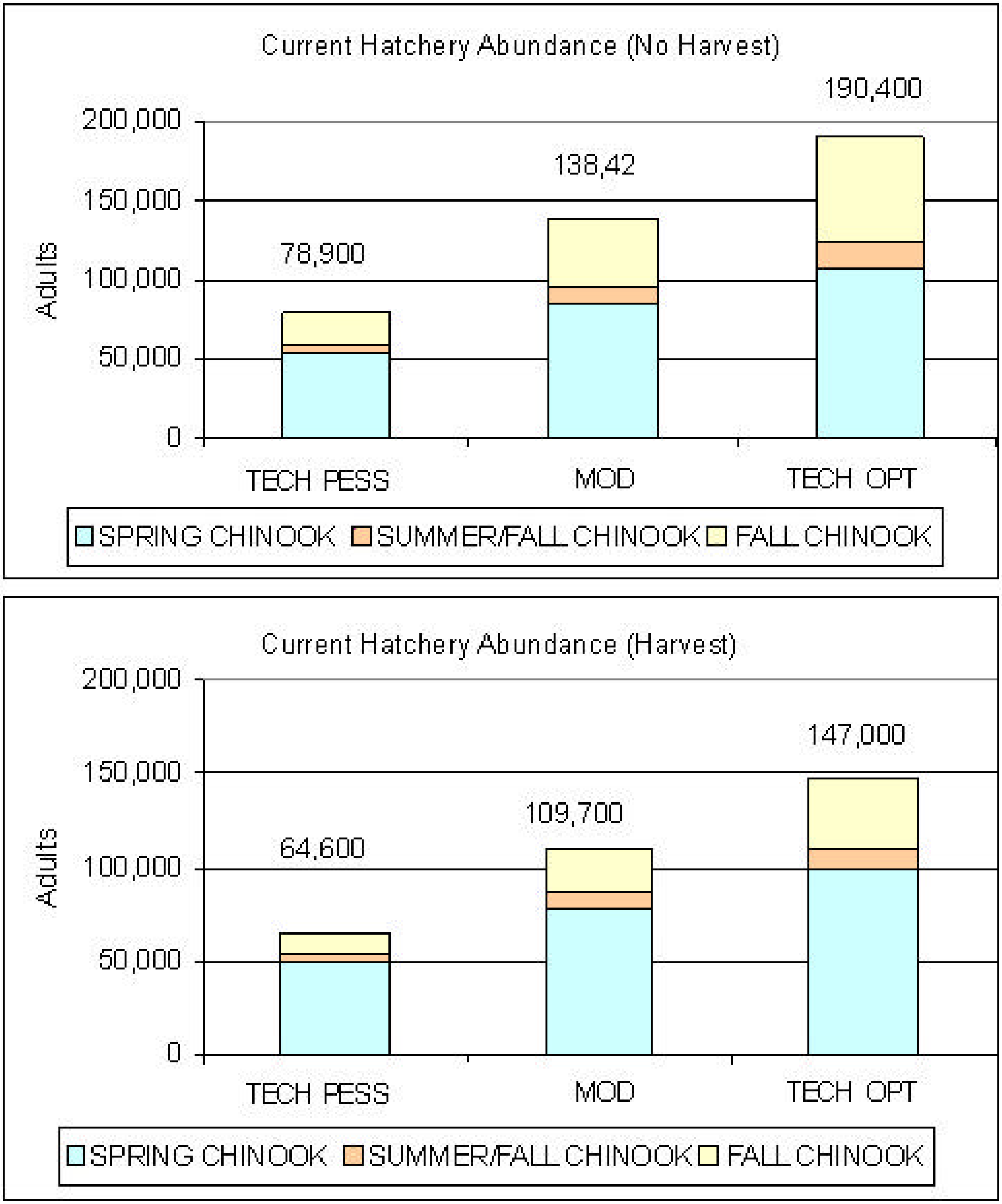


Figure IV.A.16 Total number of hatchery chinook salmon returning to the river, with and without ocean and mainstem harvest.

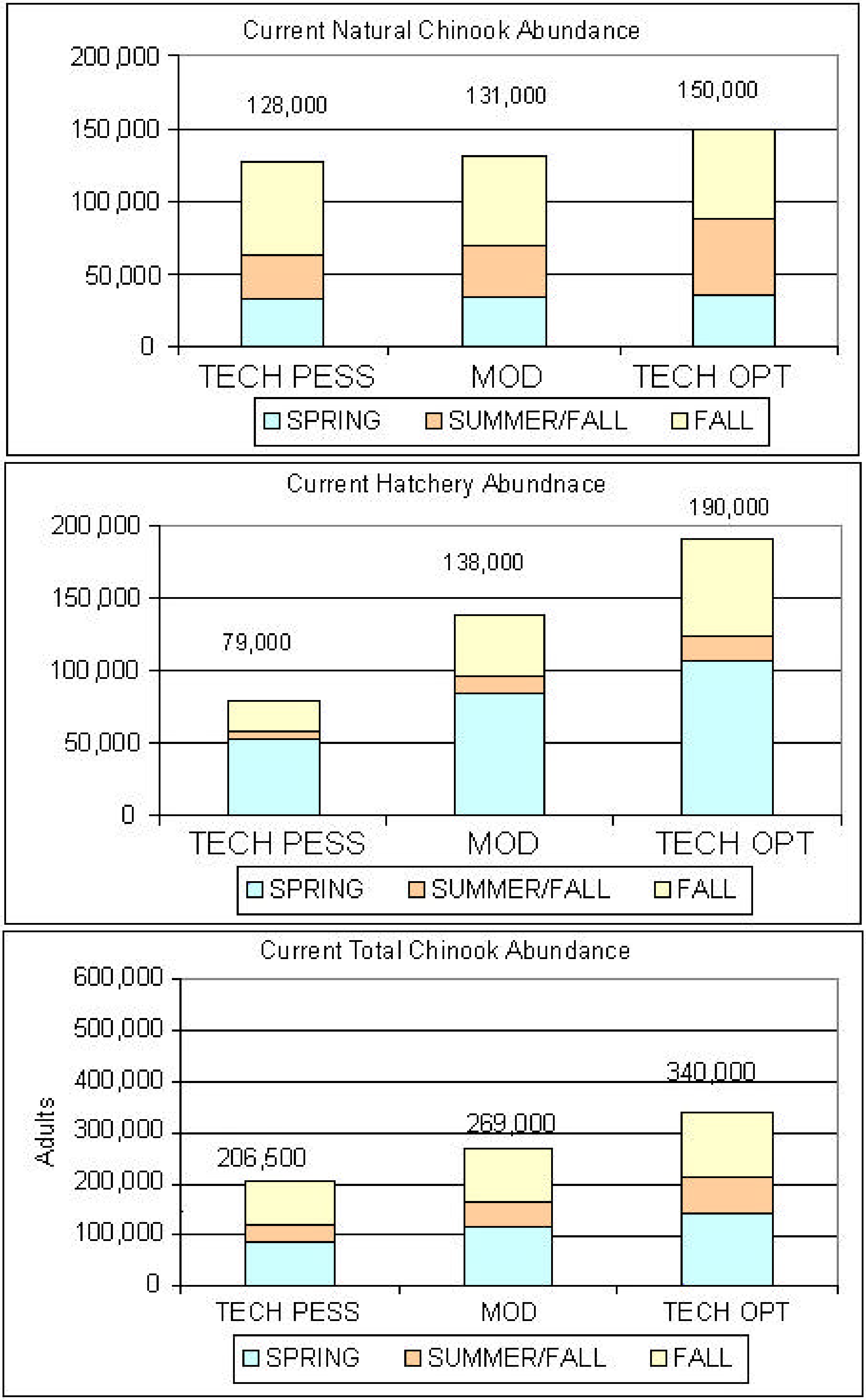


Figure IV.A.17 Current natural, hatchery, and total chinook abundance in the Columbia River basin by race and worldview (no harvest).

CURRENT POTENTIAL

Technology Pessimistic

	Abundance: Natural	% of Total	Hatchery	% of Total	Hatch + Natural	% of Total	Life Hist. Divers. Index	Productivity	Nbr. of Sust. Popul.
SPRING									
BLUE_MOUNTAIN	2,326	7%	1,285	2%	3,611	4%	46%	2.7	3
COLUMBIA_CASCADE	1,863	6%	5,641	11%	7,504	9%	79%	3.0	3
COLUMBIA_GORGE	8,255	26%	31,350	59%	39,605	47%	66%	14.3	3
COLUMBIA_PLATEAU	11,282	36%	10,804	20%	22,086	26%	31%	7.0	10
MOUNTAIN_SNAKE	8,033	25%	4,028	8%	12,061	14%	61%	2.8	9
ALL PROVINCES	31,759	100%	53,108	100%	84,867	100%	n/a	n/a	28
SUMMER/FALL CHINOOK									
BLUE_MOUNTAIN	275	1%	0	0%	275	1%	13%	3.7	1
COLUMBIA_CASCADE	10,751	35%	4,608	86%	15,358	42%	20%	6.0	3
COLUMBIA_PLATEAU	4,014	13%	0	0%	4,014	11%	8%	9.9	1
MOUNTAIN_SNAKE	15,850	51%	739	14%	16,589	46%	77%	3.6	7
ALL PROVINCES	30,889	100%	5,346	100%	36,236	100%	n/a	n/a	12
FALL CHINOOK									
BLUE_MOUNTAIN	2,197	3%	0	0%	2,197	3%	20%	1.9	1
COLUMBIA_GORGE	5,152	8%	7,774	38%	12,926	15%	37%	13.8	1
COLUMBIA_PLATEAU	57,606	89%	12,677	62%	70,282	82%	18%	10.0	4
ALL PROVINCES	64,955	100%	20,451	100%	85,405	100%	n/a	n/a	6
TOTAL CHINOOK									
BLUE_MOUNTAIN	4,798	4%	1,285	2%	6,082	3%	n/a	n/a	5
COLUMBIA_CASCADE	12,614	10%	10,249	13%	22,863	11%	n/a	n/a	6
COLUMBIA_GORGE	13,408	11%	39,124	50%	52,532	25%	n/a	n/a	4
COLUMBIA_PLATEAU	72,901	57%	23,481	30%	96,382	47%	n/a	n/a	15
MOUNTAIN_SNAKE	23,883	19%	4,767	6%	28,650	14%	n/a	n/a	16
ALL PROVINCES	127,603	100%	78,905	100%	206,509	100%	n/a	n/a	46

Moderate

	Abundance: Natural	% of Total	Hatchery	% of Total	Hatch + Natural	% of Total	Life Hist. Divers. Index	Productivity	Nbr. of Sust. Popul
SPRING									
BLUE_MOUNTAIN	3,760	11%	3,466	4%	7,225	6%	55%	3.1	3
COLUMBIA_CASCADE	2,285	7%	11,332	13%	13,617	12%	84%	3.0	3
COLUMBIA_GORGE	5,513	17%	42,774	50%	48,287	41%	67%	8.6	3
COLUMBIA_PLATEAU	9,701	29%	16,828	20%	26,528	22%	33%	5.1	10
MOUNTAIN_SNAKE	11,909	36%	10,682	13%	22,590	19%	65%	3.2	9
ALL PROVINCES	33.167	100%	85,080	100%	118.248	100%	n/a	n/a	28
SUMMER/FALL CHINOOK									
BLUE_MOUNTAIN	420	1%	0	0%	420	1%	14%	4.1	1
COLUMBIA_CASCADE	10,256	29%	9,198	83%	19,452	42%	24%	4.5	4
COLUMBIA_PLATEAU	3,391	10%	0	0%	3,391	7%	9%	7.0	1
MOUNTAIN_SNAKE	21,394	60%	1,940	17%	23,334	50%	84%	3.8	7
ALL PROVINCES	35,459	100%	11,138	100%	46,597	100%	n/a	n/a	13
FALL CHINOOK									
BLUE_MOUNTAIN	3,634	6%	0	0%	3,634	3%	49%	2.2	1
COLUMBIA_GORGE	4,636	7%	15,173	36%	19,809	19%	42%	8.3	2
COLUMBIA_PLATEAU	53,673	87%	27,031	64%	80,704	77%	20%	7.9	4
ALL PROVINCES	61,943	100%	42,204	100%	104,147	100%	n/a	n/a	7
TOTAL CHINOOK									
BLUE_MOUNTAIN	7,815	6%	3,466	3%	11,279	4%	n/a	n/a	5
COLUMBIA_CASCADE	12,540	10%	20,529	15%	33,069	12%	n/a	n/a	7
COLUMBIA_GORGE	10,148	8%	57,947	42%	68,095	25%	n/a	n/a	5
COLUMBIA_PLATEAU	66,764	51%	43,859	32%	110,623	41%	n/a	n/a	15
MOUNTAIN_SNAKE	33,302	26%	12,622	9%	45,924	17%	n/a	n/a	16
ALL PROVINCES	130,569	100%	138,421	100%	268,991	100%	n/a	n/a	48

Technology Optimistic

	Abundance: Natural	% of Total	Hatchery	% of Total	Hatch + Natural	% of Total	Life Hist. Divers. Index	Productivity	Nbr. of Sust. Popul.
SPRING									
BLUE_MOUNTAIN	5,302	15%	6,510	6%	11,812	8%	58%	3.1	3
COLUMBIA_CASCADE	2,456	7%	15,861	15%	18,317	13%	73%	2.6	3
COLUMBIA_GORGE	3,308	9%	44,485	41%	47,794	33%	70%	4.9	4
COLUMBIA_PLATEAU	10,669	30%	20,646	19%	31,315	22%	35%	3.9	11
MOUNTAIN_SNAKE	14,079	39%	19,785	18%	33,864	24%	68%	3.3	9
ALL PROVINCES	35,814	100%	107,287	100%	143,100	100%	n/a	n/a	30
SUMMER/FALL CHINOOK									
BLUE_MOUNTAIN	2,697	5%	0	0%	2,697	4%	19%	3.8	1
COLUMBIA_CASCADE	12,372	24%	13,341	79%	25,713	37%	26%	3.0	4
COLUMBIA_PLATEAU	10,844	21%	0	0%	10,844	16%	20%	3.2	3
MOUNTAIN_SNAKE	26,506	51%	3,617	21%	30,122	43%	87%	3.8	7
ALL PROVINCES	52,419	100%	16,957	100%	69,376	100%	n/a	n/a	15
FALL CHINOOK									
BLUE_MOUNTAIN	4,930	8%	0	0%	4,930	4%	75%	2.3	1
COLUMBIA_GORGE	7,388	12%	21,981	33%	29,369	23%	74%	4.6	2
COLUMBIA_PLATEAU	49,356	80%	44,170	67%	93,525	73%	24%	5.8	6
ALL PROVINCES	61,674	100%	66,151	100%	127,825	100%	n/a	n/a	9
TOTAL CHINOOK									
BLUE_MOUNTAIN	12,929	9%	6,510	3%	19,439	6%	n/a	n/a	5
COLUMBIA_CASCADE	14,828	10%	29,202	15%	44,030	13%	n/a	n/a	7
COLUMBIA_GORGE	10,696	7%	66,467	35%	77,163	23%	n/a	n/a	6
COLUMBIA_PLATEAU	70,869	47%	64,815	34%	135,684	40%	n/a	n/a	20
MOUNTAIN_SNAKE	40,585	27%	23,401	12%	63,986	19%	n/a	n/a	16
ALL PROVINCES	149,906	100%	190,395	100%	340,302	100%	n/a	n/a	54

Table IV.A.4 Biological performance results for the Current Potential, under the three worldviews.

that, Figure IV.A.16. Total number of hatchery chinook salmon returning to the river, with and without ocean and mainstem harvest.

Dependent on worldview, total chinook production potential ranges from approximately 206,000 to 340,000. Natural chinook represent between 127,000 (~62 percent) and 150,000 (~44 percent) of total production for the Technology Pessimistic and Optimistic worldviews, respectively. For these same worldviews hatchery fish constitute 38 percent (79,000) and 56 percent (190,000) of all chinook production, respectively. These results are consistent with the assumptions inherent in each worldview, i.e., hatchery fish do better under the Technology Optimistic set of assumptions than under the Technology Pessimistic set.

In Figure IV.A.18 we show Current Potential chinook production of the basin relative to the Historic Potential. This comparison shows that regardless of the worldview examined, current chinook abundance is less than ~17 percent of Historic Potential.

Note that the Historic Potential is different for the three worldviews. The Technology Pessimist estimates Current Potential at four percent of a larger number, and the Technology Optimist sees it as 17 percent of a smaller number.

These results were expected, as the analysis was undertaken in order to develop an effective approach for recovering chinook populations whose numbers are so low that they have been listed under the Endangered Species Act (ESA). We present and discuss model results by ESU later in this report.

Chinook productivity has also decreased substantially from the Historic Potential (Table IV.A.4). For example, spring chinook productivity under the Moderate worldview historically ranged from approximately 22 to 28, now it ranges from three to nine dependent on province (Moderate assumptions). The reduction in productivity means that chinook populations would recover more slowly when population abundance is reduced. Actions that increase productivity would therefore decrease the amount of time required for chinook populations to meet recovery objectives.

The life history diversity index value for summer/fall, fall, and spring chinook have dropped from an unweighted average of about 100 percent, to 33 percent, 37 percent and 61 percent, respectively (Table IV.A.4-Moderate). The large drop in life history diversity makes these populations less resilient to environmental change, thereby increasing their risk of extinction. Actions designed to increase life history diversity would help to reduce this extinction risk.

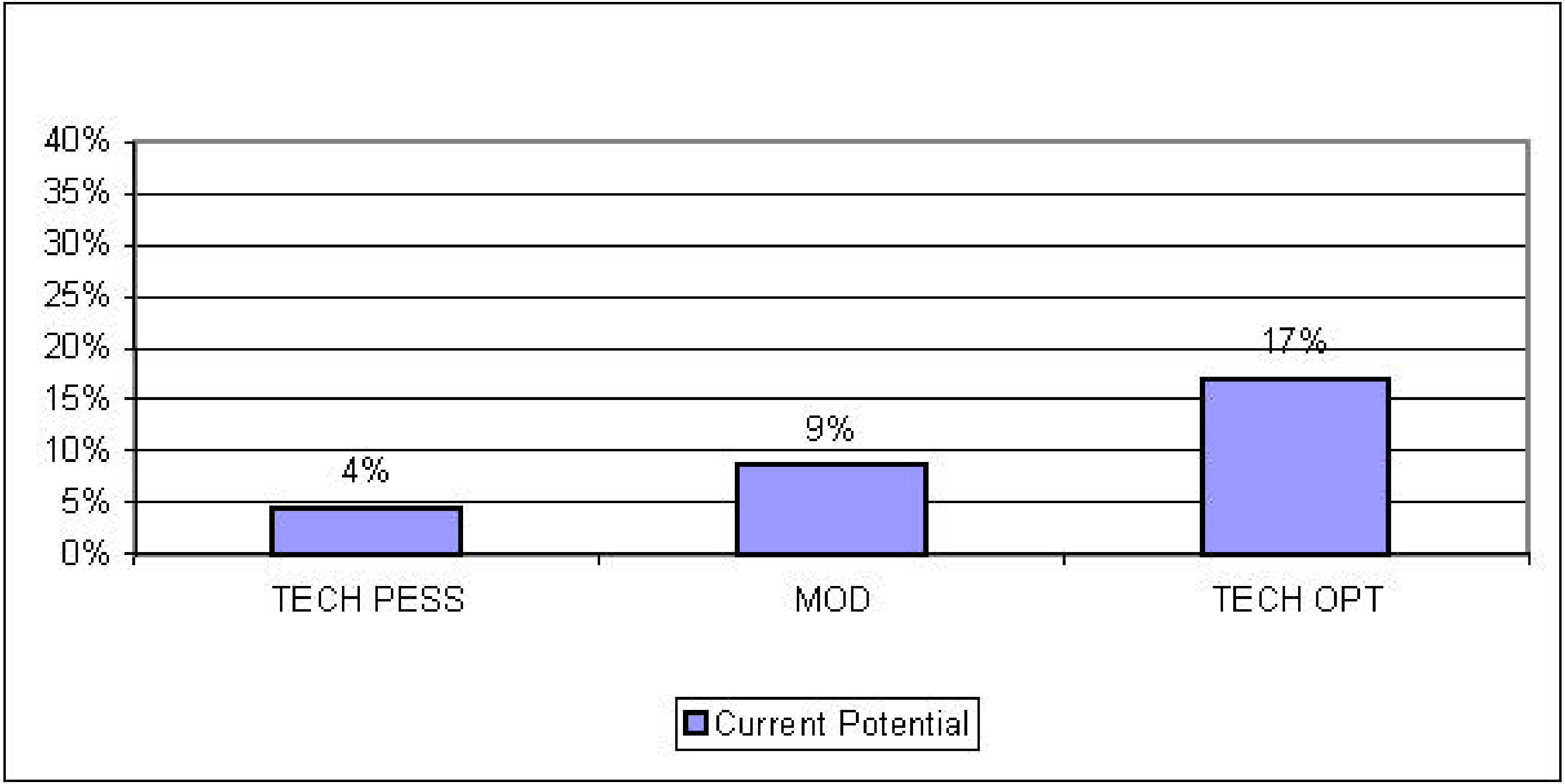


Figure IV.A.18 Current Potential chinook abundance expressed as a percent of the Historic Potential of the Columbia River Basin.

In Table IV.A.4 the reader will also see data presented on the number of fish populations present in the basin today. These data indicate that a number of populations are no longer present under the Current Potential. Under the Moderate worldview set of assumptions the number of populations have been reduced from 65 under the Historic Potential to 48 under the Current Potential. These data do not necessarily indicate the loss of a unique stock, but instead reflect a decrease in fish distribution and habitat. For example, due to the construction of the Pelton Round Butte Hydroelectric Complex (Deschutes River, OR), spring chinook no longer have access to the Crooked River and Metolius River. Modeling results therefore show a loss of two populations in the Deschutes River Basin (Columbia Plateau province).

The results presented in this section show that current chinook abundance, productivity, population numbers, and life history diversity in the Columbia River Basin have been severely reduced in comparison to the Historic Potential. In the section below we describe how chinook performance has changed over time in the five provinces.

Province Scale Analysis

Modeling results for each of the five provinces are also summarized in Table IV.A.4. Because the discussion points presented above for the basin level analysis also apply at the province level, they are not repeated here. Instead, we simply use the Moderate assumption data in Table IV.A.4 to quickly summarize the key biological performance results obtained at the province scale.

The change from historical for each of the environmental attributes modeled is presented in Table IV.A.5. The data in Table IV.A.5 represent the number of instances (data points) where the current value for the attribute exceeds the historical value. For example, there were 90 instances where the bed scour attribute was rated worse than historic conditions in the Blue Mountain province (Table IV.A.5).

The environmental attributes affect tributary freshwater habitat productivity[2]. It should be noted that the habitat environmental attributes were not included in this table, as a change in habitat diversity may have either positive or negative effects on chinook performance. Additionally, you will note that there is no data for some of the attributes listed in Table

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[2] Because of the presence of dams in the mainstem Columbia and Snake Rivers, mainstem habitat was treated (rated) differently than tributary habitat. Juvenile and adult survival through the mainstem was based on NMFS and PATH survival data, flow and juvenile travel time relationships, and predation information.

	BLUE_ MOUNTAIN	COLUMBIA_ CASCADE	COLUMBIA_ GORGE	COLUMBIA_ PLATEAU	MOUNTAIN_ SNAKE
	Current	**Current**	**Current**	**Current**	**Current**
Alkalinity					
Bed scour	90	87	33	955	350
Benthos diversity and production	84	36	36	1164	312
CONFINE					
ConfineHydro					552
Dissolved oxygen					
Embeddedness	204	312	204	1620	708
Flow - interannual variability in high flows	4			16	2
Flow - intra-annual flow pattern-monthly variation					
Flow - interannual variability in low flows	36	32	23	204	193
Fine sediment	612	564	228	2592	2580
Fish community richness					
Fish pathogens					
Fish species introductions					
Gradient					
Harvest and harassment					
Hatchery fish outplants					
SumOfHydroRegimeReg					
Icing					
Metals - in sediments/soils					
Metals - in water column					
Miscellaneous toxic pollutants - water column					84
Nutrient enrichment	115	43	12	662	522
Obstructions to fish migration					
Predation risk					
Riparian function	624	576	252	2868	2028
Salmon Carcasses					
Temperature - daily maximum (by month)	157	154	44	722	555
Temperature - daily minimum (by month)			18		
Temperature - spatial variation					
Turbidity	241	266	126	1268	522
Wood debris	624	600	300	2640	2208

Table IV.A.5 Number of instances where Current Potential environmental attributes are degraded from the Historic Potential.

Note 1: Blank cells imply values for the Level 2 attribute did not exist or that the differences between the Current Potential and the Historic

IV.A.5. This is due to the fact that there was no or little difference between values for "icing" in the Current Potential and the alternatives, or that the attribute has yet to be rated (e.g. fish pathogens).

The resulting change in tributary freshwater habitat from the Historic Potential to the Current Potential for each province is presented in Table IV.A.6. The freshwater productivity index values presented in the table represent the average number of yearling juveniles (per 1,000 eggs) that would survive to the smolt stage with the *removal of all density dependent survival factors*.

The key results embedded in this table are presented below in bullet format. Unless otherwise noted, the discussion is based on the results presented for the Moderate worldview.

- For Historic Potential the highest quality freshwater habitat was found in the Mountain Snake, followed by the Columbia Cascade, Blue Mountain, Columbia Plateau, and Columbia Gorge.
- In contrast, the highest quality habitat for the Current Potential is present in the Mountain Snake, followed by the Columbia Gorge, Columbia Cascade, Blue Mountain, and finally the Columbia Plateau.
- Freshwater habitat productivity values for the provinces are currently 20 percent-60 percent of their Historic Potential.

The data in Table IV.A.6 indicate that actions tied to improving habitat conditions in the tributaries have the potential to improve productivity significantly.

ESU Scale Analysis

The five Evolutionary Significant Units (ESUs) included in this analysis are identified in Table IV.A.7. Modeling results for each of the five ESUs are summarized in Table IV.A.8. Because the discussion points presented above for the basin level analysis also apply at the ESU level, they are not repeated here. Instead, we use the data in Table IV.A.8 to quickly summarize the key biological performance results obtained at the ESU scale.

Differences among ESUs in the patterns of change from Historic Potential suggest different sensitivities and/or causes of decline among ESUs.

> The historic potential abundance by ESU is shown in Figure IV.A.19. The key biological performance results for the Current Potential ESU analysis are as follows:

	BLUE_ MOUNTAIN		COLUMBIA_ CASCADE		COLUMBIA_ GORGE		COLUMBIA_ PLATEAU		MOUNTAIN_ SNAKE	
Alternative	Historic Potential	Current Potential	Historic Potential	Current Potential	Historic Potential	Current Potential	Historic Potential	Current Potential	Historic Potential	Current Potential
Tech.Pess.	160.2	50.5	142.3	64	142.2	70.4	157.1	35.1	185.1	102.7
Moderate	165.7	58.4	166.2	75.4	158	83.7	163.9	41.5	187.9	111.6
Tech.Opt.	170.7	71.5	155.8	89.5	157.3	94.2	168	52.7	189.6	123.7

Table IV.A.6 Freshwater productivity under Current Potential and Historic Potential by province. Productivity is expressed as number of juveniles produced per 1,000 eggs.

ESU Number	General Description
ESU-11	Mid-Columbia Spring Chinook
ESU-12	Mid/Upper Columbia Summer and Fall Chinook
ESU-13	Upper Columbia Spring Chinook
ESU-14	Snake Fall Chinook
ESU-15	Snake Summer and Spring Chinook

Table IV.A.7 Identification of Columbia River Ecological Significant Units (ESUs) included in this analysis (Source: NMFS website at http://www.nmfs.noaa.gov).

	ESU-11	ESU-12	ESU-13	ESU-14	ESU-15
Abundance	6%	9%	7%	1%	7%
Productivity	22%	30%	11%	17%	13%
Diversity	38%	44%	84%	16%	75%

Table IV.A.8 Current Potential as a percent of Historic Potential.

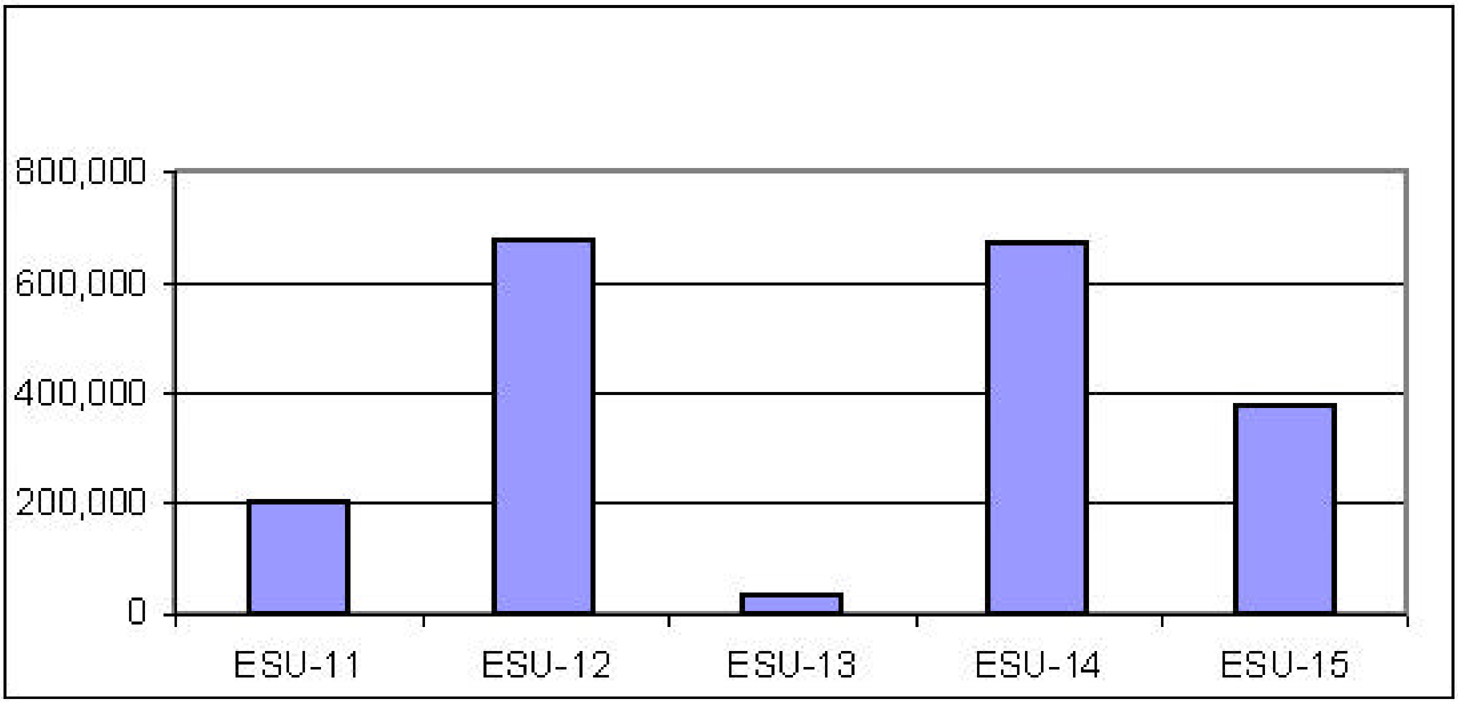


Figure IV.A.19 Historic Potential abundance by ESU.

- All ESUs have been reduced to less than 10 percent of Historic Potential abundance.
- ESU-14 has experienced the greatest loss of abundance potential – it is currently at only one percent of Historic Potential.
- Current Potential productivity ranges from 11 percent of Historic Potential for ESU-13 to 30 percent for ESU-12.
- Life history diversity ranges from a high of 84 percent of Historic Potential for ESU-13 to 16 percent for ESU-14.

Alternative 2

EDT modeling results for Alternative 2 are presented in this section. Results are described at the basin, province, and ESU geographic scales. We also use the Framework graph presented earlier in this report to show the linkage between Alternative 2 actions, environmental attributes, and biological performance.

Alternative Overview

For review purposes we have listed below the major actions included in Alternative 2 to improve chinook performance in the basin. These actions are as follows:

- The breeching of John Day and the four lower Snake River hydroelectric projects.
- Implement hatchery supplementation program and improved hatchery rearing techniques to increase the quantity and quality of fish returning to the basin.
- A moderate improvement in freshwater tributary habitat—habitat actions were applied with equal intensity on both public (2) and private lands (2).
- As is the case with all alternatives, ocean and mainstem harvest has been eliminated in Alternative 2.

The effect that the combined actions had on the environmental attributes and the resulting biological performance (chinook abundance) is shown graphically in Figure IV.A.20. The values in the environmental attributes table represent the percent improvement over Current Potential resulting from the implementation of the alternative. The biological performance figure shows the percent improvement in natural chinook abundance for

Alternative 2

Actions ⟷ (Rationale) ⟷ Environmental Attributes ⟷ (Rationale) ⟷ Biological Performance

Actions:

Habitat

Hatcheries

Hydro

Affected These Attributes →

Ecoprovinces

Environmental Atribute	**BM A2**	**CC A2**	**CG A2**	**CP A2**	**MS A2**
Alkalinity					
Bed Scour	42	48	59	44	43
Benthic Comm. Richness	30	26	22	32	30
Confinement Hydro					21
Embeddedness	44	46	45	46	46
Flow High	11			12	12
Flow Low	26	25	22	28	16
Fine Sediment	57	65	59	57	54
Misc. Toxic Waste					16
Nutrient enrichment	23	23	24	26	22
Riparian Function	48	47	47	48	47
Max Temp Month	38	34	33	39	34
Min Temp Month			45		
Turbidity	49	50	50	48	45
Woody Debris	55	57	58	56	54

To Produce This Performance →

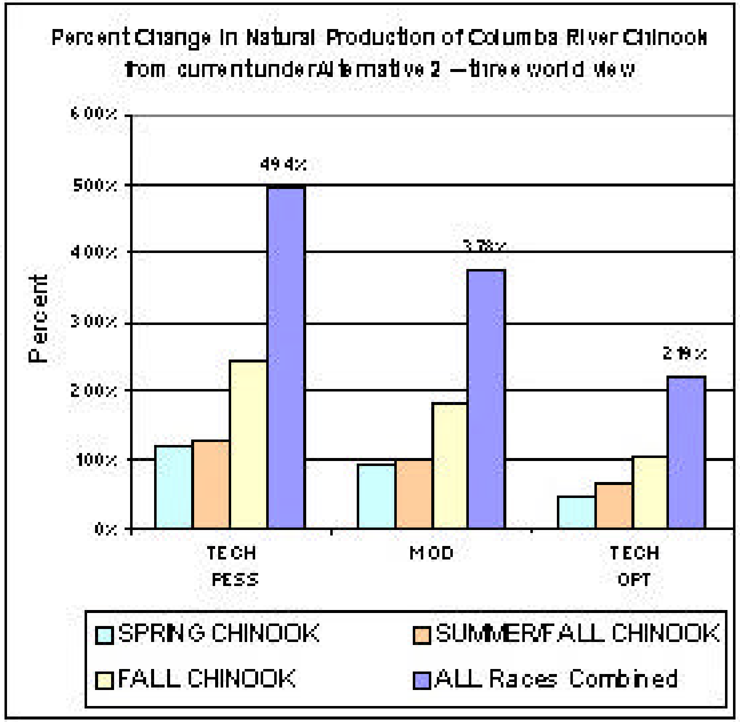


Figure IV.A.20 Framework logic for Alternative 2. Table data shows the percent improvement over Current Potential for each listed attribute.

all races combined. The percent values presented by race show the proportion that each contributed to the entire total. The reader should be aware that the Hydro and Hatchery related environmental attributes were not included in this chart due to space constraints. However, the change in these attributes does have an effect on resulting biological performance for each alternative. In a later section of this report we will identify these attributes and show how they could be used in establishing biological objectives for each alternative.

The increase in freshwater habitat productivity under this alternative is shown in Table IV.A.9. The percent change in freshwater productivity over current (Moderate) varied from 25 percent for the Mountain Snake to ~112 percent in the Columbia Plateau. For all provinces combined, freshwater productivity increased by an average of ~61 percent. Whether or not Alternative 2 habitat actions would actually achieve this level of improvement would be dependent on the region's ability to successfully implement the actions and their eventual effectiveness.

However, the reader should note that the environmental data driving these productivity values would be reviewed for accuracy during the assessment and subbasin planning phases of the Framework process. The incorporation of more accurate data may change estimates of resulting productivity significantly.

Columbia Basin Scale Analysis

In Table IV.A.10 we present a summary of modeling results for Alternative 2. The data in this table include information on abundance, productivity, life history diversity, number of natural and hatchery fish, and number of populations[3].

Alternative 2 is expected to increase chinook abundance over the Current Potential from 164 percent to 381 percent dependent on the true state-of-nature (worldview) (Figure IV.A.21). This alternative provides the greatest increase under the Technology Pessimistic worldview and the least amount of change under the Technology Optimistic set of assumptions.

The percent change from current for both natural and hatchery production for this alternative is shown in Figure IV.A.22. The data in this figure indicate that natural production increases from 219 percent to 494 percent, hatchery production from 120 percent to 197 percent, dependent on worldview.

[3] Population numbers increase either when actions in the alternative allow fish access to previously blocked habitat (extends range) or when an existing population's productivity value exceeds 1.0.

	BLUE_MOUNTAIN			COLUMBIA_CASCADE			COLUMBIA_GORGE			COLUMBIA_PLATEAU			MOUNTAIN_SNAKE		
Alt	Historic Potential	Current Potential	A2	Historic Potential	Current Potential	A2	Historic Potential	Current Potential	A2	Historic Potential	Current Potential	A2	Historic Potential	Current Potential	A2
Tech Pess	160.2	50.5	95.7	142.3	64	91.6	142.2	70.4	101.3	157.1	35.1	77.3	185.1	102.7	129.9
Mod	165.7	58.4	107.2	166.2	75.4	111.2	158	83.7	116.5	163.9	41.5	88	187.9	111.6	139.2
Tech Opt	170.7	71.5	119.8	155.8	89.5	117	157.3	94.2	126.1	168	52.7	101.9	189.6	123.7	149.5

Table IV.A.9 Freshwater productivity under Current, Historic, and alternative 2 conditions by province. Productivity is expressed as number of juveniles produced per 1,000 eggs.

ALTERNATIVE 2

Technology Pessimistic

	Abundance: Nautral	% of Total	Hatchery	% of Total	Hatch + Natural	% of Total	Life Hist. Divers. Index	Productivity	Nbr. of Sust. Popul.
SPRING									
BLUE_MOUNTAIN	29,739	16%	8,796	6%	38,535	12%	96%	10.2	3
COLUMBIA_CASCADE	5,525	3%	14,596	10%	20,121	6%	95%	5.3	3
COLUMBIA_GORGE	22,120	12%	59,648	42%	81,768	25%	100%	21.8	4
COLUMBIA_PLATEAU	68,281	37%	32,231	23%	100,512	31%	68%	14.3	14
MOUNTAIN_SNAKE	58,606	32%	26,398	19%	85,003	26%	76%	11.9	9
ALL PROVINCES	184,270	100%	141,669	100%	325,939	100%	n/a	n/a	33
SUMMER/FALL CHINOOK									
BLUE_MOUNTAIN	12,502	6%	0	0%	12,502	5%	100%	15.4	1
COLUMBIA_CASCADE	26,729	13%	29,112	85%	55,842	24%	43%	7.8	4
COLUMBIA_PLATEAU	48,774	24%	0	0%	48,774	21%	64%	12.5	4
MOUNTAIN_SNAKE	111,233	56%	5,026	15%	116,258	50%	100%	15.0	7
ALL PROVINCES	199,237	100%	34,138	100%	233,375	100%	n/a	n/a	16
FALL CHINOOK									
BLUE_MOUNTAIN	28,621	8%	0	0%	28,621	7%	92%	8.5	1
COLUMBIA_GORGE	23,529	6%	16,307	28%	39,837	9%	97%	14.0	2
COLUMBIA_PLATEAU	322,788	86%	42,158	72%	364,946	84%	69%	11.0	8
ALL PROVINCES	374,938	100%	58,466	100%	433,403	100%	n/a	n/a	11
TOTAL CHINOOK									
BLUE_MOUNTAIN	70,861	9%	8,796	4%	79,658	8%	n/a	n/a	5
COLUMBIA_CASCADE	32,254	4%	43,709	19%	75,963	8%	n/a	n/a	7
COLUMBIA_GORGE	45,649	6%	75,955	32%	121,605	12%	n/a	n/a	6
COLUMBIA_PLATEAU	439,842	58%	74,389	32%	514,232	52%	n/a	n/a	26
MOUNTAIN_SNAKE	169,838	22%	31,423	13%	201,262	20%	n/a	n/a	16
ALL PROVINCES	758,445	100%	234,272	100%	992,718	100%	n/a	n/a	60

Moderate

	Abundance: Nautral	% of Total	Hatchery	% of Total	Hatch + Natural	% of Total	Life Hist. Divers. Index	Productivity	Nbr. of Sust. Popul.
SPRING									
BLUE_MOUNTAIN	26,870	18%	12,081	7%	38,951	12%	97%	8.2	3
COLUMBIA_CASCADE	6,138	4%	22,131	13%	28,268	9%	95%	5.1	3
COLUMBIA_GORGE	14,103	9%	64,200	37%	78,303	24%	100%	12.5	4
COLUMBIA_PLATEAU	52,351	35%	40,553	23%	92,904	28%	69%	10.0	14
MOUNTAIN_SNAKE	51,498	34%	36,213	21%	87,711	27%	76%	9.5	9
ALL PROVINCES	150,961	100%	175,176	100%	326,138	100%	n/a	n/a	33
SUMMER/FALL CHINOOK									
BLUE_MOUNTAIN	10,288	6%	0	0%	10,288	5%	100%	10.7	1
COLUMBIA_CASCADE	23,844	14%	48,081	87%	71,925	32%	46%	5.6	4
COLUMBIA_PLATEAU	39,989	24%	0	0%	39,989	18%	66%	8.5	4
MOUNTAIN_SNAKE	95,335	56%	6,876	13%	102,211	46%	100%	11.0	7
ALL PROVINCES	169,457	100%	54,956	100%	224,413	100%	n/a	n/a	16
FALL CHINOOK									
BLUE_MOUNTAIN	22,657	7%	0	0%	22,657	6%	96%	6.4	1
COLUMBIA_GORGE	18,726	6%	36,599	39%	55,325	14%	99%	9.7	2
COLUMBIA_PLATEAU	261,852	86%	57,251	61%	319,103	80%	74%	8.0	8
ALL PROVINCES	303,235	100%	93,850	100%	397,085	100%	n/a	n/a	11
TOTAL CHINOOK									
BLUE_MOUNTAIN	59,816	10%	12,081	4%	71,896	8%	n/a	n/a	5
COLUMBIA_CASCADE	29,982	5%	70,211	22%	100,193	11%	n/a	n/a	7
COLUMBIA_GORGE	32,829	5%	100,799	31%	133,628	14%	n/a	n/a	6
COLUMBIA_PLATEAU	354,192	57%	97,803	30%	451,996	48%	n/a	n/a	26
MOUNTAIN_SNAKE	146,834	24%	43,088	13%	189,922	20%	n/a	n/a	16
ALL PROVINCES	623,653	100%	323,982	100%	947,636	100%	n/a	n/a	60

Technology Optimistic

	Abundance: Nautral	% of Total	Hatchery	% of Total	Hatch + Natural	% of Total	Life Hist. Divers. Index	Productivity	Nbr. of Sust. Popul.
SPRING									
BLUE_MOUNTAIN	19,111	18%	14,198	7%	33,309	11%	98%	5.6	3
COLUMBIA_CASCADE	5,279	5%	27,092	14%	32,371	11%	83%	3.7	3
COLUMBIA_GORGE	8,014	8%	65,059	33%	73,073	24%	100%	6.8	4
COLUMBIA_PLATEAU	36,253	35%	45,455	23%	81,708	27%	81%	6.2	14
MOUNTAIN_SNAKE	36,300	35%	42,513	22%	78,813	26%	93%	6.3	10
ALL PROVINCES	104,958	100%	194,316	100%	299,275	100%	n/a	n/a	34
SUMMER/FALL CHINOOK									
BLUE_MOUNTAIN	7,746	5%	0	0%	7,746	3%	100%	7.1	1
COLUMBIA_CASCADE	24,320	17%	75,087	90%	99,407	44%	48%	3.8	5
COLUMBIA_PLATEAU	41,557	29%	0	0%	41,557	19%	93%	5.0	4
MOUNTAIN_SNAKE	67,835	48%	8,087	10%	75,923	34%	100%	7.4	7
ALL PROVINCES	141,459	100%	83,174	100%	224,633	100%	n/a	n/a	17
FALL CHINOOK									
BLUE_MOUNTAIN	17,490	8%	0	0%	17,490	5%	101%	4.7	1
COLUMBIA_GORGE	13,662	6%	32,486	23%	46,148	12%	99%	6.6	2
COLUMBIA_PLATEAU	200,888	87%	109,365	77%	310,253	83%	82%	5.9	8
ALL PROVINCES	232,040	100%	141,850	100%	373,891	100%	n/a	n/a	11
TOTAL CHINOOK									
BLUE_MOUNTAIN	44,346	9%	14,198	3%	58,545	7%	n/a	n/a	5
COLUMBIA_CASCADE	29,599	6%	102,179	24%	131,778	15%	n/a	n/a	8
COLUMBIA_GORGE	21,677	5%	97,545	23%	119,222	13%	n/a	n/a	6
COLUMBIA_PLATEAU	278,699	58%	154,819	37%	433,518	48%	n/a	n/a	26
MOUNTAIN_SNAKE	104,136	22%	50,600	12%	154,736	17%	n/a	n/a	17
ALL PROVINCES	478,457	100%	419,341	100%	897,799	100%	n/a	n/a	62

Table IV.A.10 Biological performance results for Alternative 2 conditions, under the three worldviews.

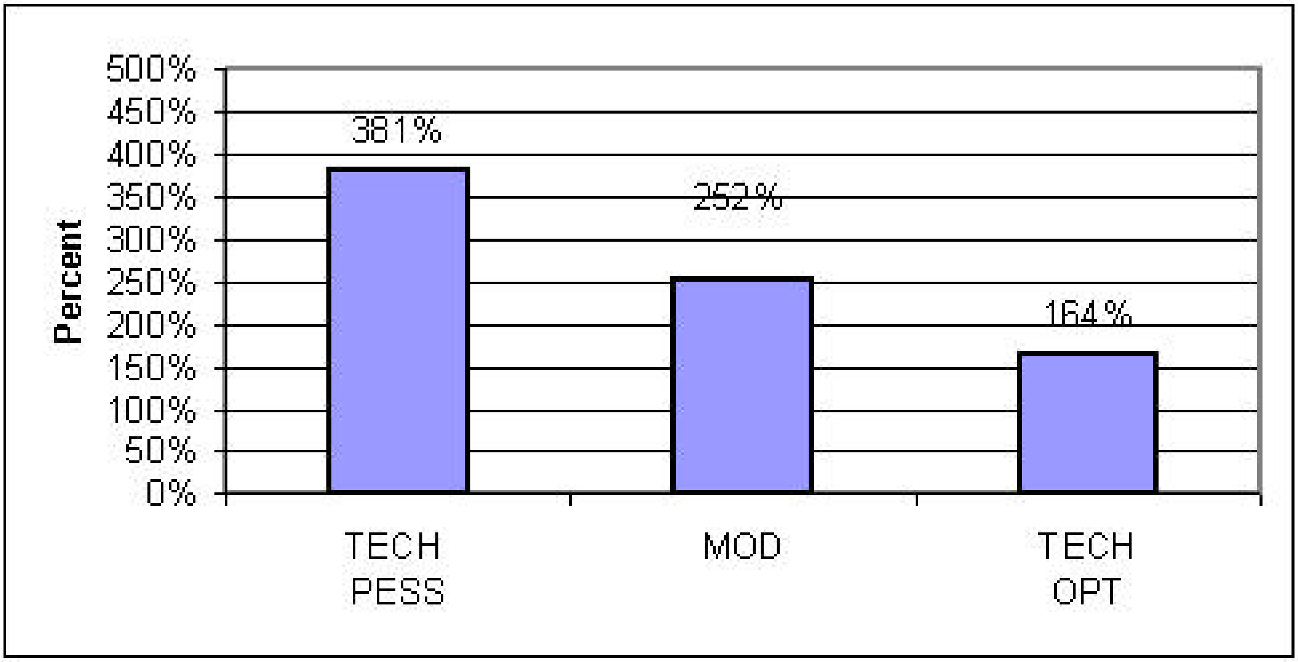
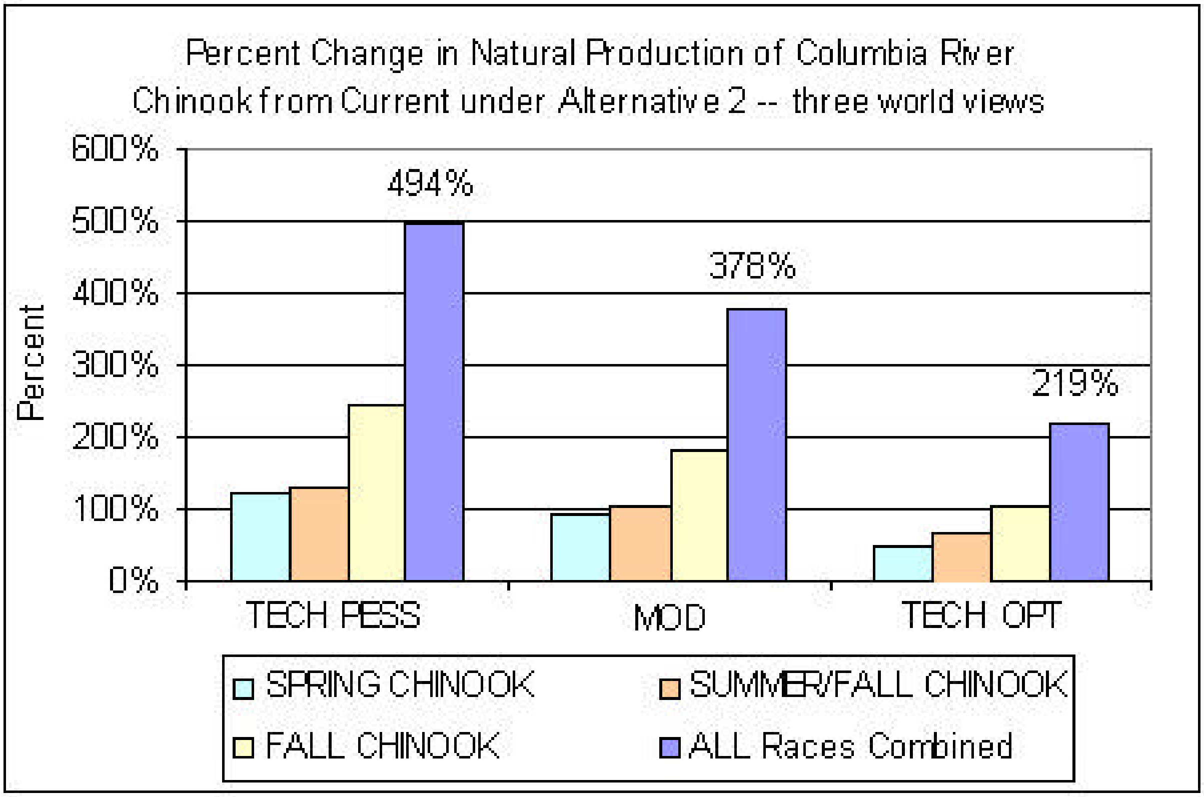


Figure IV.A.21 Percent change in chinook abundance over Current Potential for Alternative 2, under the three worldviews.



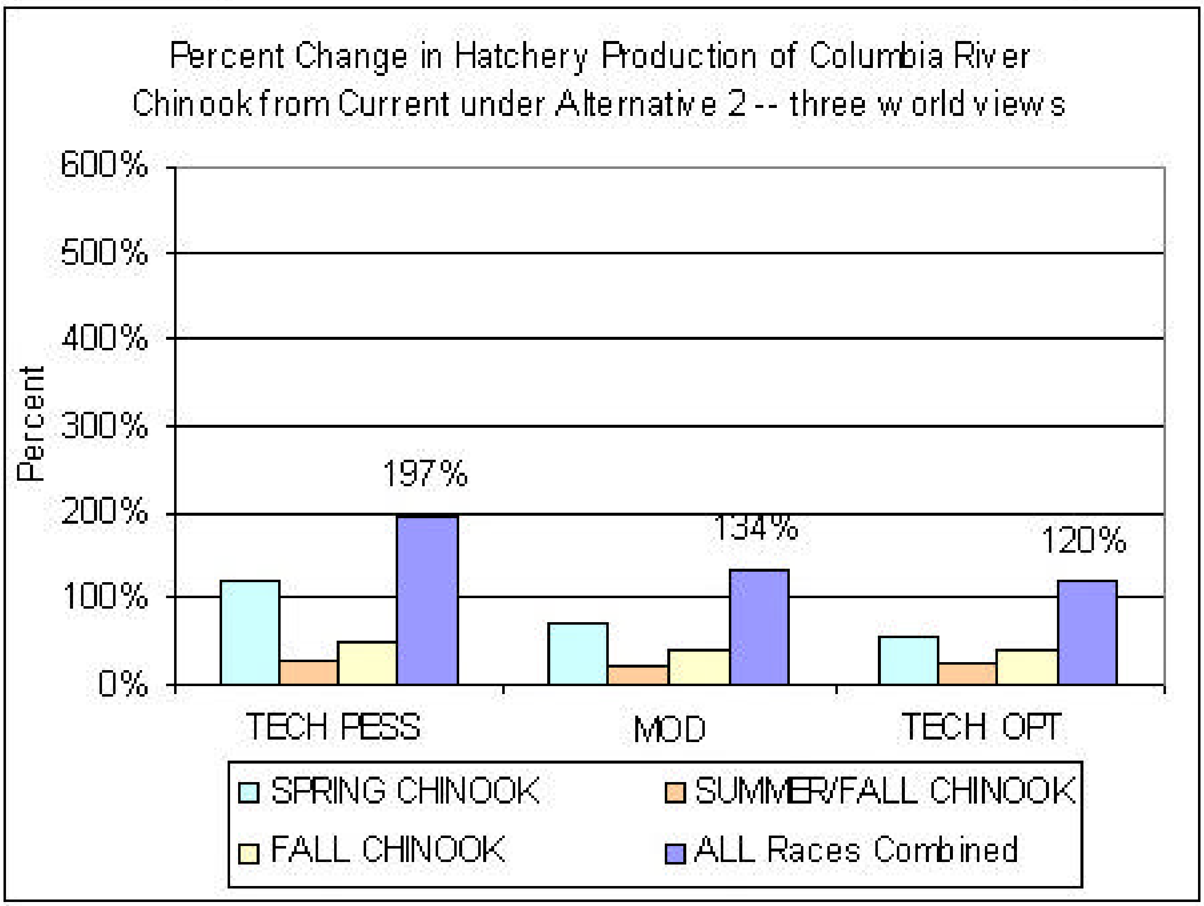


Figure IV.A.22 Percent change in natural and hatchery abundance for Alternairve 2, under the three worldviews.

The proportion of natural and hatchery fish produced for each worldview is presented in Figure IV.A.23. Note that the proportion of hatchery fish increase in the Technology Optimistic worldview due primarily to the assumption regarding hatchery fish fitness and post-release survival.

Alternative 2 performs best when the following assumptions about the state-of-nature are correct:

- The current juvenile transportation program is ineffective,
- Current in-river juvenile migration survival rates are low,
- Freshwater habitat degradation is high,
- Hatchery fish fitness is low, and
- Ocean survival rates are high.

The key biological performance results for the Alternative 2 province analysis are as follows:

- The largest increase over current for natural chinook abundance potential occurs in the Blue Mountain province (665 percent). Although all actions inherent in the alternative affect total abundance, the majority of the increase can be attributed to the dam removal strategy.
- Natural production increases the least in the Columbia Cascade (139 percent). This result is not surprising as many of the actions inherent in this alternative (e.g., dam removal) were designed to help Snake River chinook.
- The largest increase in hatchery fish abundance occurs in the Blue Mountain (249 percent) followed closely by the Columbia Cascade (242 percent).
- Alternative 2 increases chinook productivity in all provinces for all races. The largest increase in productivity occurs for spring chinook populations in the Mountain Snake (193 percent) the lowest for fall chinook in the Columbia Plateau (two percent)
- Life history diversity also increases in each province for all races. The Columbia Plateau life history diversity value for summer/fall chinook shows the greatest increase moving

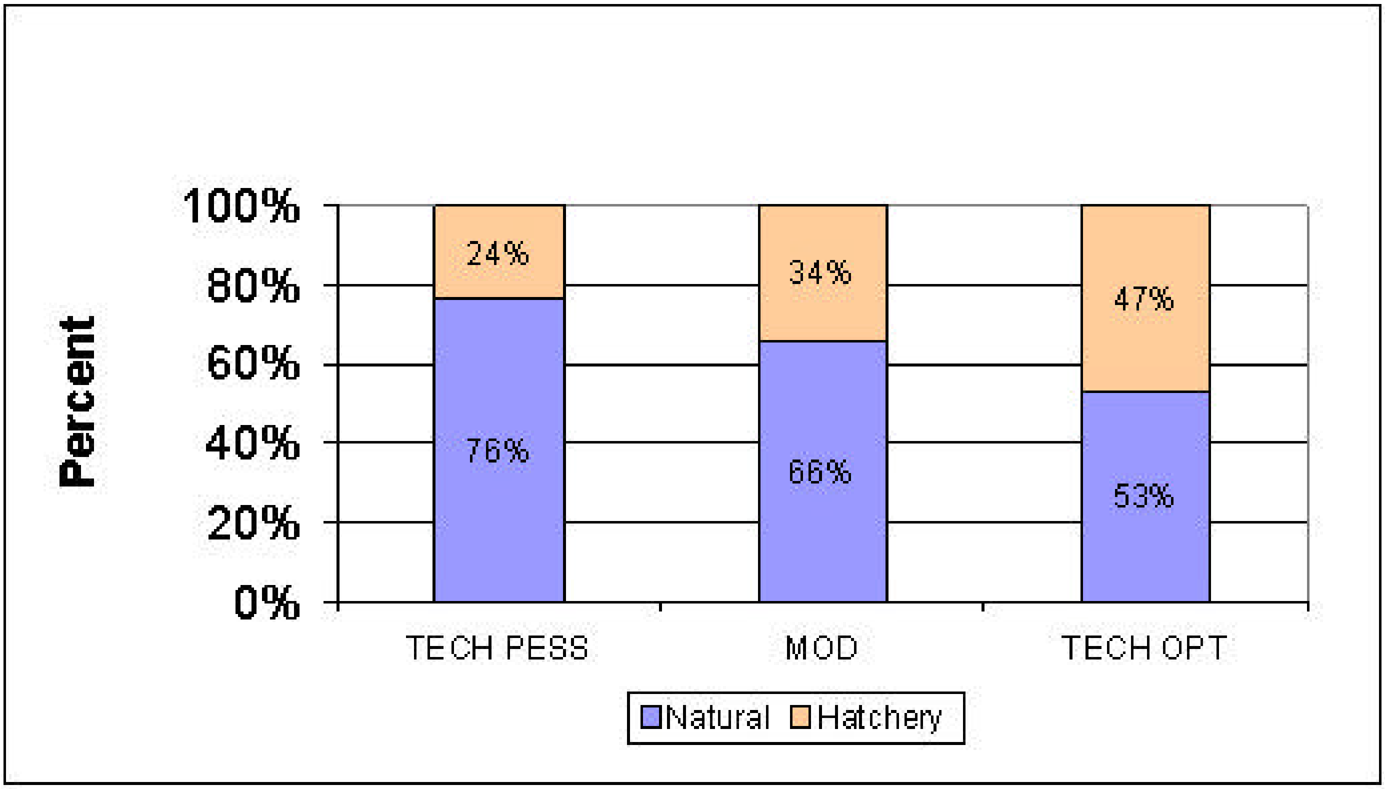


Figure IV.A.23 Percent natural and hatchery chinook for Alternative 2, under the three worldviews.

from a nine percent value under the Current Potential to ~66 percent.

- The number of viable populations increases from 48 under the Current Potential to 60.

Chinook productivity under this alternative increases by the amounts shown in Figure IV.A.24. These data indicate that average (weighted) spring chinook productivity increases from 70 percent to 106 percent, summer chinook from 75 percent to 157 percent, and fall chinook by six percent to 10 percent dependent on worldview. The small increase in fall chinook productivity results from the large influence the already productive Columbia Plateau population (Hanford Reach) has on model results. Of the ~303,000 natural fall chinook produced under this alternative, 262,000 are produced in this province. Again, increased productivity would improve the species' ability to rebound when population size is reduced to low numbers.

The life history values for each race and worldview are also presented in Table IV.A.10. Overall, spring, summer and fall chinook diversity values increased dramatically for most provinces and worldviews. Populations that can sustain a wide variety of life history patterns are likely to be more resilient to environmental change, which in turn should reduce their risk of extinction.

Under Alternative 2 the number of viable populations, in comparison to the current, increases by 12 to 14. For example, for the Moderate worldview spring, summer, and fall population numbers increase by five, three, and four respectively. As was noted previously in the discussion on Current Potential model results, the increase in viable populations generally results from an increase in range or habitat usage as new habitat becomes available from actions such as dam removal.

Province Scale Analysis

Modeling results for each of the five provinces are also summarized in Table IV.A.10 by race and worldview. Because the major points presented for the basin level analysis also apply at the province level, they are not repeated here. Instead we use a series of tables and figures to highlight the key biological performance results obtained at the province scale (Figure IV.A.25 and Table IV.A.11). Unless otherwise noted, the discussion will revolve around model results for the Moderate worldview. We will compare worldview modeling results for this and the other alternatives when we discuss uncertainty later in the report.

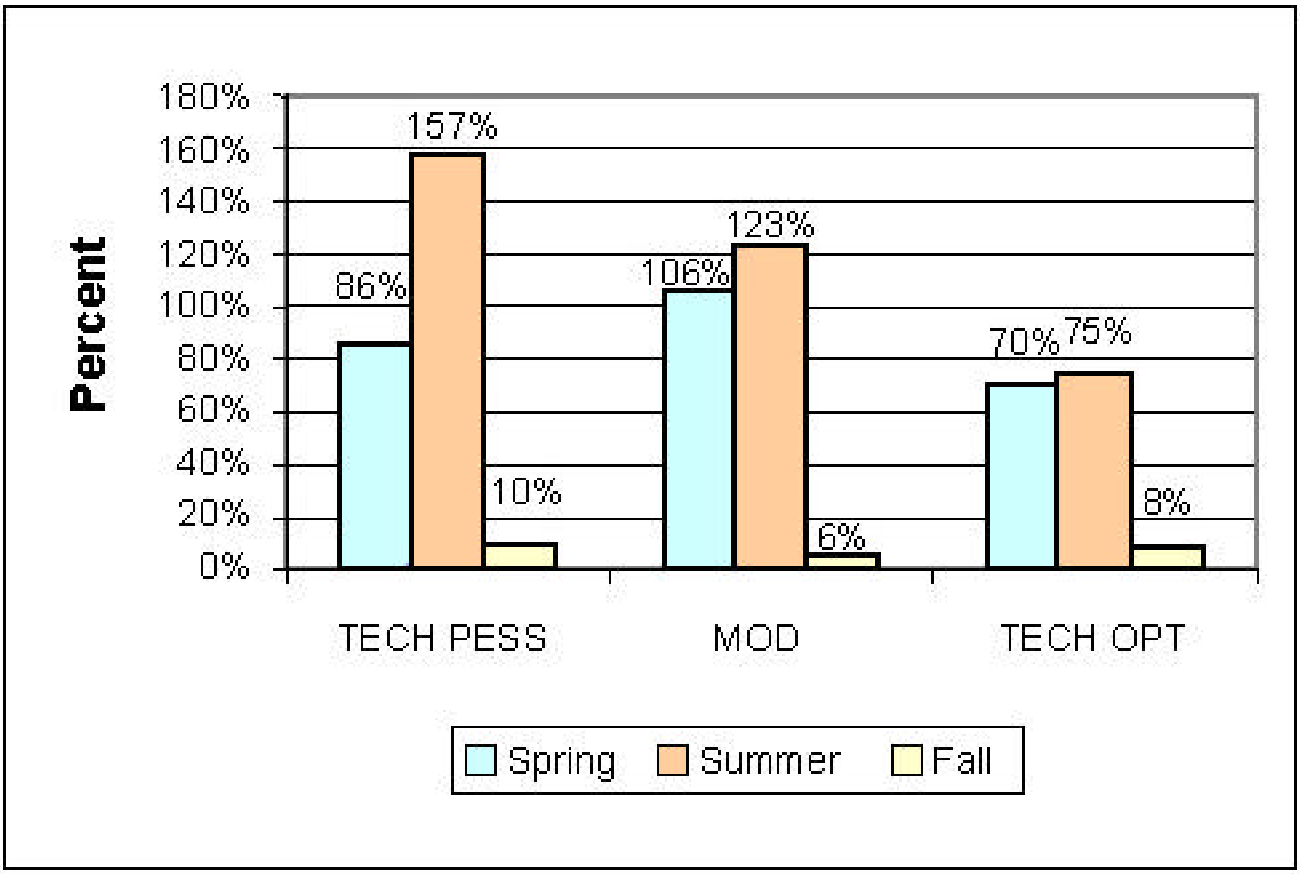


Figure IV.A.24 Percent change in chinook productivity over Current Potential for Alternative 2, by race and worldview.

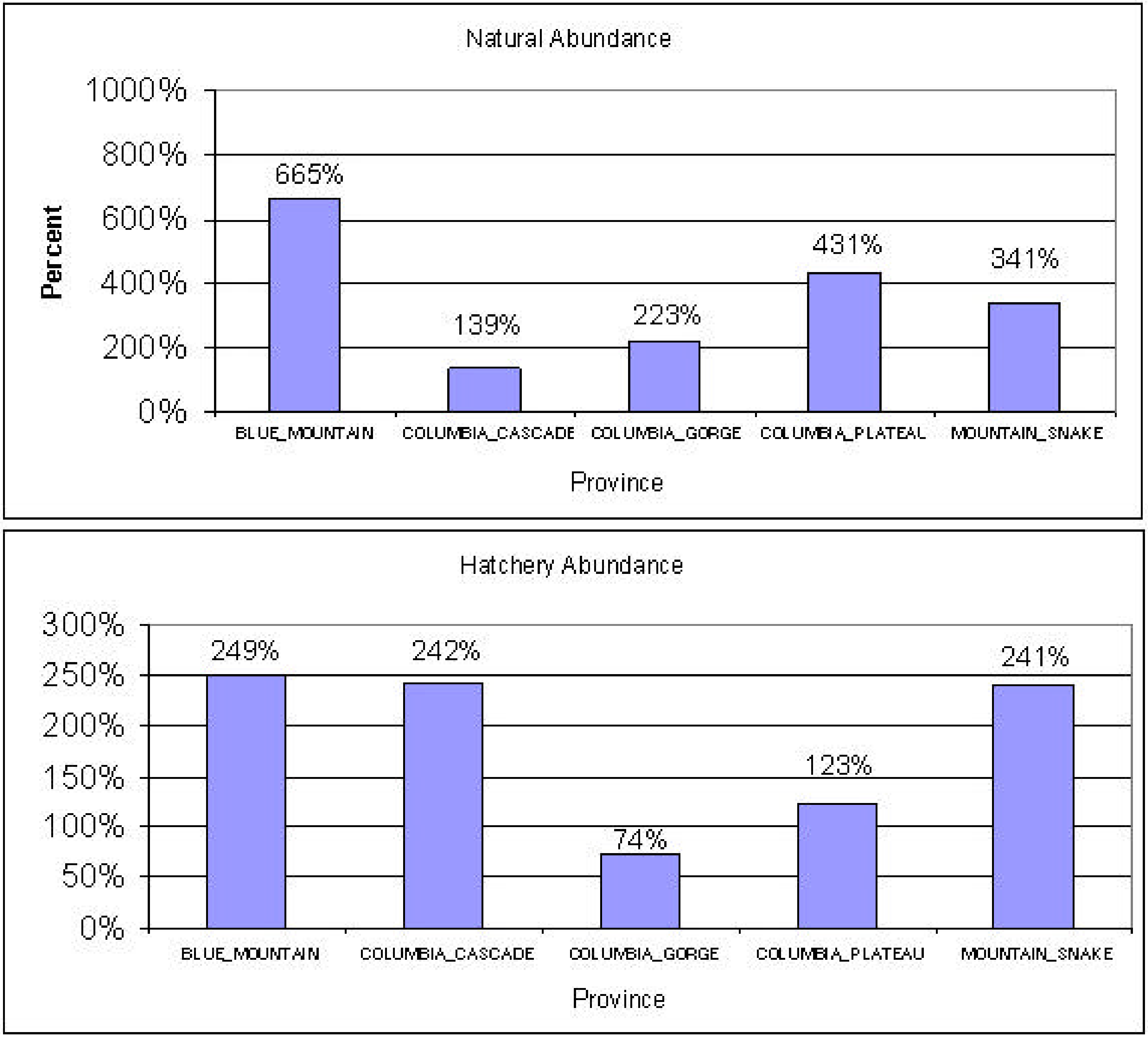


Figure IV.A.25 Percent change in natural chinook abundance potential from Current Potential by province for Alternative 2, under the Moderate worldview.

ALTERNATIVE 2

Technology Pessimistic

ALTERNATIVE 2	Abundance: Nautral	% of Total	Hatchery	% of Total	Hatch + Natural	% of Total	Life Hist. Divers. Index	Productivity	Nbr. of Sust. Popul.
SPRING									
BLUE_MOUNTAIN	29,739	16%	8,796	6%	38,535	12%	96%	10.2	3
COLUMBIA_CASCADE	5,525	3%	14,596	10%	20,121	6%	95%	5.3	3
COLUMBIA_GORGE	22,120	12%	59,648	42%	81,768	25%	100%	21.8	4
COLUMBIA_PLATEAU	68,281	37%	32,231	23%	100,512	31%	68%	14.3	14
MOUNTAIN_SNAKE	58,606	32%	26,398	19%	85,003	26%	76%	11.9	9
ALL PROVINCES	184,270	100%	141,669	100%	325,939	100%	n/a	n/a	33
SUMMER/FALL CHINOOK									
BLUE_MOUNTAIN	12,502	6%	0	0%	12,502	5%	100%	15.4	1
COLUMBIA_CASCADE	26,729	13%	29,112	85%	55,842	24%	43%	7.8	4
COLUMBIA_PLATEAU	48,774	24%	0	0%	48,774	21%	64%	12.5	4
MOUNTAIN_SNAKE	111,233	56%	5,026	15%	116,258	50%	100%	15.0	7
ALL PROVINCES	199,237	100%	34,138	100%	233,375	100%	n/a	n/a	16
FALL CHINOOK									
BLUE_MOUNTAIN	28,621	8%	0	0%	28,621	7%	92%	8.5	1
COLUMBIA_GORGE	23,529	6%	16,307	28%	39,837	9%	97%	14.0	2
COLUMBIA_PLATEAU	322,788	86%	42,158	72%	364,946	84%	69%	11.0	8
ALL PROVINCES	374,938	100%	58,466	100%	433,403	100%	n/a	n/a	11
TOTAL CHINOOK									
BLUE_MOUNTAIN	70,861	9%	8,796	4%	79,658	8%	n/a	n/a	5
COLUMBIA_CASCADE	32,254	4%	43,709	19%	75,963	8%	n/a	n/a	7
COLUMBIA_GORGE	45,649	6%	75,955	32%	121,605	12%	n/a	n/a	6
COLUMBIA_PLATEAU	439,842	58%	74,389	32%	514,232	52%	n/a	n/a	26
MOUNTAIN_SNAKE	169,838	22%	31,423	13%	201,262	20%	n/a	n/a	16
ALL PROVINCES	758,445	100%	234,272	100%	992,718	100%	n/a	n/a	60

Moderate

ALTERNATIVE 2	Abundance: Nautral	% of Total	Hatchery	% of Total	Hatch + Natural	% of Total	Life Hist. Divers. Index	Productivity	Nbr. of Sust. Popul.
SPRING									
BLUE_MOUNTAIN	26,870	18%	12,081	7%	38,951	12%	97%	8.2	3
COLUMBIA_CASCADE	6,138	4%	22,131	13%	28,268	9%	95%	5.1	3
COLUMBIA_GORGE	14,103	9%	64,200	37%	78,303	24%	100%	12.5	4
COLUMBIA_PLATEAU	52,351	35%	40,553	23%	92,904	28%	69%	10.0	14
MOUNTAIN_SNAKE	51,498	34%	36,213	21%	87,711	27%	76%	9.5	9
ALL PROVINCES	150,961	100%	175,176	100%	326,138	100%	n/a	n/a	33
SUMMER/FALL CHINOOK									
BLUE_MOUNTAIN	10,288	6%	0	0%	10,288	5%	100%	10.7	1
COLUMBIA_CASCADE	23,844	14%	48,081	87%	71,925	32%	46%	5.6	4
COLUMBIA_PLATEAU	39,989	24%	0	0%	39,989	18%	66%	8.5	4
MOUNTAIN_SNAKE	95,335	56%	6,876	13%	102,211	46%	100%	11.0	7
ALL PROVINCES	169,457	100%	54,956	100%	224,413	100%	n/a	n/a	16
FALL CHINOOK									
BLUE_MOUNTAIN	22,657	7%	0	0%	22,657	6%	96%	6.4	1
COLUMBIA_GORGE	18,726	6%	36,599	39%	55,325	14%	99%	9.7	2
COLUMBIA_PLATEAU	261,852	86%	57,251	61%	319,103	80%	74%	8.0	8
ALL PROVINCES	303,235	100%	93,850	100%	397,085	100%	n/a	n/a	11
TOTAL CHINOOK									
BLUE_MOUNTAIN	59,816	10%	12,081	4%	71,896	8%	n/a	n/a	5
COLUMBIA_CASCADE	29,982	5%	70,211	22%	100,193	11%	n/a	n/a	7
COLUMBIA_GORGE	32,829	5%	100,799	31%	133,628	14%	n/a	n/a	6
COLUMBIA_PLATEAU	354,192	57%	97,803	30%	451,996	48%	n/a	n/a	26
MOUNTAIN_SNAKE	146,834	24%	43,088	13%	189,922	20%	n/a	n/a	16
ALL PROVINCES	623,653	100%	323,982	100%	947,636	100%	n/a	n/a	60

Technology Optimistic

ALTERNATIVE 2	Abundance: Nautral	% of Total	Hatchery	% of Total	Hatch + Natural	% of Total	Life Hist. Divers. Index	Productivity	Nbr. of Sust. Popul.
SPRING									
BLUE_MOUNTAIN	19,111	18%	14,198	7%	33,309	11%	98%	5.6	3
COLUMBIA_CASCADE	5,279	5%	27,092	14%	32,371	11%	83%	3.7	3
COLUMBIA_GORGE	8,014	8%	65,059	33%	73,073	24%	100%	6.8	4
COLUMBIA_PLATEAU	36,253	35%	45,455	23%	81,708	27%	81%	6.2	14
MOUNTAIN_SNAKE	36,300	35%	42,513	22%	78,813	26%	93%	6.3	10
ALL PROVINCES	104,958	100%	194,316	100%	299,275	100%	n/a	n/a	34
SUMMER/FALL CHINOOK									
BLUE_MOUNTAIN	7,746	5%	0	0%	7,746	3%	100%	7.1	1
COLUMBIA_CASCADE	24,320	17%	75,087	90%	99,407	44%	48%	3.8	5
COLUMBIA_PLATEAU	41,557	29%	0	0%	41,557	19%	93%	5.0	4
MOUNTAIN_SNAKE	67,835	48%	8,087	10%	75,923	34%	100%	7.4	7
ALL PROVINCES	141,459	100%	83,174	100%	224,633	100%	n/a	n/a	17
FALL CHINOOK									
BLUE_MOUNTAIN	17,490	8%	0	0%	17,490	5%	101%	4.7	1
COLUMBIA_GORGE	13,662	6%	32,486	23%	46,148	12%	99%	6.6	2
COLUMBIA_PLATEAU	200,888	87%	109,365	77%	310,253	83%	82%	5.9	8
ALL PROVINCES	232,040	100%	141,850	100%	373,891	100%	n/a	n/a	11
TOTAL CHINOOK									
BLUE_MOUNTAIN	44,346	9%	14,198	3%	58,545	7%	n/a	n/a	5
COLUMBIA_CASCADE	29,599	6%	102,179	24%	131,778	15%	n/a	n/a	8
COLUMBIA_GORGE	21,677	5%	97,545	23%	119,222	13%	n/a	n/a	6
COLUMBIA_PLATEAU	278,699	58%	154,819	37%	433,518	48%	n/a	n/a	26
MOUNTAIN_SNAKE	104,136	22%	50,600	12%	154,736	17%	n/a	n/a	17
ALL PROVINCES	478,457	100%	419,341	100%	897,799	100%	n/a	n/a	62

Table IV.A.10 Biological performance results for Alternative 2 conditions, under the three worldviews.

Species/Province	Worldview		
Spring Chinook	TECH PESS	MOD	TECH OPT
BLUE_MOUNTAIN	280%	168%	80%
COLUMBIA_CASCADE	74%	71%	46%
COLUMBIA_GORGE	52%	46%	39%
COLUMBIA_PLATEAU	105%	95%	59%
MOUNTAIN_SNAKE	332%	193%	90%
Summer/Fall			
BLUE_MOUNTAIN	318%	164%	89%
COLUMBIA_CASCADE	31%	26%	26%
COLUMBIA_PLATEAU	26%	20%	57%
MOUNTAIN_SNAKE	318%	188%	96%
Fall			
BLUE_MOUNTAIN	359%	189%	100%
COLUMBIA_GORGE	1%	17%	43%
COLUMBIA_PLATEAU	10%	2%	1%

Table IV.A.11 Percent change in natural chinook productivity over Current Potential for Alternative 2, under the three worldviews.

The results presented in this section indicate that Alternative 2 increased chinook abundance, productivity, and life history diversity substantially in all provinces modeled. We next examine how chinook performance changes under this alternative at the ESU level.

> The key biological performance results for the Alternative 2 ESU analysis are as follows:
>
> - All ESUs improve significantly in abundance, productivity and life history diversity.
> - ESU-15 sees the greatest improvement, recovering 31 percent of the lost abundance potential, and 27 percent of the productivity loss.
> - ESU-12 benefits less than the other ESUs under Alternative 2, with less than 10 percent recovery of abundance and productivity losses.

ESU Scale Analysis

Modeling results for each of the five ESUs are also summarized in Table IV.A.12. Data in this table represent the percent of chinook production loss recovered by ESU for Alternative 2. By loss we mean the difference between Historic Potential and Current Potential described in the previous section. Because the major points presented for the basin level analysis also apply at the ESU level, they are not repeated here. Instead we use a series of tables and figures to highlight the key biological performance results obtained at the ESU scale. Unless otherwise noted, the discussion will revolve around model results for the Moderate worldview. We will compare worldview modeling results for this and the other alternatives when we discuss uncertainty later in the report.

The results presented in this section indicate that Alternative 2 increases chinook abundance, productivity, and life history diversity substantially in all ESUs modeled.

Alternative 5

EDT modeling results for Alternative 5 are presented in this section. Results are described at the basin, province, and ESU geographic scales. We also use the Framework graph presented earlier in this report to show

	ESU-11	ESU-12	ESU-13	ESU-14	ESU-15
Abundance	23%	9%	13%	35%	31%
Productivity	21%	7%	9%	13%	27%
Diversity	51%	60%	74%	68%	96%

Table IV.A.12 Percent of difference between Historic and Current Potentials recovered under Alternative 2.

the linkage between Alternative 5 actions, environmental attributes, and biological performance.

Alternative Overview

For review purposes we have listed below the major actions included in Alternative 5 to improve chinook performance in the basin. These actions are as follows:

- Eliminate juvenile transportation program during the spring and early summer juvenile migration period.
- Increase mainstem Columbia River average spring and summer flows by as much as 12 percent.
- Increase juvenile in-river survival through the addition of state-of-the-art surface collection / bypass systems at mainstem projects and increased spill.
- Use hatchery supplementation and improved hatchery facilities and rearing practices to increase the quantity and quality of fish returning to the basin.
- Improve freshwater habitat on both public and private lands. Habitat actions were assigned an intensity value of 2 for private lands, and a 3 on public lands.
- As is the case with all alternatives, eliminate ocean and mainstem harvest.

The effect that the combined actions in Alternative 5 had on the environmental attributes and natural chinook biological performance is shown graphically in Figure IV.A.26. The values in the environmental attributes table in this figure represent the percent improvement over Current Potential. The biological performance chart shows the percent improvement in natural chinook abundance for all races combined. The percent values presented for each show the proportion that each race contributed to the entire total.

The reader should be aware that the Hydrology and Hatchery related environmental attributes were not included in this chart due to space constraints. However, the change in these attributes does have an effect on resulting biological performance for this and other alternatives. In a later section of this report we will identify these attributes and show how they could be used in establishing biological objectives for each alternative.

The increase in freshwater habitat productivity under this alternative is shown in Table IV.A.14. The percent change in freshwater productivity over current (Moderate) varied from 31 percent for the Mountain Snake to

Alternative 5

Actions:

Habitat

Hatcheries

Hydro

Affected These Attributes →

Ecoprovinces

Environmental Attribute	BM A5	CC A5	CG A5	CP A5	MS A5
Alkalinity					
Bed Scour	54	69	75	55	71
Benthic Comm. Richness	30	29	23	34	41
Confinement Hydro					32
Embeddedness	50	64	60	56	65
Flow High	11			13	29
Flow Low	31	31	31	29	33
Fine Sediment	68	83	75	68	76
Misc. Toxic Waste					29
Nutrient enrichment	27	26	25	29	33
Riparian Function	58	64	60	58	66
Max Temp Month	46	47	41	47	48
Min Temp Month			69		
Turbidity	52	64	61	55	59
Woody Debris	65	74	72	66	76

To Produce This Performance →

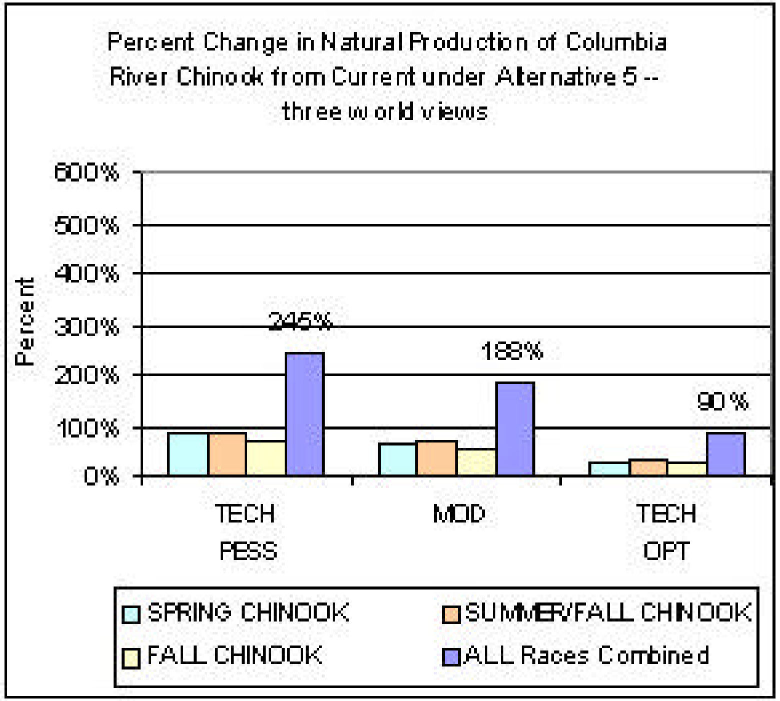


Figure IV.A.26 Framework logic for Alternative 5. Table data shows the percent improvement over Current Potential for each listed attribute.

ALTERNATIVE 5

Technology Pessimistic

	Abundance: Nautral (Natural)	% of Total	Hatchery (Hatchery)	% of Total	Hatch + Natural	% of Total	Life Hist. Divers. Index (DI)	Productivity (Prod)	Nbr. of Sust. Popul. (Num Pop)
SPRING									
BLUE_MOUNTAIN	19,084	12%	5,072	5%	24,156	9%	95%	6.4	3
COLUMBIA_CASCADE	5,642	4%	13,061	12%	18,703	7%	98%	5.0	3
COLUMBIA_GORGE	24,619	16%	59,553	55%	84,171	32%	99%	23.1	4
COLUMBIA_PLATEAU	69,640	45%	14,930	14%	84,570	32%	68%	14.4	14
MOUNTAIN_SNAKE	36,698	24%	15,354	14%	52,053	20%	76%	7.5	9
ALL PROVINCES	155,684	100%	107,969	100%	263,653	100%	n/a	n/a	33
SUMMER/FALL CHINOOK									
BLUE_MOUNTAIN	6,306	4%	0	0%	6,306	3%	90%	8.9	1
COLUMBIA_CASCADE	25,704	16%	25,660	83%	51,364	27%	44%	7.3	4
COLUMBIA_PLATEAU	64,224	41%	0	0%	64,224	34%	78%	10.7	4
MOUNTAIN_SNAKE	60,695	39%	5,259	17%	65,954	35%	92%	8.5	7
ALL PROVINCES	156,929	100%	30,919	100%	187,848	100%	n/a	n/a	16
FALL CHINOOK									
BLUE_MOUNTAIN	10,966	9%	4,730	7%	15,696	8%	61%	3.5	1
COLUMBIA_GORGE	23,262	18%	20,742	29%	44,004	22%	96%	16.1	2
COLUMBIA_PLATEAU	93,916	73%	46,427	65%	140,342	70%	43%	9.8	6
ALL PROVINCES	128.143	100%	71.899	100%	200.042	100%	n/a	n/a	9
TOTAL CHINOOK									
BLUE MOUNTAIN	36,356	8%	9,802	5%	46,158	7%	n/a	n/a	5
COLUMBIA CASCADE	31,346	7%	38,721	18%	70,066	11%	n/a	n/a	7
COLUMBIA GORGE	47,880	11%	80,295	38%	128,175	20%	n/a	n/a	6
COLUMBIA PLATEAU	227,780	52%	61,356	29%	289,137	44%	n/a	n/a	24
MOUNTAIN SNAKE	97,393	22%	20,613	10%	118,007	18%	n/a	n/a	16
ALL PROVINCES	440,756	100%	210,787	100%	651,543	100%	n/a	n/a	58

Moderate

	Abundance: Nautral (Natural)	% of Total	Hatchery (Hatchery)	% of Total	Hatch + Natural	% of Total	Life Hist. Divers. Index (DI)	Productivity (Prod)	Nbr. of Sust. Popul. (Num Pop)
SPRING									
BLUE_MOUNTAIN	17,902	14%	7,553	5%	25,455	9%	96%	5.4	3
COLUMBIA_CASCADE	6,063	5%	20,163	13%	26,226	9%	99%	4.7	3
COLUMBIA_GORGE	15,576	12%	64,206	42%	79,782	29%	99%	13.1	4
COLUMBIA_PLATEAU	53,135	42%	37,167	24%	90,302	32%	69%	9.7	14
MOUNTAIN_SNAKE	33,584	27%	22,621	15%	56,206	20%	76%	6.3	9
ALL PROVINCES	126,261	100%	151,710	100%	277,972	100%	n/a	n/a	33
SUMMER/FALL CHINOOK									
BLUE_MOUNTAIN	5,354	4%	0	0%	5,354	3%	96%	6.5	1
COLUMBIA_CASCADE	22,942	17%	42,274	80%	65,216	34%	50%	5.2	4
COLUMBIA_PLATEAU	55,292	40%	0	0%	55,292	29%	85%	7.5	4
MOUNTAIN_SNAKE	54,540	39%	10,318	20%	64,857	34%	93%	6.6	7
ALL PROVINCES	138,128	100%	52,591	100%	190,720	100%	n/a	n/a	16
FALL CHINOOK									
BLUE_MOUNTAIN	9,909	9%	8,885	7%	18,794	8%	65%	2.9	1
COLUMBIA_GORGE	18,657	17%	34,060	28%	52,717	23%	99%	10.7	2
COLUMBIA_PLATEAU	82,756	74%	77,492	64%	160,248	69%	48%	7.4	6
ALL PROVINCES	111,322	100%	120,436	100%	231,758	100%	n/a	n/a	9
TOTAL CHINOOK									
BLUE MOUNTAIN	33,165	9%	16,437	5%	49,603	7%	n/a	n/a	5
COLUMBIA CASCADE	29,005	8%	62,437	19%	91,442	13%	n/a	n/a	7
COLUMBIA GORGE	34,234	9%	98,265	30%	132,499	19%	n/a	n/a	6
COLUMBIA PLATEAU	191,183	51%	114,659	35%	305,842	44%	n/a	n/a	24
MOUNTAIN SNAKE	88,124	23%	32,939	10%	121,063	17%	n/a	n/a	16
ALL PROVINCES	375,711	100%	324,737	100%	700,460	100%	n/a	n/a	58

Technology Optimistic

	Abundance: Nautral (Natural)	% of Total	Hatchery (Hatchery)	% of Total	Hatch + Natural	% of Total	Life Hist. Divers. Index (DI)	Productivity (Prod)	Nbr. of Sust. Popul. (Num Pop)
SPRING									
BLUE_MOUNTAIN	12,452	15%	9,201	5%	21,653	9%	96%	3.8	3
COLUMBIA_CASCADE	4,793	6%	24,433	15%	29,225	12%	86%	3.3	3
COLUMBIA_GORGE	8,702	10%	64,950	39%	73,651	29%	99%	7.0	4
COLUMBIA_PLATEAU	34,671	42%	41,749	25%	76,420	30%	81%	5.9	14
MOUNTAIN_SNAKE	22,693	27%	27,408	16%	50,101	20%	77%	4.3	10
ALL PROVINCES	83,311	100%	167,740	100%	251,052	100%	n/a	n/a	34
SUMMER/FALL CHINOOK									
BLUE_MOUNTAIN	3,995	4%	0	0%	3,995	2%	100%	4.4	1
COLUMBIA_CASCADE	21,937	20%	66,175	76%	88,112	45%	51%	3.5	4
COLUMBIA_PLATEAU	43,367	40%	0	0%	43,367	22%	97%	5.1	4
MOUNTAIN_SNAKE	38,882	36%	20,364	24%	59,246	30%	94%	4.5	7
ALL PROVINCES	108,180	100%	86,540	100%	194,720	100%	n/a	n/a	16
FALL CHINOOK									
BLUE_MOUNTAIN	8,483	9%	15,897	8%	24,380	9%	78%	2.4	1
COLUMBIA_GORGE	13,441	14%	50,978	27%	64,419	23%	99%	7.1	2
COLUMBIA_PLATEAU	70,771	76%	122,851	65%	193,623	69%	55%	5.4	6
ALL PROVINCES	92,695	100%	189,727	100%	282,421	100%	n/a	n/a	9
TOTAL CHINOOK									
BLUE MOUNTAIN	24,930	9%	25,098	6%	50,028	7%	n/a	n/a	5
COLUMBIA CASCADE	26,729	9%	90,608	20%	117,337	16%	n/a	n/a	7
COLUMBIA GORGE	22,142	8%	115,928	26%	138,070	19%	n/a	n/a	6
COLUMBIA PLATEAU	148,808	52%	164,600	37%	313,409	43%	n/a	n/a	24
MOUNTAIN SNAKE	61,575	22%	47,772	11%	109,347	15%	n/a	n/a	26
ALL PROVINCES	284,185	100%	444,006	100%	728,193	100%	n/a	n/a	59

Table IV.A.14 Biological performance results for Alternative 5 conditions, under the three worldviews.

~134 percent in the Columbia Plateau. For all provinces combined, freshwater productivity increased by an average of ~61 percent[4]. Whether or not alternative 5 habitat actions would actually achieve this level of improvement would be dependent on the region's ability to successfully implement the actions and their eventual effectiveness. However, the reader should note that the environmental data driving these productivity values would be reviewed for accuracy during the assessment and subbasin planning phases of the Framework process. The incorporation of more accurate data may change estimates of resulting freshwater habitat productivity significantly.

Columbia Basin Scale Analysis

In Table IV.A.14 we present a summary of modeling results for Alternative 5. The data in this table include information on chinook abundance, productivity, life history diversity, number of natural and hatchery fish, and number of populations[5].

Alternative 5 is expected to increase chinook abundance over Current Potential from 114 percent to 216 percent dependent on the worldview examined (Figure IV.A.27). This alternative provides the greatest increase under the Technology Pessimistic worldview and the least amount of change under the Technology Optimistic set of assumptions.

The percent change from current for both natural and hatchery production for this alternative is shown in Figure IV.A.28. The data in this figure indicate that natural production increases from 90 percent to 245 percent and hatchery production from 133 percent to 167 percent.

The proportion of natural and hatchery fish produced for each worldview is presented in Figure IV.A.29. Note that the hatchery fish component increases as the worldviews change from Technology Pessimistic to Technology Optimistic. This increase is a direct result of the higher hatchery post-release survival assumptions used in the Moderate and Technology Optimistic worldviews. For example, the post-release survival values used for hatchery fish under the Technology Pessimistic, Moderate and Technology Optimistic worldviews are 15 percent, 30 percent and 60 percent, respectively[6].

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[4] This is an unweighted average for all provinces combined.

[5] Population numbers increase either when actions in the alternative allow fish access to previously blocked habitat (extends range) or when an existing population's productivity value exceeds 1.0.

[6] These post-release survival values are for hatchery fish reared using innovative hatchery practices.

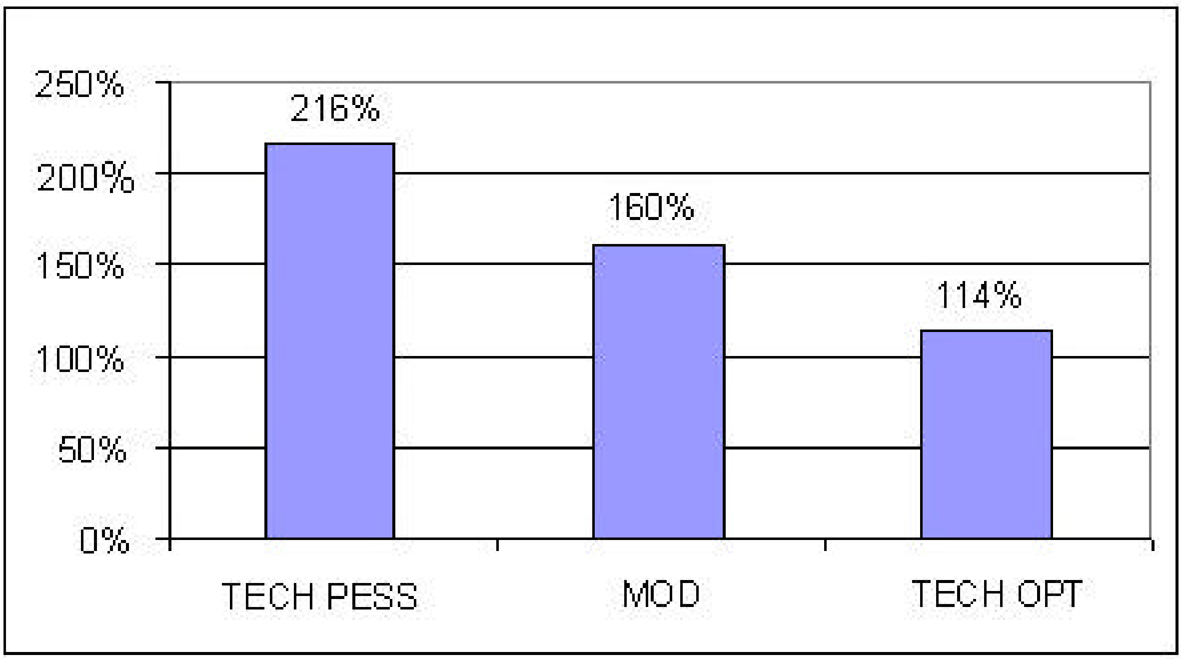


Figure IV.A.27 Percent change in total chinook abundance over current for Alternative 5, under the three worldviews.

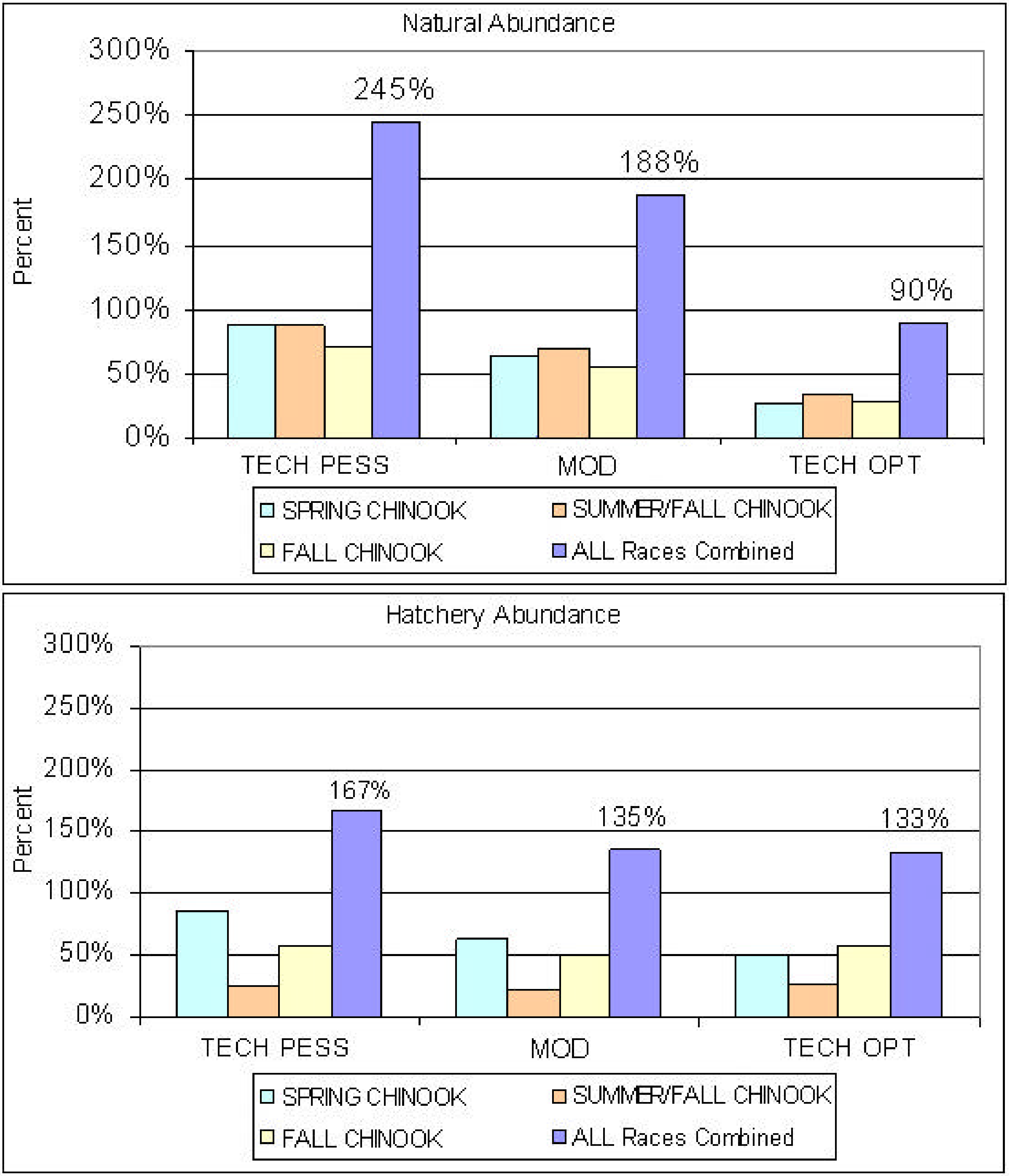


Figure IV.A.28 Percent change in natural and hatchery chinook abundance from current for Alternative 5, under the three worldviews.

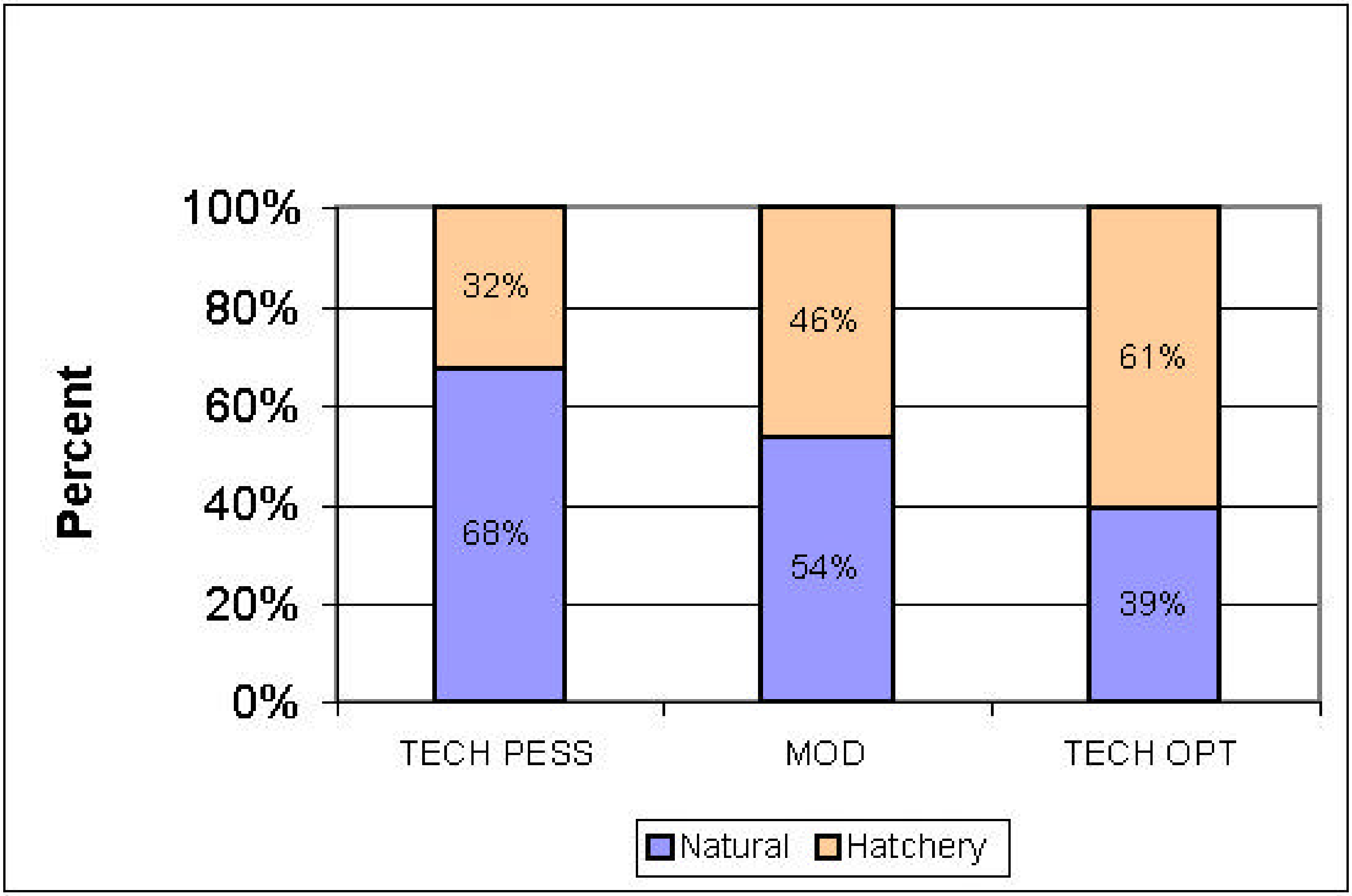


Figure IV.A.29 Percent natural and hatchery chinook production for Alternative 5, under the three worldviews.

Chinook productivity under this alternative increases by the amounts shown in Figure IV.A.30. These data indicate that average (weighted) spring chinook productivity changes from 43 percent to 77 percent, summer chinook from 32 percent to 76 percent, and fall chinook by minus one percent to four percent depending on the worldview.

The life history values for each race and worldview are also presented in Table IV.A.14. Overall, spring, summer and fall chinook diversity values increased for all provinces under all worldviews. Populations that can sustain a wide variety of life history patterns are likely to be more resilient to environmental change, which in turn should reduce their risk of extinction.

Under Alternative 5 the number of viable populations, in comparison to the current, increases from 48 to 58 (Table IV.A.14-Moderate). The majority of the population gains come from the Columbia Plateau province.

Now that we have seen how Alternative 5 affected chinook production at the basin level we next examine how each of the provinces fared.

Province Scale Analysis

Alternative 5 Modeling results for each of the five provinces are summarized in Table IV.A.14 by race and worldview. Because the major points presented for the basin level analysis also apply at the province level, they are not repeated here. Instead we use a series of tables and figures to highlight the key biological performance results obtained at the province scale. Unless otherwise noted, the discussion will revolve around model results for the Moderate worldview.

The results presented in this section indicate that Alternative 5 increased chinook abundance, productivity, and life history diversity substantially for most provinces and races modeled. We next examine how chinook performance changes under this alternative at the ESU level (Figure IV.A.31, Table IV.A.15).

ESU Scale Analysis

Modeling results for each of the five ESUs are summarized in Table IV.A.16. Data in this table represents chinook response to the actions of Alternative 5 as the percent of the loss recovered. By loss we mean the difference between Historic Potential and Current Potential described in the previous section. Because the major points presented for the basin level analysis also apply at the ESU level, they are not repeated here.

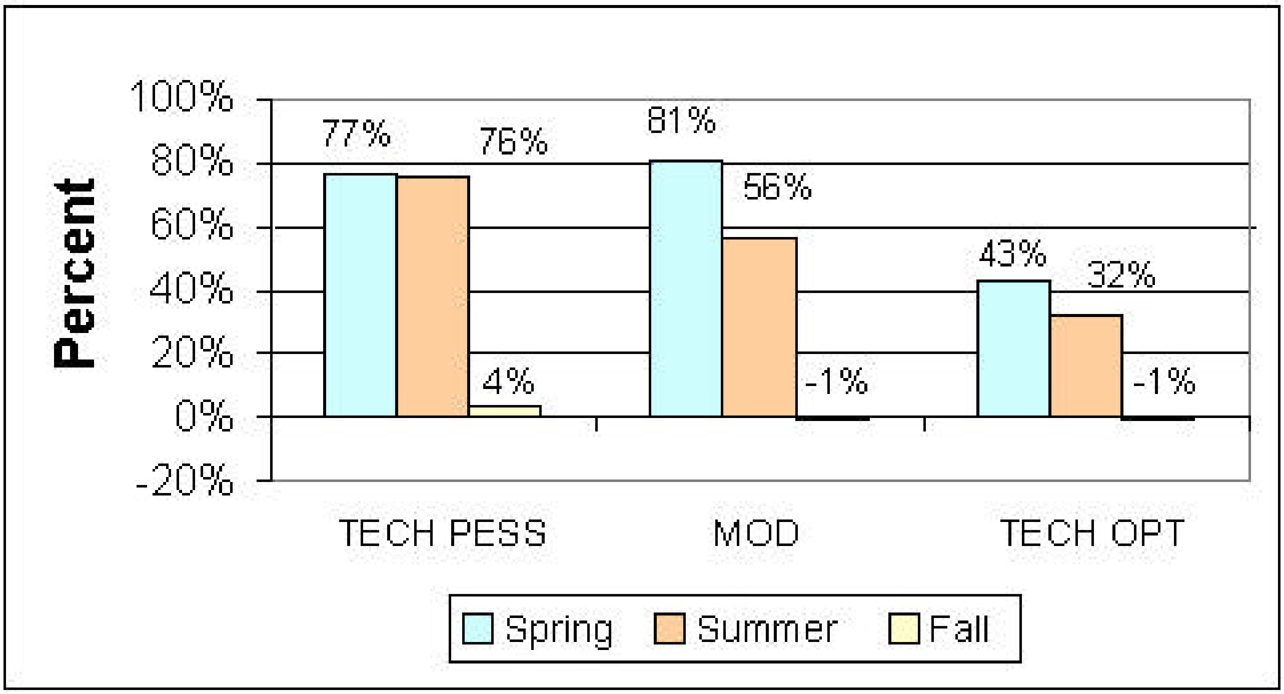


Figure IV.A.30 Percent change in chinook productivity from current for Alternaitve 5 by race and worldview.

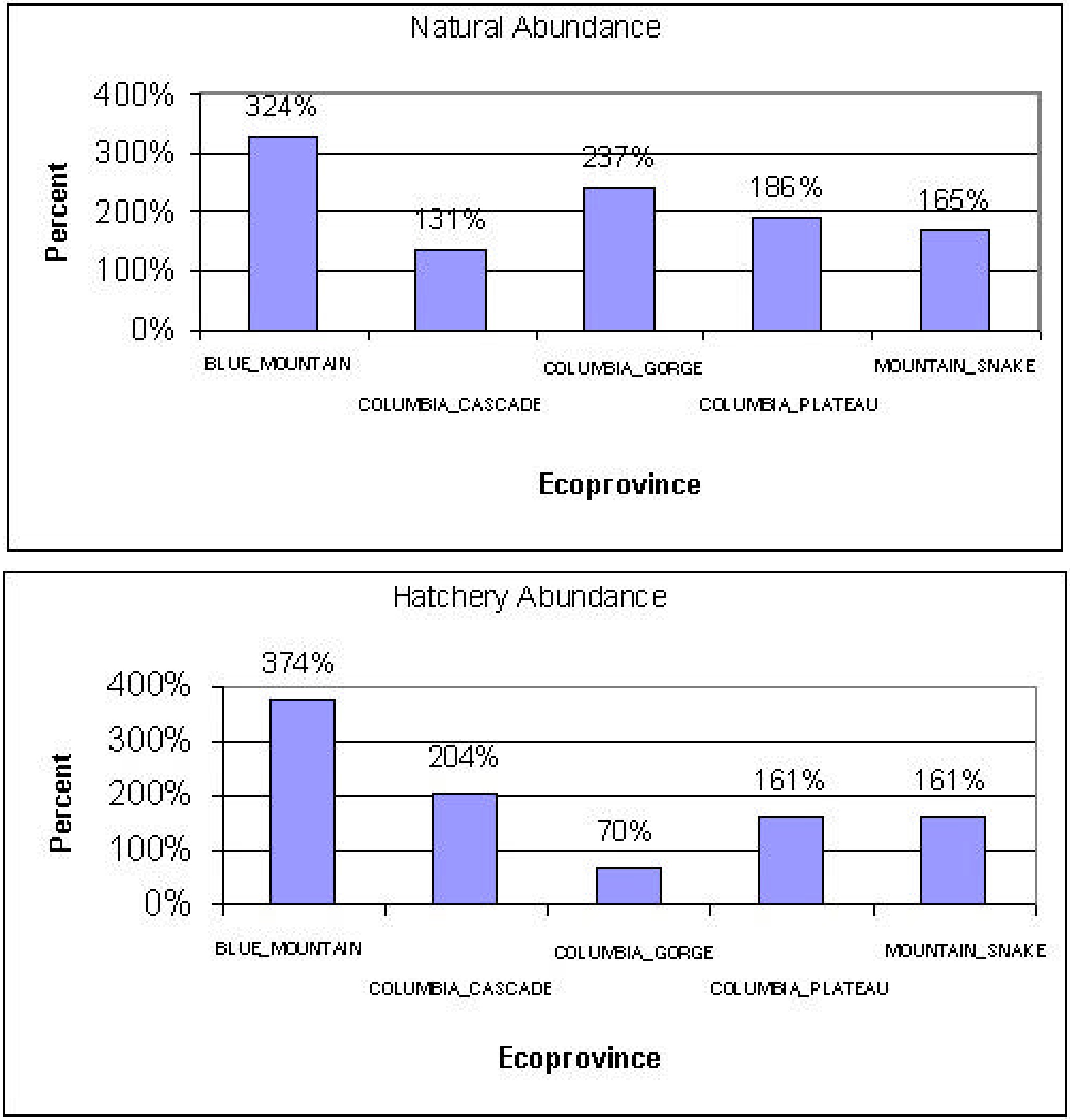


Figure IV.A.31 Percent change in nautral and hatchery chinook production by ecoprovince for Alternative 5, under the Moderate worldview.

ALTERNATIVE 5

Technology Pessimistic

	Abundance: Nautral	% of Total	Hatchery	% of Total	Hatch + Natural	% of Total	Life Hist. Divers. Index	Productivity	Nbr. of Sust. Popul.
SPRING	Natural		Hatchery				DI	Prod	Num Pop
BLUE_MOUNTAIN	19,084	12%	5,072	5%	24,156	9%	95%	6.4	3
COLUMBIA_CASCADE	5,642	4%	13,061	12%	18,703	7%	98%	5.0	3
COLUMBIA_GORGE	24,619	16%	59,553	55%	84,171	32%	99%	23.1	4
COLUMBIA_PLATEAU	69,640	45%	14,930	14%	84,570	32%	68%	14.4	14
MOUNTAIN_SNAKE	36,698	24%	15,354	14%	52,053	20%	76%	7.5	9
ALL PROVINCES	155,684	100%	107,969	100%	263,653	100%	n/a	n/a	33
SUMMER/FALL CHINOOK									
BLUE_MOUNTAIN	6,306	4%	0	0%	6,306	3%	90%	8.9	1
COLUMBIA_CASCADE	25,704	16%	25,660	83%	51,364	27%	44%	7.3	4
COLUMBIA_PLATEAU	64,224	41%	0	0%	64,224	34%	78%	10.7	4
MOUNTAIN_SNAKE	60,695	39%	5,259	17%	65,954	35%	92%	8.5	7
ALL PROVINCES	156,929	100%	30,919	100%	187,848	100%	n/a	n/a	16
FALL CHINOOK									
BLUE_MOUNTAIN	10,966	9%	4,730	7%	15,696	8%	61%	3.5	1
COLUMBIA_GORGE	23,262	18%	20,742	29%	44,004	22%	96%	16.1	2
COLUMBIA_PLATEAU	93,916	73%	46,427	65%	140,342	70%	43%	9.8	6
ALL PROVINCES	128.143	100%	71.899	100%	200.042	100%	n/a	n/a	9
TOTAL CHINOOK									
BLUE MOUNTAIN	36,356	8%	9,802	5%	46,158	7%	n/a	n/a	5
COLUMBIA CASCADE	31,346	7%	38,721	18%	70,066	11%	n/a	n/a	7
COLUMBIA GORGE	47,880	11%	80,295	38%	128,175	20%	n/a	n/a	6
COLUMBIA PLATEAU	227,780	52%	61,356	29%	289,137	44%	n/a	n/a	24
MOUNTAIN SNAKE	97,393	22%	20,613	10%	118,007	18%	n/a	n/a	16
ALL PROVINCES	440,756	100%	210,787	100%	651,543	100%	n/a	n/a	58

Moderate

	Abundance: Nautral	% of Total	Hatchery	% of Total	Hatch + Natural	% of Total	Life Hist. Divers. Index	Productivity	Nbr. of Sust. Popul.
SPRING	Natural		Hatchery				DI	Prod	Num Pop
BLUE_MOUNTAIN	17,902	14%	7,553	5%	25,455	9%	96%	5.4	3
COLUMBIA_CASCADE	6,063	5%	20,163	13%	26,226	9%	99%	4.7	3
COLUMBIA_GORGE	15,576	12%	64,206	42%	79,782	29%	99%	13.1	4
COLUMBIA_PLATEAU	53,135	42%	37,167	24%	90,302	32%	69%	9.7	14
MOUNTAIN_SNAKE	33,584	27%	22,621	15%	56,206	20%	76%	6.3	9
ALL PROVINCES	126,261	100%	151,710	100%	277,972	100%	n/a	n/a	33
SUMMER/FALL CHINOOK									
BLUE_MOUNTAIN	5,354	4%	0	0%	5,354	3%	96%	6.5	1
COLUMBIA_CASCADE	22,942	17%	42,274	80%	65,216	34%	50%	5.2	4
COLUMBIA_PLATEAU	55,292	40%	0	0%	55,292	29%	85%	7.5	4
MOUNTAIN_SNAKE	54,540	39%	10,318	20%	64,857	34%	93%	6.6	7
ALL PROVINCES	138,128	100%	52,591	100%	190,720	100%	n/a	n/a	16
FALL CHINOOK									
BLUE_MOUNTAIN	9,909	9%	8,885	7%	18,794	8%	65%	2.9	1
COLUMBIA_GORGE	18,657	17%	34,060	28%	52,717	23%	99%	10.7	2
COLUMBIA_PLATEAU	82,756	74%	77,492	64%	160,248	69%	48%	7.4	6
ALL PROVINCES	111,322	100%	120,436	100%	231,758	100%	n/a	n/a	9
TOTAL CHINOOK									
BLUE MOUNTAIN	33,165	9%	16,437	5%	49,603	7%	n/a	n/a	5
COLUMBIA CASCADE	29,005	8%	62,437	19%	91,442	13%	n/a	n/a	7
COLUMBIA GORGE	34,234	9%	98,265	30%	132,499	19%	n/a	n/a	6
COLUMBIA PLATEAU	191,183	51%	114,659	35%	305,842	44%	n/a	n/a	24
MOUNTAIN SNAKE	88,124	23%	32,939	10%	121,063	17%	n/a	n/a	16
ALL PROVINCES	375,711	100%	324,737	100%	700,460	100%	n/a	n/a	58

Technology Optimistic

	Abundance: Nautral	% of Total	Hatchery	% of Total	Hatch + Natural	% of Total	Life Hist. Divers. Index	Productivity	Nbr. of Sust. Popul.
SPRING	Natural		Hatchery				DI	Prod	Num Pop
BLUE_MOUNTAIN	12,452	15%	9,201	5%	21,653	9%	96%	3.8	3
COLUMBIA_CASCADE	4,793	6%	24,433	15%	29,225	12%	86%	3.3	3
COLUMBIA_GORGE	8,702	10%	64,950	39%	73,651	29%	99%	7.0	4
COLUMBIA_PLATEAU	34,671	42%	41,749	25%	76,420	30%	81%	5.9	14
MOUNTAIN_SNAKE	22,693	27%	27,408	16%	50,101	20%	77%	4.3	10
ALL PROVINCES	83,311	100%	167,740	100%	251,052	100%	n/a	n/a	34
SUMMER/FALL CHINOOK									
BLUE_MOUNTAIN	3,995	4%	0	0%	3,995	2%	100%	4.4	1
COLUMBIA_CASCADE	21,937	20%	66,175	76%	88,112	45%	51%	3.5	4
COLUMBIA_PLATEAU	43,367	40%	0	0%	43,367	22%	97%	5.1	4
MOUNTAIN_SNAKE	38,882	36%	20,364	24%	59,246	30%	94%	4.5	7
ALL PROVINCES	108,180	100%	86,540	100%	194,720	100%	n/a	n/a	16
FALL CHINOOK									
BLUE_MOUNTAIN	8,483	9%	15,897	8%	24,380	9%	78%	2.4	1
COLUMBIA_GORGE	13,441	14%	50,978	27%	64,419	23%	99%	7.1	2
COLUMBIA_PLATEAU	70,771	76%	122,851	65%	193,623	69%	55%	5.4	6
ALL PROVINCES	92,695	100%	189,727	100%	282,421	100%	n/a	n/a	9
TOTAL CHINOOK									
BLUE MOUNTAIN	24,930	9%	25,098	6%	50,028	7%	n/a	n/a	5
COLUMBIA CASCADE	26,729	9%	90,608	20%	117,337	16%	n/a	n/a	7
COLUMBIA GORGE	22,142	8%	115,928	26%	138,070	19%	n/a	n/a	6
COLUMBIA PLATEAU	148,808	52%	164,600	37%	313,409	43%	n/a	n/a	24
MOUNTAIN SNAKE	61,575	22%	47,772	11%	109,347	15%	n/a	n/a	26
ALL PROVINCES	284,185	100%	444,006	100%	728,193	100%	n/a	n/a	59

Table IV.A.14 Biological performance results for Alternative 5 conditions, under the three worldviews.

Species/Province	Worldview		
Spring Chinook	TECH PESS	MOD	TECH OPT
BLUE_MOUNTAIN	140%	77%	20%
COLUMBIA_CASCADE	65%	57%	30%
COLUMBIA_GORGE	61%	53%	43%
COLUMBIA_PLATEAU	107%	90%	50%
MOUNTAIN_SNAKE	172%	94%	28%
Summer/Fall			
BLUE_MOUNTAIN	142%	60%	18%
COLUMBIA_CASCADE	22%	16%	18%
COLUMBIA_PLATEAU	8%	7%	62%
MOUNTAIN_SNAKE	136%	73%	21%
Fall			
BLUE_MOUNTAIN	90%	32%	3%
COLUMBIA_GORGE	17%	30%	53%
COLUMBIA_PLATEAU	-2%	-7%	-7%

Table IV.A.15 Percent change in natural chinook productivity over Current Potential for Alternative 2, under the three worldviews.

	ESU-11	ESU-12	ESU-13	ESU-14	ESU-15
Abundance	24%	5%	12%	11%	15%
Productivity	20%	-1%	7%	9%	11%
Diversity	52%	63%	97%	49%	95%

Table IV.A.16 Percent of difference between Historic and Current Potentials recovered under Alternative 5.

The key biological performance results for the Alternative 5 ESU analysis are as follows:

- All ESUs increase in abundance under Alternative 5.
- ESU-11 sees the greatest improvements, recovering 24 percent of abundance losses and 20 percent of productivity losses.
- ESU-12 improves in abundance, but decreases in productivity. The reason for this is that as previously unsustainable life history pathways are restored, the mean productivity of the ESU as a whole decreases slightly.

Alternative 6

EDT modeling results for the Alternative 6 are presented below. Results are described at the basin, province, and ESU geographic scales. We also use the Framework graph presented earlier in this report to show the linkage between Alternative 6 actions, environmental attributes, and biological performance.

Alternative Overview

For review purposes we have listed below the major actions included in Alternative 6 to improve chinook performance in the basin. These actions are as follows:

- Maximize juvenile transportation for both spring and summer migrants
- Reduce spring flows; increase summer flows
- Eliminate spill when river conditions permit at all juvenile collector projects
- Improve freshwater habitat on both public and private lands. Habitat actions were assigned an intensity value of 1 for private lands, a 3 for public lands
- Use hatchery supplementation and improved hatchery facilities and rearing practices to increase the quality of the fish released.
- As is the case in all alternatives, ocean and mainstem harvest was eliminated for analysis purposes.

The effect the combined actions in Alternative 6 had on the environmental attributes and chinook biological performance is shown graphically in Figure IV.A.32. The values in the environmental attributes table in this figure represent the percent improvement over the Current Potential. The biological performance chart shows the percent improvement in natural chinook abundance for all races combined. The percent values presented for each show the proportion each race contributed to the entire total. The reader should be aware that the Hydro and Hatchery related environmental attributes were not included in this chart due to space constraints. However, the change in these attributes does have an effect on resulting biological performance for this and other alternatives. In a later section of this report we will identify these attributes and show how they could be used in establishing biological objectives for each alternative.

The increase in freshwater habitat productivity under this alternative is shown in Table IV.A.17. The percent change in freshwater productivity over current (Moderate) varied from 26 percent for the Mountain Snake to ~82 percent in the Columbia Plateau. For all provinces combined, freshwater productivity increased by an average of ~44 percent[7].

Whether or not Alternative 6 habitat actions would actually achieve this level of improvement would be dependent on the region's ability to successfully implement the actions and their eventual effectiveness. However, the reader should note that the environmental data driving these productivity values would be reviewed for accuracy during the assessment and subbasin planning phases of the Framework process. The incorporation of more Framework process incorporation of more accurate data may change estimates of freshwater habitat productivity significantly.

Columbia Basin Scale Analysis

In Table IV.A.18 we present a summary of modeling results for Alternative 6. The data in this table include information on chinook abundance, productivity, life history diversity, number of natural and hatchery fish, and number of populations[8].

Alternative 6 is expected to increase chinook abundance over current from 107 percent to 122 percent dependent on the worldview examined (Figure IV.A.33). This alternative provides the greatest increase under the

[7] This is an unweighted average for all provinces combined.

[8] Population numbers increase either when actions in the alternative allow fish access to previously blocked habitat (extends range) or when an existing population's productivity value exceeds 1.0.

Alternative 6

Actions:

Habitat

Hatcheries

Hydro

Affected These Attributes

Ecoprovinces

Environmental Attributes	BM A6	CC A6	CG A6	CP A6	MS A6
Alkalinity					
Bed Scour	36	60	53	34	65
Benthic Comm. Richness	10	12	9	14	32
Confinement Hydro					27
Embeddedness	22	54	44	33	42
Flow High	4			7	21
Flow Low	23	25	25	19	31
Fine Sediment	46	70	59	46	67
Misc. Toxic Waste					28
Nutrient enrichment	14	15	9	14	27
Riparian Function	38	57	45	39	59
Max Temp Month	28	38	25	26	40
Min Temp Month			65		
Turbidity	27	52	44	32	40
Woody Debris	47	70	62	46	71

To Produce This Performance

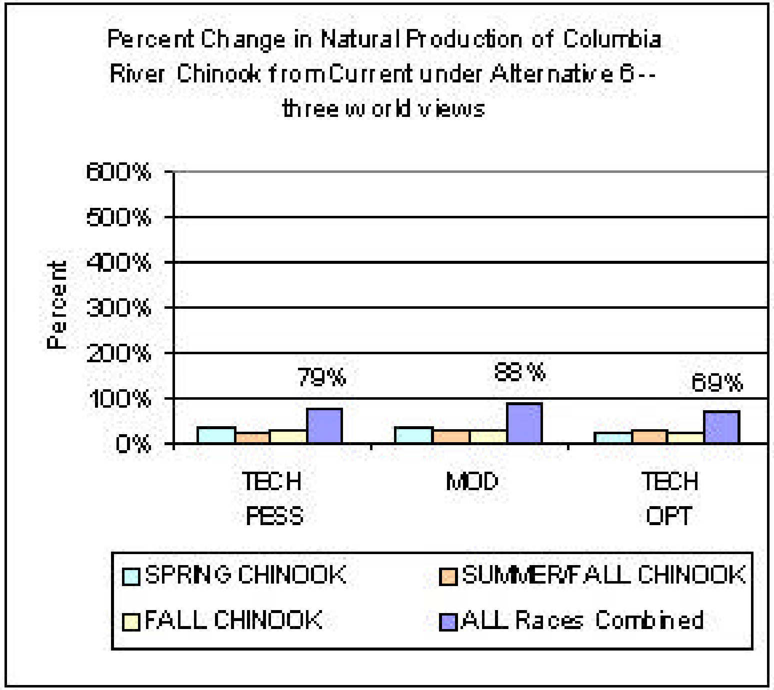


Figure IV.A.32 Framework logic for alternative 6. Table data shows the percent improvement over Current Potential for each listed attribute.

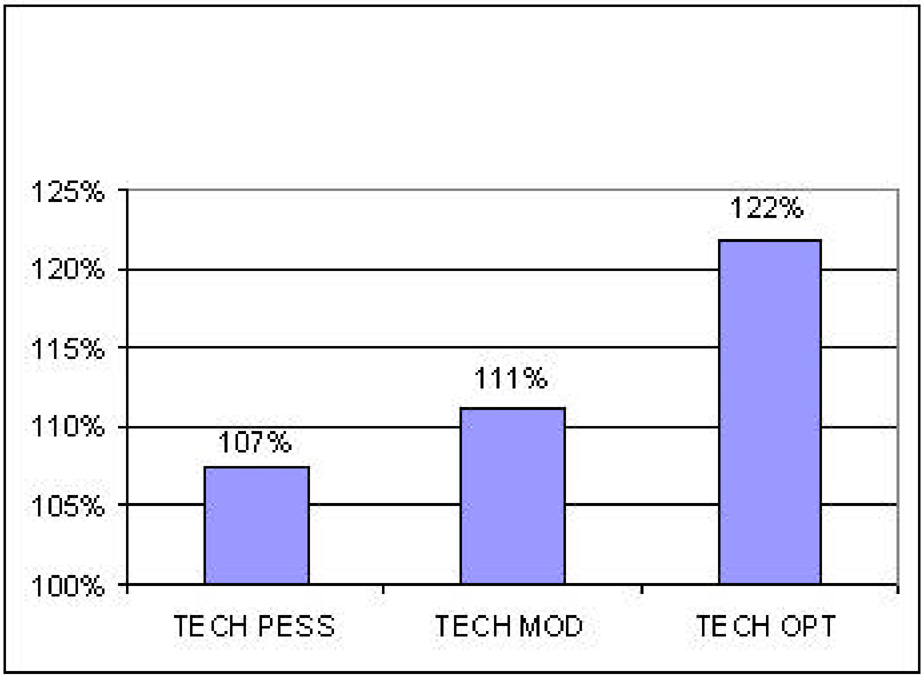


Figure IV.A.33 Percent change in total chinook abundance over current for Alternative 6, under the three worldviews.

	BLUE_MOUNTAIN			COLUMBIA_CASCADE			COLUMBIA_GORGE			COLUMBIA_PLATEAU			MOUNTAIN_SNAKE		
Alt	Historic Potential	Current Potential	A2	Historic Potential	Current Potential	A2	Historic Potential	Current Potential	A2	Historic Potential	Current Potential	A2	Historic Potential	Current Potential	A2
T Pess	160.2	50.5	50.5	142.3	64	94.6	142.2	70.4	100.2	157.1	35.1	66.4	185.1	102.7	133.2
Mod	165.7	58.4	58.4	166.2	75.4	113.3	158	83.7	113	163.9	41.5	75.5	187.9	111.6	141
T Opt	170.7	71.5	71.5	155.8	89.5	118.1	157.3	94.2	122.8	168	52.7	87.8	189.6	123.7	150.1

Table IV.A.17 Freshwater habitat quality index values for the Historic Potential, Current Potential, and Alternative 6.

ALTERNATIVE 6

	Technology Pessimistic								
	Abundance						Life Hist. Divers. Index	Productivity	Nbr. of Sust. Popul.
	Nautral	% of Total	Hatchery	% of Total	Hatch + Natural	% of Total			
SPRING	Natural		Hatchery				DI	Prod	Num Pop
BLUE_MOUNTAIN	5,971	6%	2,289	2%	8,260	4%	70%	3.6	3
COLUMBIA_CASCADE	2,860	3%	6,874	7%	9,734	5%	94%	2.8	3
COLUMBIA_GORGE	24,198	25%	58,372	59%	82,570	42%	97%	22.0	4
COLUMBIA_PLATEAU	46,395	48%	24,486	25%	70,881	36%	58%	12.0	14
MOUNTAIN_SNAKE	16,426	17%	7,070	7%	23,496	12%	75%	3.8	9
ALL PROVINCES	95,849	100%	99,092	100%	194,941	100%	n/a	n/a	33
SUMMER/FALL CHINOOK									
BLUE_MOUNTAIN	1,361	2%	0	0%	1,361	2%	60%	3.0	1
COLUMBIA_CASCADE	13,845	22%	23,890	95%	37,735	43%	36%	4.8	4
COLUMBIA_PLATEAU	24,287	39%	0	0%	24,287	28%	44%	10.9	4
MOUNTAIN_SNAKE	22,883	37%	1,377	5%	24,260	28%	89%	4.0	7
ALL PROVINCES	62,377	100%	25,267	100%	87,643	100%	n/a	n/a	16
FALL CHINOOK									
BLUE_MOUNTAIN	1,323	2%	3,273	4%	4,596	3%	10%	1.6	1
COLUMBIA_GORGE	15,330	22%	20,051	27%	35,380	24%	70%	14.2	2
COLUMBIA_PLATEAU	53,860	76%	51,926	69%	105,786	73%	26%	8.4	5
ALL PROVINCES	70,513	100%	75,250	100%	145,762	100%	n/a	n/a	8
TOTAL CHINOOK									
BLUE_MOUNTAIN	8,655	4%	5,562	3%	14,217	3%	n/a	n/a	5
COLUMBIA_CASCADE	16,705	7%	30,764	15%	47,469	11%	n/a	n/a	7
COLUMBIA_GORGE	39,528	17%	78,422	39%	117,950	28%	n/a	n/a	6
COLUMBIA_PLATEAU	124,542	54%	76,413	38%	200,955	47%	n/a	n/a	23
MOUNTAIN_SNAKE	39,308	17%	8,447	4%	47,755	11%	n/a	n/a	16
ALL PROVINCES	228,739	100%	199,608	100%	428,347	100%	n/a	n/a	57

	Moderate								
	Abundance						Life Hist. Divers. Index	Productivity	Nbr. of Sust. Popul.
	Nautral	% of Total	Hatchery	% of Total	Hatch + Natural	% of Total			
SPRING	Natural		Hatchery				DI	Prod	Num Pop
BLUE_MOUNTAIN	10,153	11%	5,580	4%	15,733	7%	74%	4.6	3
COLUMBIA_CASCADE	3,435	4%	12,426	10%	15,862	7%	94%	3.0	3
COLUMBIA_GORGE	15,139	17%	62,835	49%	77,974	36%	97%	12.4	4
COLUMBIA_PLATEAU	36,226	40%	31,266	24%	67,492	31%	60%	7.9	14
MOUNTAIN_SNAKE	25,442	28%	16,973	13%	42,415	19%	75%	4.9	9
ALL PROVINCES	90,395	100%	129,081	100%	219,475	100%	n/a	n/a	33
SUMMER/FALL CHINOOK									
BLUE_MOUNTAIN	2,892	4%	0	0%	2,892	2%	86%	3.8	1
COLUMBIA_CASCADE	15,578	20%	44,912	87%	60,490	47%	44%	4.1	4
COLUMBIA_PLATEAU	20,796	27%	0	0%	20,796	16%	45%	7.6	4
MOUNTAIN_SNAKE	38,148	49%	6,737	13%	44,886	35%	93%	5.0	7
ALL PROVINCES	77,415	100%	51,649	100%	129,064	100%	n/a	n/a	16
FALL CHINOOK									
BLUE_MOUNTAIN	5,270	7%	15,027	11%	20,297	9%	48%	2.3	1
COLUMBIA_GORGE	15,603	20%	32,976	23%	48,579	22%	78%	9.1	2
COLUMBIA_PLATEAU	56,915	73%	93,573	66%	150,489	69%	29%	7.3	5
ALL PROVINCES	77,788	100%	141,576	100%	219,364	100%	n/a	n/a	8
TOTAL CHINOOK									
BLUE_MOUNTAIN	18,315	7%	20,608	6%	38,922	7%	n/a	n/a	5
COLUMBIA_CASCADE	19,014	8%	57,338	18%	76,352	13%	n/a	n/a	7
COLUMBIA_GORGE	30,742	13%	95,811	30%	126,552	22%	n/a	n/a	6
COLUMBIA_PLATEAU	113,938	46%	124,840	39%	238,777	42%	n/a	n/a	23
MOUNTAIN_SNAKE	63,590	26%	23,711	7%	87,301	15%	n/a	n/a	16
ALL PROVINCES	245,598	100%	322,306	100%	567,904	100%	n/a	n/a	57

	Technology Optimistic								
	Abundance						Life Hist. Divers. Index	Productivity	Nbr. of Sust. Popul.
	Nautral	% of Total	Hatchery	% of Total	Hatch + Natural	% of Total			
SPRING	Natural		Hatchery				DI	Prod	Num Pop
BLUE_MOUNTAIN	10,599	14%	9,535	6%	20,134	8%	78%	4.1	3
COLUMBIA_CASCADE	4,500	6%	22,284	14%	26,783	11%	82%	3.1	3
COLUMBIA_GORGE	8,690	11%	63,824	39%	72,513	30%	97%	6.7	4
COLUMBIA_PLATEAU	28,712	38%	40,479	25%	69,191	29%	71%	5.3	14
MOUNTAIN_SNAKE	23,668	31%	28,476	17%	52,144	22%	76%	4.5	10
ALL PROVINCES	76,168	100%	164,597	100%	240,766	100%	n/a	n/a	34
SUMMER/FALL CHINOOK									
BLUE_MOUNTAIN	3,302	4%	0	0%	3,302	2%	94%	3.6	1
COLUMBIA_CASCADE	18,714	20%	80,833	81%	99,547	51%	46%	3.2	4
COLUMBIA_PLATEAU	32,519	35%	0	0%	32,519	17%	71%	4.0	4
MOUNTAIN_SNAKE	39,631	42%	19,375	19%	59,005	30%	94%	4.6	7
ALL PROVINCES	94,166	100%	100,208	100%	194,374	100%	n/a	n/a	16
FALL CHINOOK									
BLUE_MOUNTAIN	7,055	9%	34,003	14%	41,058	13%	72%	2.4	1
COLUMBIA_GORGE	11,654	14%	49,462	21%	61,117	19%	93%	5.8	2
COLUMBIA_PLATEAU	63,624	77%	154,032	65%	217,657	68%	38%	5.7	6
ALL PROVINCES	82,334	100%	237,498	100%	319,832	100%	n/a	n/a	9
TOTAL CHINOOK									
BLUE_MOUNTAIN	20,956	8%	43,538	9%	64,494	9%	n/a	n/a	5
COLUMBIA_CASCADE	23,214	9%	103,117	21%	126,330	17%	n/a	n/a	7
COLUMBIA_GORGE	20,344	8%	113,286	23%	133,630	18%	n/a	n/a	6
COLUMBIA_PLATEAU	124,856	49%	194,512	39%	319,367	42%	n/a	n/a	24
MOUNTAIN_SNAKE	63,298	25%	47,851	10%	111,149	15%	n/a	n/a	17
ALL PROVINCES	252,668	100%	502,303	100%	754,971	100%	n/a	n/a	59

Table IV.A.18 Summary of EDT modeling results for Alternative 6 conditions, under the three worldviews.

Technology Optimistic worldview and the least amount of change under the Technology Pessimistic set of assumptions.

The percent change from current for both natural and hatchery production for this alternative is shown in Figure IV.A.34. The data in this figure indicate that natural production increases from 69 percent to 89 percent and hatchery production from 133 percent to 164 percent.

The proportion of natural and hatchery fish produced for each worldview is presented in Figure IV.A.35. Note that the hatchery fish component increases as the worldviews change from Technology Pessimistic to Technology Optimistic. This increase is a direct result of the higher hatchery post-release survival assumptions used in the Moderate and Technology Optimistic worldviews. For example, the post-release survival values used for hatchery fish under the Technology Pessimistic, Moderate and Technology Optimistic worldviews are 15 percent, 25 percent and 60 percent, respectively[9].

> Alternative 6 performs best relative to the others when the following assumption about the state-of-nature are correct:
>
> - The current juvenile transportation program is effective,
> - Current in-river juvenile migration survival rates are high,
> - Freshwater habitat degradation is low,
> - Hatchery fish fitness is high, and
> - Ocean survival rates are low.

Chinook productivity under this alternative increases by the amounts shown in Figure IV.A.36. These data indicate that average (weighted) spring chinook productivity changes from 39 percent to 70 percent, summer chinook from 18 percent to 30 percent, and fall chinook from one percent to negative five percent, depending on worldview.

The life history values for each race and worldview are also presented in Table IV.A.18. Overall, spring, summer and fall chinook diversity values increased for all provinces under all worldviews. Populations that can sustain a wide variety of life history patterns are likely to be more resilient

[9] These post-release survival values are for hatchery fish reared using innovative hatchery practices.

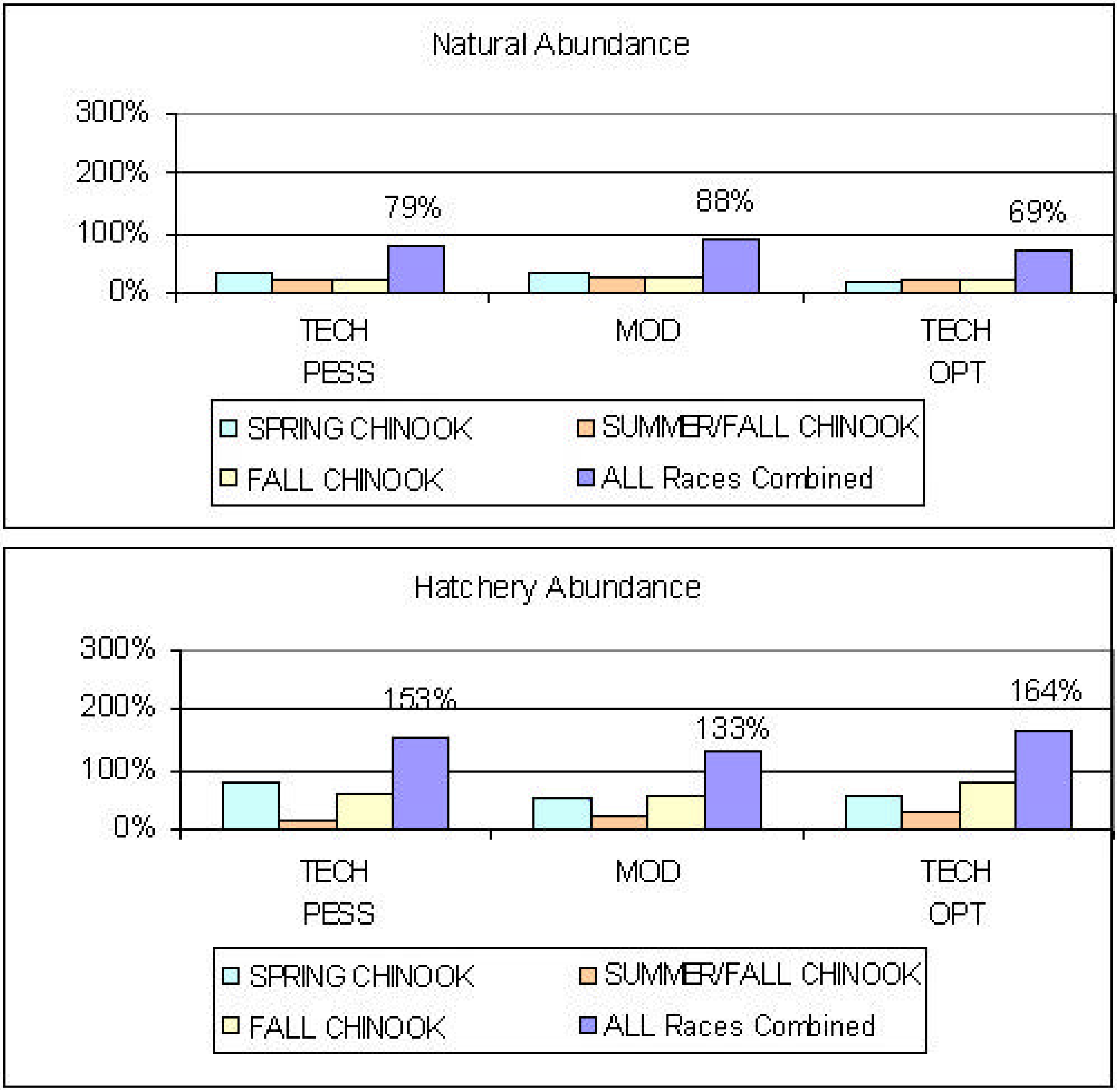


Figure IV.A.34 Percent change in natural and hatchery chinook abundance over Current Potential for Alternative 6, under the three worldviews.

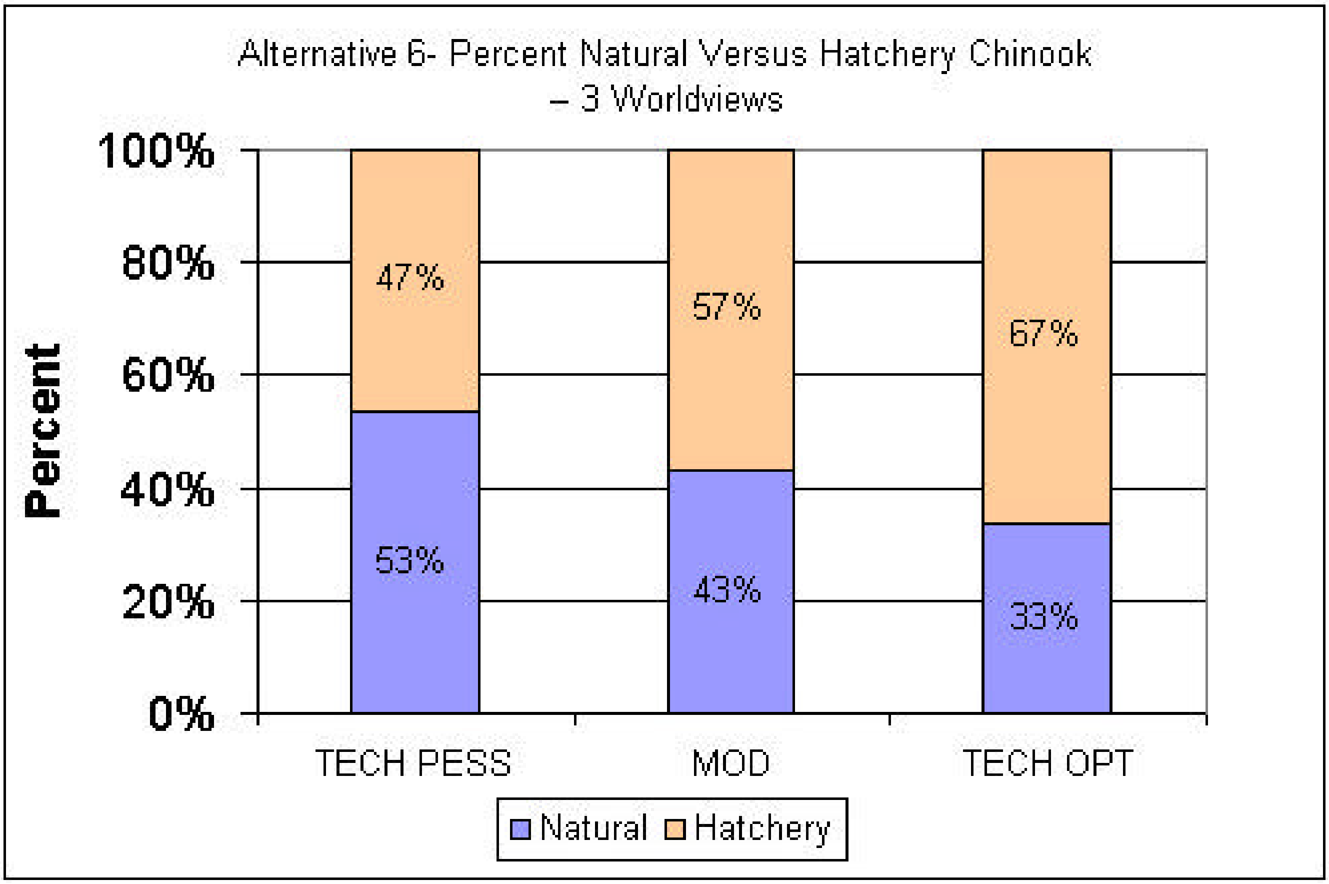


Figure IV.A.35 Percent natural and hatchery chinook production for Alternative 6, under the three worldviews.

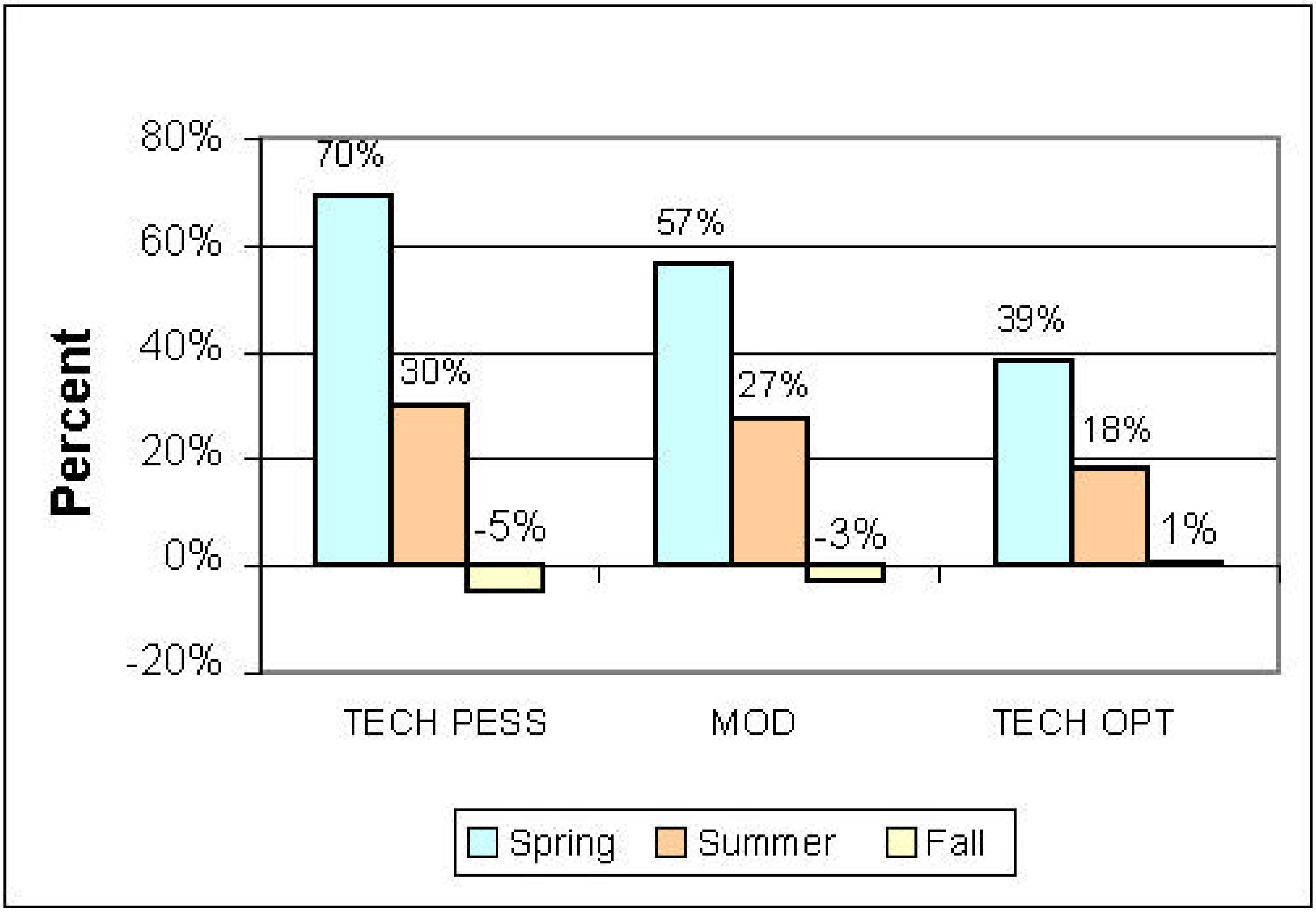


Figure IV.A.36 Percent change in chinook productivity from current for Alternative 6, by race and worldview.

to environmental change, which in turn should reduce their risk of extinction.

Under Alternative 6 the number of viable populations, in comparison to the current, increases from 48 to 57 (Table IV.A.18). The majority of the population gains come from the Columbia Plateau province.

Now that we have seen how Alternative 6 affected chinook production at the basin level we next to see how each of the provinces fared.

Province Scale Analysis

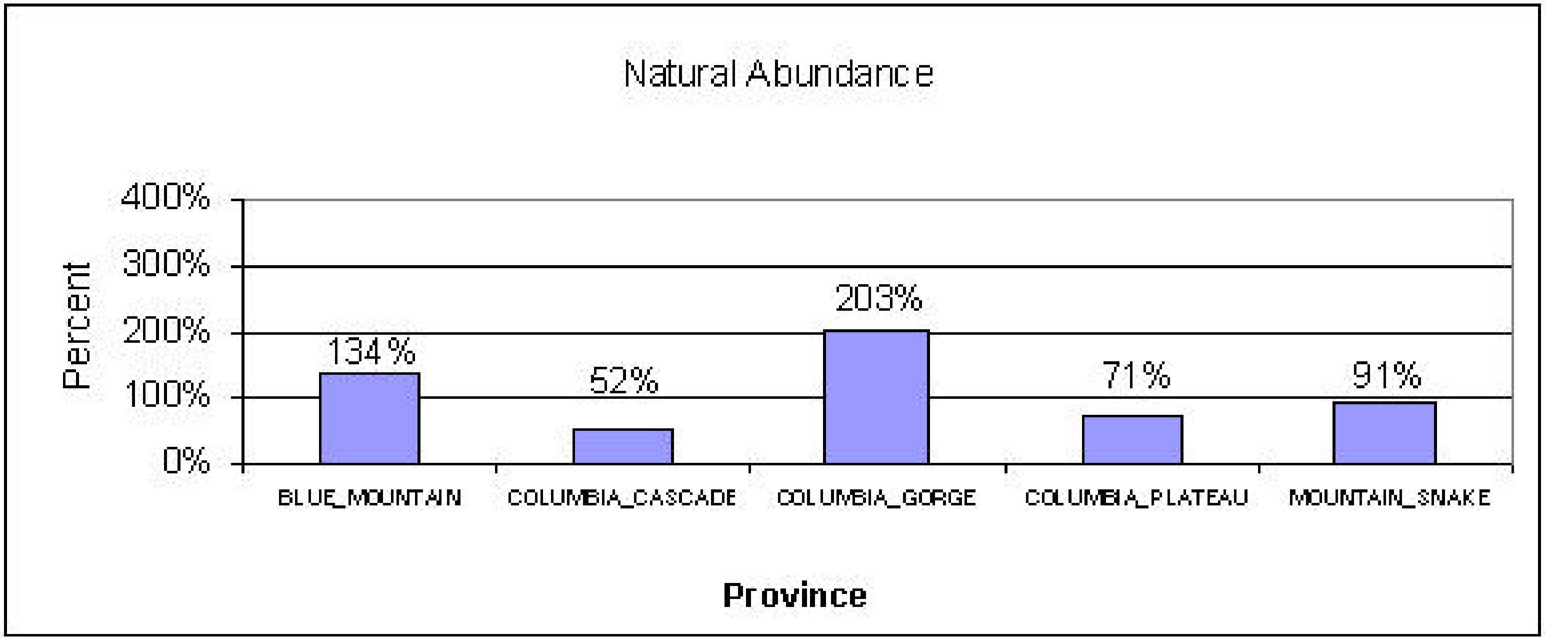
Alternative 6 Modeling results for each of the five provinces are summarized in Table IV.A.18 by race and worldview. Because the major points presented for the basin level analysis also apply at the province level, they are not repeated here. Instead we use a series of tables and figures (Figure IV.A.37 and Table IV.A.19) to highlight the key biological performance results obtained at the province scale. Unless otherwise noted, the discussion will revolve around model results for the Moderate worldview. We will spend more time highlighting the differences in worldviews for each alternative in the uncertainty section of this report.

The results presented in this section indicate that Alternative 6 increased chinook abundance, productivity, and life history diversity substantially for most provinces and races modeled. We next examine how chinook performance changes under this alternative at the ESU level.

ESU Scale Analysis

Modeling results for each of the five ESUs are summarized in Table IV.A.20. Data in this table represent the percent of chinook production loss recovered by ESU for Alternative 6. By loss we mean the difference between Historic Potential and Current Potential described in the previous section. Because the major points presented for the basin level analysis also apply at the ESU level, they are not repeated here. Instead we use a series of tables and figures to highlight the key biological performance results obtained at the ESU scale. Unless otherwise noted, the discussion will revolve around model results for the Moderate worldview. We will compare worldview-modeling results for this and the other alternatives when we discuss uncertainty later in the report.

> The key biological performance results for the Alternative 6 ESU analysis are as follows:
>
> - ESUs 11,14, and 15 increase in abundance and productivity



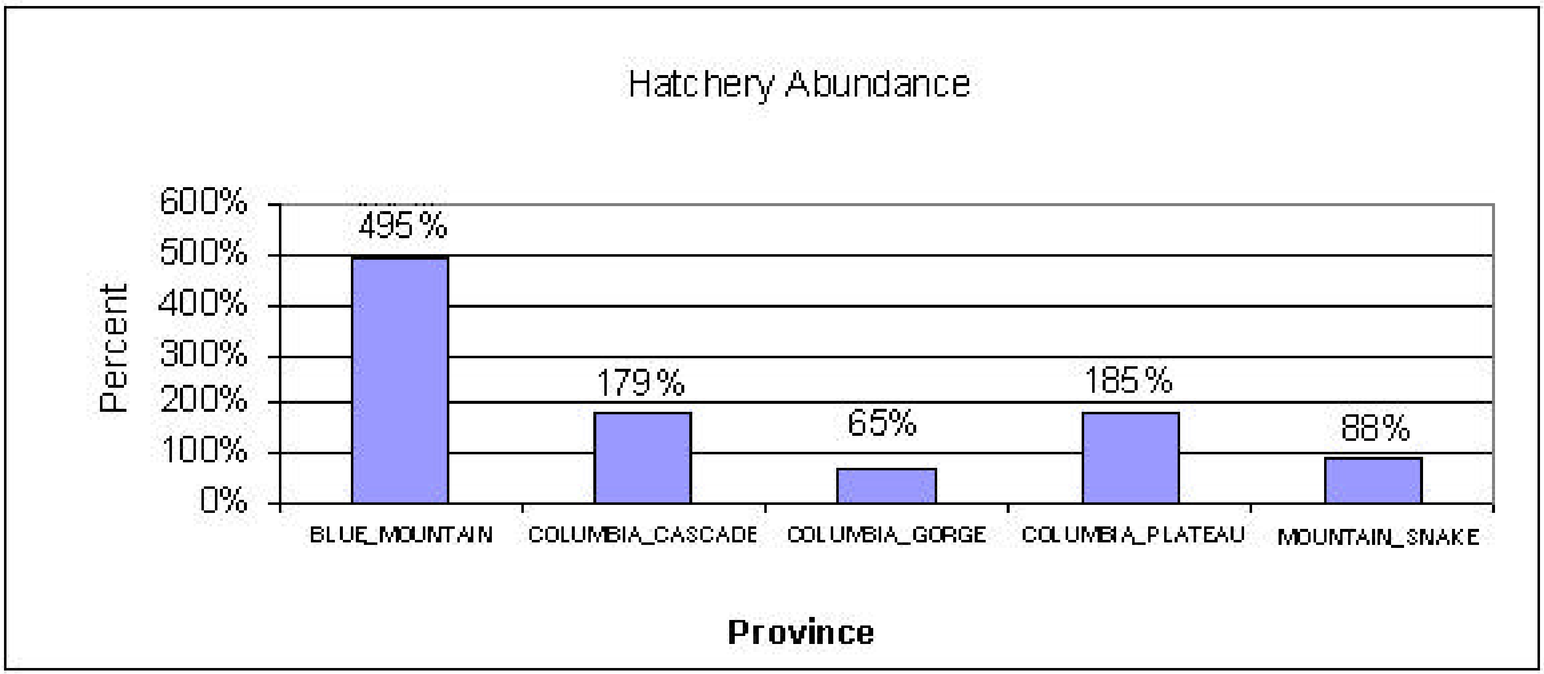


Figure IV.A.37 Percent change in natural and hatchery chinook production for Alternative 6, by province and Moderate worldview.

Species/Province	Worldview		
Spring Chinook	TECH PESS	MOD	TECH OPT
BLUE_MOUNTAIN	36%	51%	32%
COLUMBIA_CASCADE	-9%	1%	21%
COLUMBIA_GORGE	53%	45%	37%
COLUMBIA_PLATEAU	72%	54%	36%
MOUNTAIN_SNAKE	37%	50%	37%
Summer/Fall			
BLUE_MOUNTAIN	-18%	-7%	-5%
COLUMBIA_CASCADE	-20%	-8%	7%
COLUMBIA_PLATEAU	10%	8%	26%
MOUNTAIN_SNAKE	10%	32%	23%
Fall			
BLUE_MOUNTAIN	-15%	4%	3%
COLUMBIA_GORGE	3%	11%	26%
COLUMBIA_PLATEAU	-16%	-7%	-2%

Table IV.A.19 Percent change in natural chinook productivity over Current Potential for Alternative 6, under the three worldviews.

	ESU-11	ESU-12	ESU-13	ESU-14	ESU-15
Abundance	15%	1%	4%	3%	8%
Productivity	12%	-4%	0%	9%	5%
Diversity	41%	40%	70%	15%	63%

Table IV.A.20 Percent of difference between Historic and Current Potentials recovered under Alternative 6.

under Alternative 6.

- ESU-12 sees little or no improvement under Alternative 6.
- ESU-11 benefits the most among the ESUs, recovering 15 percent of lost abundance potential and 12 percent of the productivity loss.

Relative to the other alternatives analyzed, Alternative 6 provides relatively limited benefits under the Moderate worldview. If the Technology Optimistic worldview better represents the true state of nature, then Alternative 6 will compare much more favorably with the other alternatives. There is further discussion about the consequences of uncertainty about the true state of nature in the uncertainty section below.

RESULTS - WILDLIFE

This section of the Results addresses wildlife; it is organized as follows:

Wildlife Species

Habitat Performance

Biological Performance

Wildlife Species

In this section, we present analysis results on selected individual wildlife species and their habitat performance under the planning alternatives at three time periods.

Habitat Performance

Wildlife habitat type maps are the basis for determining habitat performance in the United States portion of the Columbia River Basin. Two maps (Figure IV.B.1 and Figure IV.B.2), compiled by the Northwest Habitat Institute, illustrate historic conditions (circa 1850) and current conditions. Habitat performance was evaluated by comparing the amounts of various wildlife habitats for historic, current, and future (i.e., alternative strategies) conditions. Each of the 32 wildlife habitat types is depicted as a colored polygon with each color representing a terrestrial, freshwater or marine habitat type. This representation of wildlife habitat types is the first of its kind for the U. S. portion of the basin (discussions with Canadian biologists are proceeding to continue the mapping effort for the whole basin). This consistent mapping effort will result in a hierarchical analysis of the provinces, subbasins, and watersheds.

The results for habitat performance are summarized for a few of the habitats (i.e., shrub steppe, agriculture, and eastside mixed conifer) that illustrate great change since the 1850s. All wildlife habitats and their value for wildlife are integrated into the Habitat Condition Indices and Functional Analyses presented in the following sections. A summary of these data (Table IV.B.1**)** is the basis for illustrating changes between historic, current, and alternative strategies for the basin and provinces.

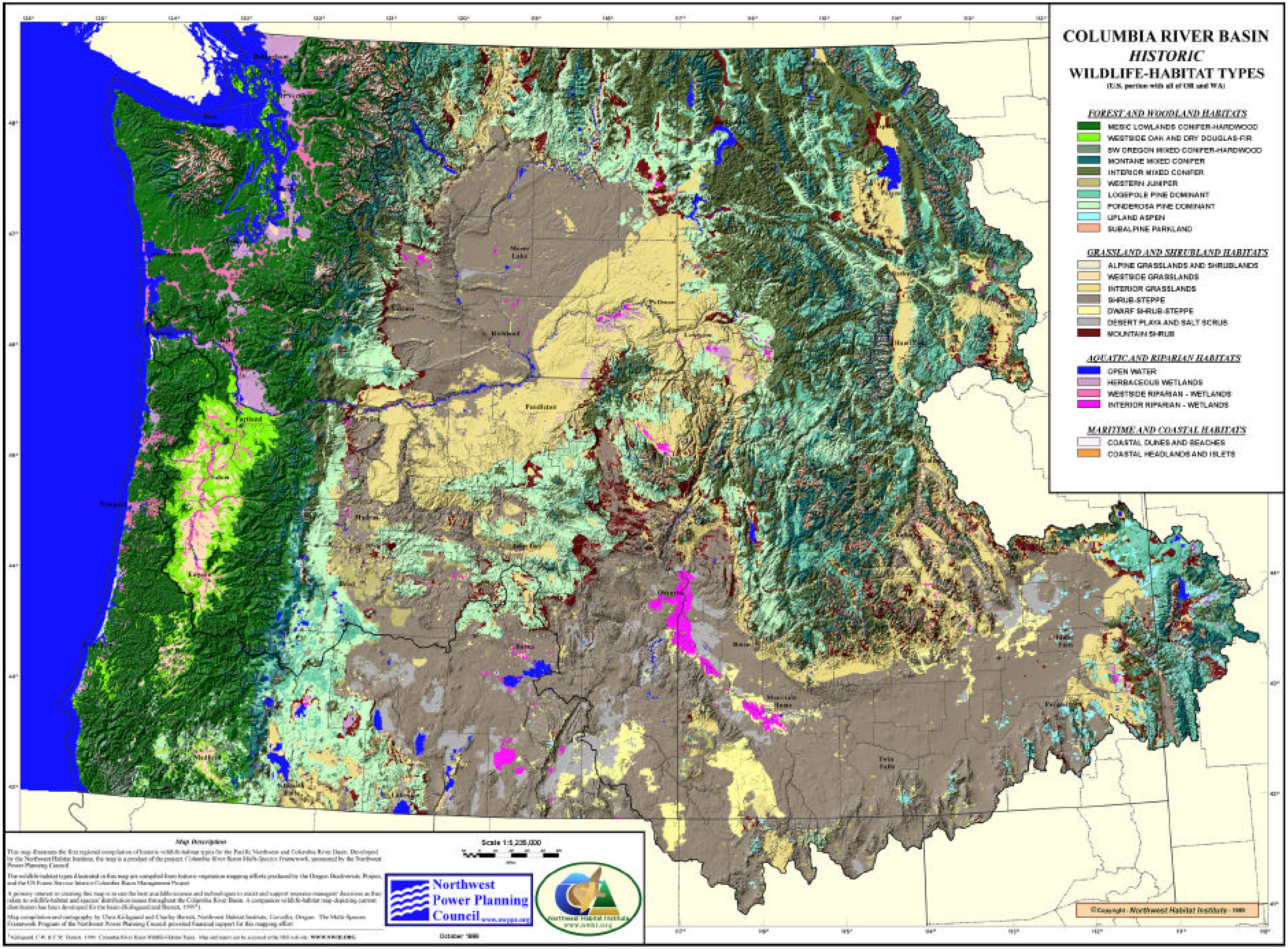


Figure IV.B.1 Historical wildlife habitat types in the Columbia Basin.

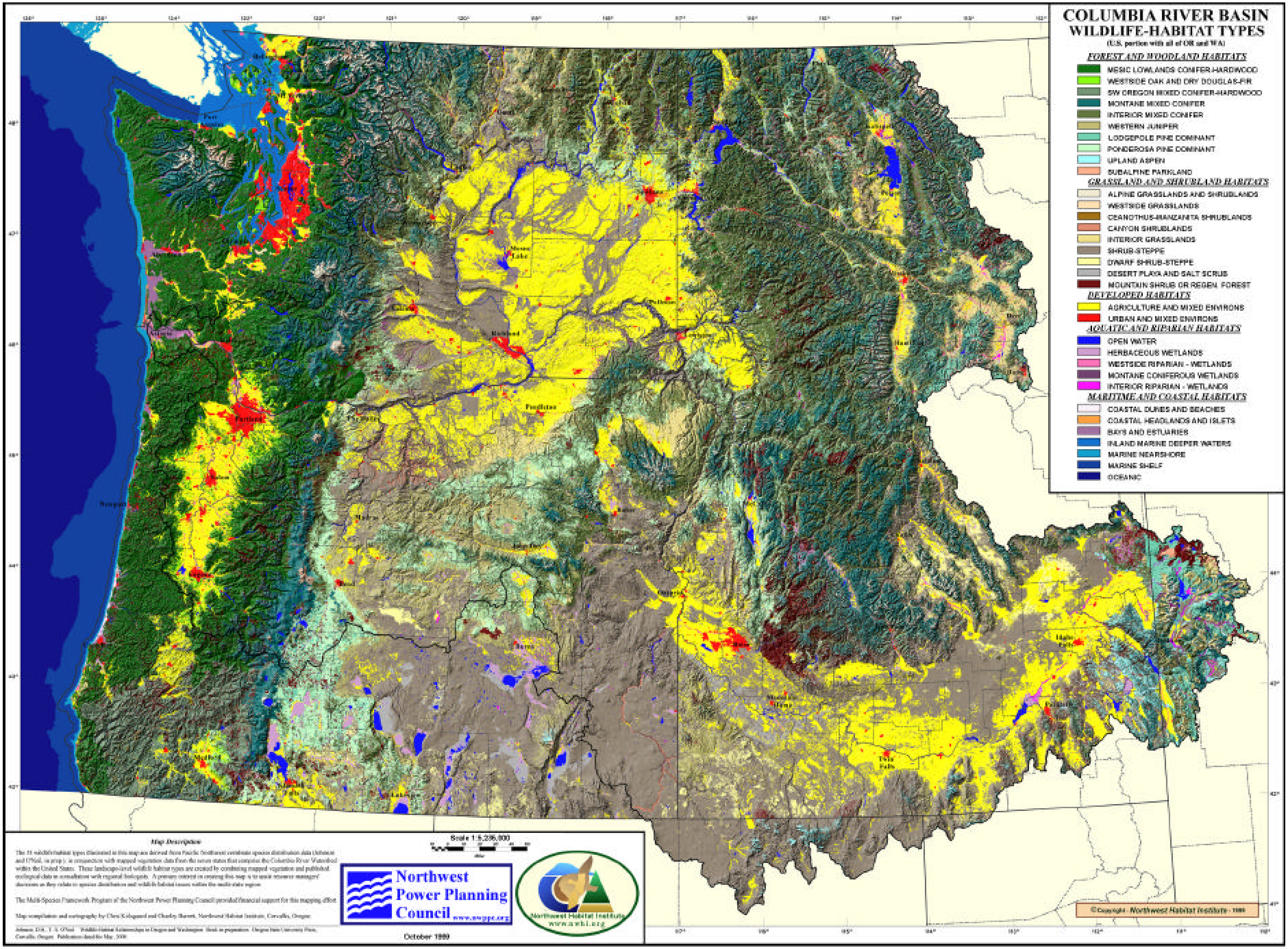


Figure IV.B.2 Current wildlife habitat types in the Columbia Basin.

Table IV.B.1 Change results for a sample of the analysis constructed for wildlife-habitat types, specific species (bald eagle) and functional analysis (total functional diversity, TFD, and functional redundancy, FR) are the basis for historgrams assessing the basin and provinces for historic, current and alternative conditions.

		Change Summaries															
		Hist-Curr	Curr-Alt2	Curr-Alt5	Curr-Alt6	Hist-Curr			Curr-Alt2			Curr-Alt5			Curr-Alt6		
Province	Environmental Attributes					Positive	Negative	No	Positive	Negative	No	Positive	Negative	No	Positive	Negative	No
BLUE_MOUNTAINS	Shrub-steppe	186457	-284029	-218413	-214101	Yes	No		No	Yes		No	Yes		No	Yes	
	Agriculture	386735	651	519	-5227	Yes	No		Yes	No		Yes	No		No	Yes	
	Eastside Mixed Conifer	540809	59862	42344	41981	Yes	No		Yes	No		Yes	No		Yes	No	
	Eagle HCI					71	150	12	66	58	109	61	63	109	57	68	108
	TFD					91	141	1	129	103	1	125	107	1	126	106	1
	FR					105	125	3	146	81	6	144	83	6	144	83	6
COLUMBIA_GORGE	Shrub-steppe	5933	-5131	-5349	-5340	Yes	No		No	Yes		No	Yes		No	Yes	
	Agriculture	36656	-11130	-12280	-12345	Yes	No		No	Yes		No	Yes		No	Yes	
	Eastside Mixed Conifer	-435310	13714	15099	-16098	No	Yes		Yes	No		Yes	No		Yes	No	
	Eagle HCI					9	30	0	17	18	4	17	18	4	17	18	4
	TFD					18	21	0	20	19	0	20	19	0	21	18	0
	FR					8	34	0	30	9	0	30	9	0	31	8	0
INTER_MOUNTAIN	Shrub-steppe	-97226	-27582	-24140	-9563	No	Yes		No	Yes		No	Yes		No	Yes	
	Agriculture	1076818	-448393	-499074	-498907	Yes	No		No	Yes		No	Yes		No	Yes	
	Eastside Mixed Conifer	903068	209460	216245	210793	Yes	No		Yes	No		Yes	No		Yes	No	
	Eagle HCI					112	162	2	93	173	10	93	173	10	91	175	10
	TFD					27	249	0	248	28	0	251	25	0	250	26	0
	FR					41	235	0	239	37	0	239	37	0	240	36	0
MIDDLE_SNAKE	Shrub-steppe	743903	-1573174	-1625847	-1577298	Yes	No		No	Yes		No	Yes		No	Yes	
	Agriculture	2493738	-727601	-795871	-812187	Yes	No		No	Yes		No	Yes		No	Yes	
	Eastside Mixed Conifer	623343	2074	5473	5500	Yes	No		Yes	No		Yes	No		Yes	No	
	Eagle HCI					283	368	588	261	351	627	257	355	627	255	356	628
	TFD					343	855	41	712	483	44	716	479	44	718	477	44
	FR					513	443	283	534	404	301	533	405	301	531	407	301
MOUNTAIN_SNAKE	Shrub-steppe	677255	-489660	-512592	-512592	Yes	No		No	Yes		No	Yes		No	Yes	
	Agriculture	878513	-388610	-427488	-427488	Yes	No		No	Yes		No	Yes		No	Yes	
	Eastside Mixed Conifer	2103950	-12663	-14134	-14134	Yes	No		No	Yes		No	Yes		No	Yes	
	Eagle HCI					364	628	14	372	339	295	370	341	295	370	341	295
	TFD					498	508	0	783	223	0	787	219	0	787	219	0
	FR					485	521	0	672	333	1	672	333	1	672	333	1

COLUMBIA_CASCADE	Shrub-steppe	494254	-481141	-574002	-479328	Yes	No		No	Yes		No	Yes		No	Yes	
	Agriculture	539476	-188290	-215364	-205802	Yes	No		No	Yes		No	Yes		No	Yes	
	Eastside Mixed Conifer	223716	157674	171269	162585	Yes	No		Yes	No		Yes	No		Yes	No	
	Eagle HCI					223	66	10	112	171	16	113	170	16	114	169	16
	TFD					60	239	0	208	91	0	204	95	0	208	91	0
	FR					46	250	3	245	51	3	247	49	3	245	51	3
COLUMBIA_PLATEAU	Shrub-steppe	-3084958	795232	952563	952563	No	Yes		Yes	No		Yes	No		Yes	No	
	Agriculture	8992071	-4678675	-5134312	-5134312	Yes	No		No	Yes		No	Yes		No	Yes	
	Eastside Mixed Conifer	1279241	37790	39212	39212	Yes	No		Yes	No		Yes	No		Yes	No	
	Eagle HCI					780	447	173	208	847	345	187	869	344	183	873	344
	TFD					168	1232	0	1124	275	1	1127	272	1	1129	270	1
	FR					763	561	76	593	725	82	594	724	82	587	731	82
LOWER_COLUMBIA	Shrub-steppe	0	0	0	0												
	Agriculture	2078113	-909365	-1017371	-1027531	Yes	No		No	Yes		No	Yes		No	Yes	
	Eastside Mixed Conifer	2652	85	117	117	Yes	No		Yes	No		Yes	No		Yes	No	
	Eagle HCI					115	173	0	84	180	24	80	184	24	81	183	24
	TFD					38	250	0	178	110	0	181	107	0	187	101	0
	FR					122	166	0	183	105	0	186	102	0	183	105	0
MOUNTAIN_COLUMBIA	Shrub-steppe	262735	-218281	-223622	-217625	Yes	No		No	Yes		No	Yes		No	Yes	
	Agriculture	826476	-219776	-233226	-227406	Yes	No		No	Yes		No	Yes		No	Yes	
	Eastside Mixed Conifer	1408442	205176	216689	215458	Yes	No		Yes	No		Yes	No		Yes	No	
	Eagle HCI					1133	44	61	671	500	67	673	498	67	669	502	67
	TFD					451	787	0	929	309	0	925	313	0	927	311	0
	FR					429	809	0	940	298	0	937	301	0	939	299	0
UPPER_SNAKE	Shrub-steppe	-2871658	721532	876448	876448	No	Yes		Yes	No		Yes	No		Yes	No	
	Agriculture	5941645	-2964045	-3255359	-3255359	Yes	No		No	Yes		No	Yes		No	Yes	
	Eastside Mixed Conifer	-403624	191146	200985	200985	No	Yes		Yes	No		Yes	No		Yes	No	
	Eagle HCI					837	18	189	187	658	199	186	659	199	186	659	199
	TFD					263	776	5	727	313	4	728	312	4	728	312	4
	FR					486	483	75	565	401	78	564	402	78	564	402	78
TOTAL_BASIN	Shrub-steppe	-3683305	-1562235	-1354954	-1147825	No	Yes		No	Yes		No	Yes		No	Yes	
	Agriculture	23250240	-10535235	-11589827	-11615880	Yes	No		No	Yes		No	Yes		No	Yes	
	Eastside Mixed Conifer	6246288	864318	893299	877841	Yes	No		Yes	No		Yes	No		Yes	No	
	Eagle HCI					3927	2086	1049	2071	3295	1696	2037	3330	1695	2023	3344	1695
	TFD					1957	5058	47	5058	1954	50	5064	1948	50	5081	1931	50
	FR					2995	3627	440	4147	2444	471	4146	2445	471	4136	2455	471

TFD: Total Functional Diversity **FR: Functional Redundancy**

Table IV.B.1 Change results for a sample of the analysis constructed for wildlife-habitat types, specific species (bald eagle) and functional analysis (total functional diversity, TFD, and functional redundancy, FR) are the basis for historgrams assessing the basin and provinces for historic, current and alternative conditions.

Historic

Columbia Basin Scale Analysis

The historic wildlife habitat type map (Figure IV.B.1) was created to illustrate the norm circa 1850 for the U.S. portion of the Columbia Basin. This map provides an idea of what the historic (and future) potential for an area might be. The historic map is coarse at 1.6 miles (1 km) resolution compared to the finer scale current map. The coarse scale map at the basin and the province levels can under-represent some wildlife habitat types. For example, the historic map indicates relatively large wetland areas in the Willamette and Snake River valleys. Narrow riparian wetlands along small streams in headwater situations are not represented at the coarse scale. The fact that these narrow wetlands are not shown means that they are underrepresented in the historic map and that there is less difference shown between historic and current conditions than likely what actually occurred. Other wildlife habitats such as shrub steppe are less likely under represented on the historic map and changes between historic and current are likely more representative of actual changes.

The historic wildlife habitat types serve as a reference for wildlife restoration across the basin. Management Activities or strategies that change current conditions toward the historic condition are likely to restore wildlife habitat types for native wildlife species and communities. The historic and current maps also provide insight to ecosystem processes that have resulted in ecosystem change. Insights into ecosystem processes and functions are likely to help understand and guide the direction (but not the detail) of what a future alternative might be.

General amounts of the three examples of wildlife habitat types in the basin are represented by the grand total column in Figure IV.B.3. The shrub-steppe habitat comprised about 28 percent, east-side mixed conifer about 14 percent, and agriculture was nearly absent in the basin under historic conditions. The detail of the amount of these and the other wildlife habitat in the basin will come later in the analyses for the subbasin assessments. The historic wildlife habitat types are most interesting when compared to the map of current wildlife habitats (see below).

Province Scale Analysis

The province scale analysis of wildlife habitat types was conducted for three wildlife habitat types as an example of the type of analysis that might be conducted to assess differences in wildlife habitat across the basin, and as a basis for assessing change in space and time (Figure IV.B.4). Eastside mixed conifer habitat occurs in all provinces with the

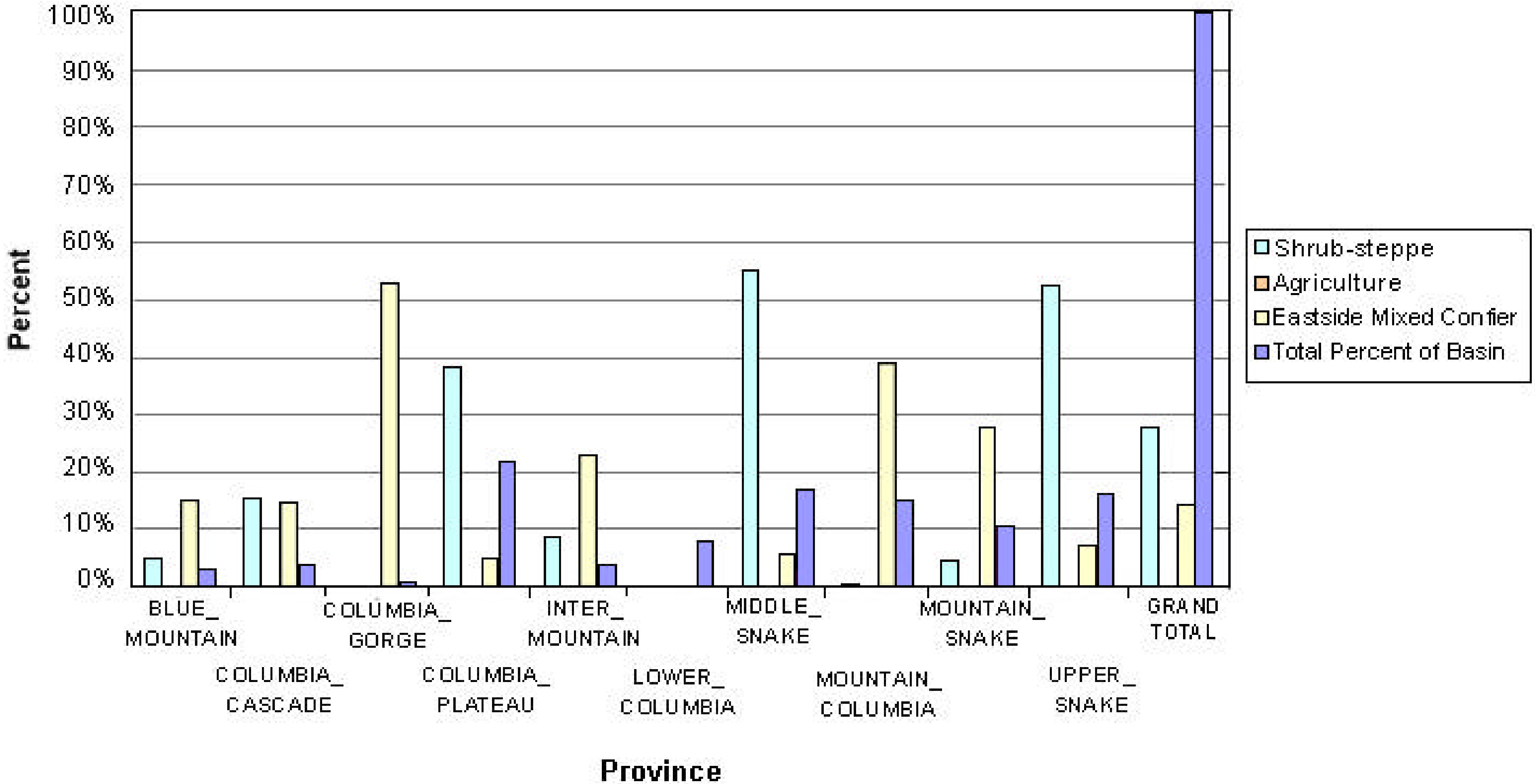


Figure IV.B.3 Percent of three wildlife habitat types in each of the ten provinces for historic conditions. These three habitat types are presented as examples of the 28 aquatic and terrestrial (non-marine) wildlife-habitat types illustrated in Figure 1.

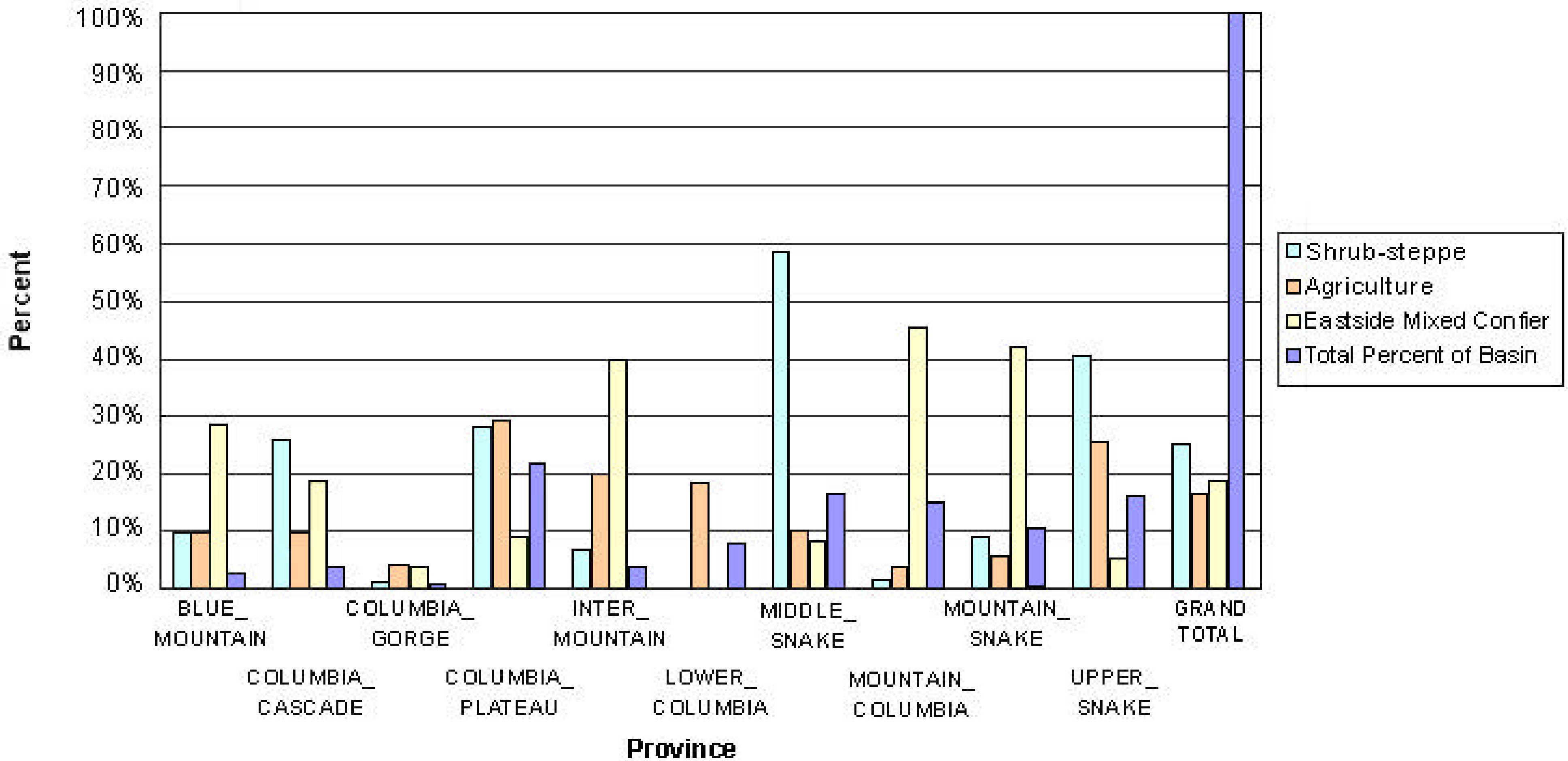


Figure IV.B.4 Percent of three wildlife habitat types in each of the ten provinces for current conditions. These three habitat types are presented as an example of the 28 aquatic and terrestrial (non-marine) wildlife-habitat types illustrated in figure IV.B.2.

exception of the Lower Columbia. This habitat is more common in the Columbia Gorge, Inter Mountain, Mountain Columbia, and Mountain Snake Provinces. Shrub steppe habitat is also present in nine of the ten provinces. It is most common in the Columbia Plateau, Middle Snake, and Upper Snake Provinces. The agricultural habitat type is close to zero in all provinces.

Current

Columbia Basin Scale Analysis

Wildlife habitat types mapped for the current conditions (Figure IV.B.2) are depicted at a minimum mapping unit of 250 acres (100 ha). The most notable changes from the historic map are: (1) conversion of the shrub steppe and dwarf shrub steppe to agriculture, (2) conversion of the Willamette and Snake River Valley wetlands and grasslands to agriculture, and (3) conversion of eastside ponderosa pine forest to mixed conifer forest (due to fire suppression, selective logging, and grazing). Conversion of wetlands is detectable for large areas such as the Willamette Valley and the Vancouver Lake area along the Lower Columbia. These large changes give managers a perspective of the general magnitude and location of changes that have occurred. The minimum mapping unit of the historic map precludes an accurate representation of the relatively narrow (i.e., less than 1,000 feet wide) historic wetlands that occurred along many of the smaller tributaries that were likely important to beaver and salmon in historic times. Accurate analyses of wetland and riparian changes will have to await later analyses at the subbasin and watershed scales.

The grand total percents of the three habitats at the basin scale indicate shrub steppe is just over 20 percent, and eastside mixed conifer is just under 20 percent of the basin (Figure IV.B.3). The most dramatic change between historic and current conditions is the increase of 23.5 million acres of agriculture (Figure IV.B.5). A relatively small portion of this change came from shrub steppe wildlife habitat type. Other wildlife habitat types such as grassland, forest and dwarf shrub steppe have also been converted to agriculture (Hessburg et al. 2000, Huff et al. 1995).

Province Scale Analysis

Changes in shrub-steppe and eastside mixed conifer wildlife habitat types likely are better (than wetlands) represented at the province scale. The percent of these wildlife habitat types for current conditions (Figure IV.B.3) in the various provinces indicates where conversions to agriculture are the greatest. For example, about 6 percent (0.4 million acres) of the

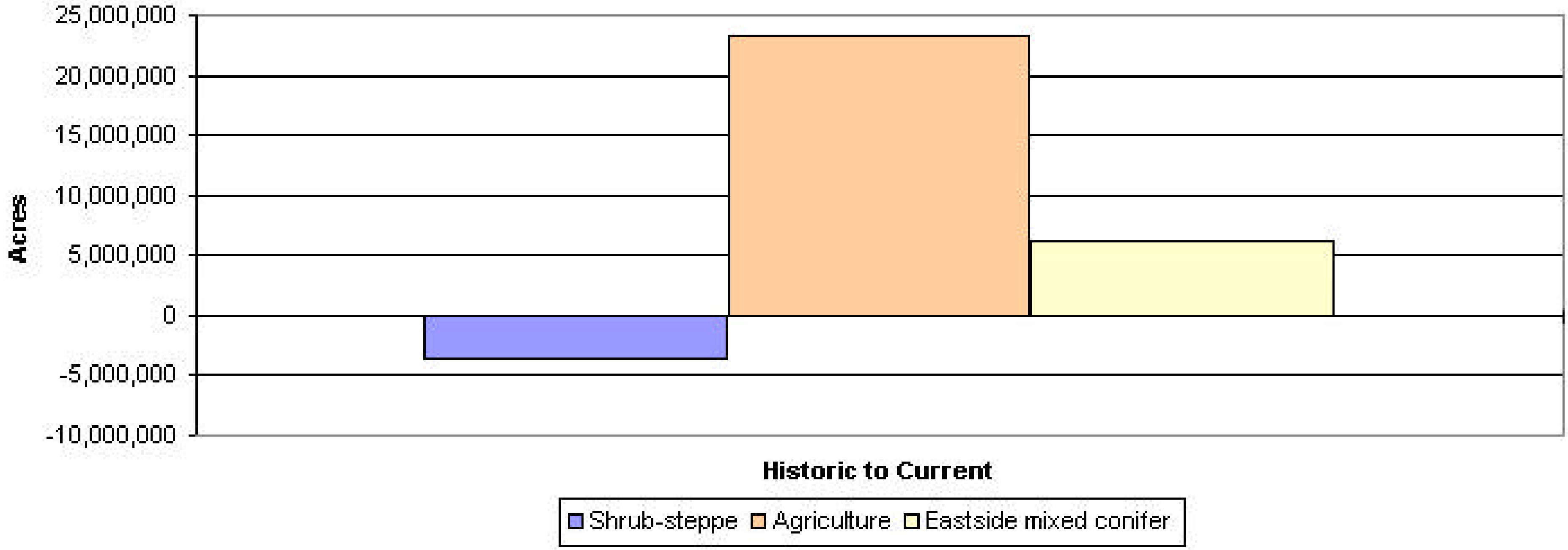


Figure IV.B.5 Change in acres of three wildlife-habitat types in the U.S. portion of the Columbia Basin from historic to current conditions. These three habitat types are presented as examples of the changes in the 32 aquatic and terrestrial (non-marine) habitats in the basin. Agricultural acreage has increased by 23 million acres during the past 150 years. A relatively small portion of this increase has come from the shrub-steppe wildlife-habitat type.

Mountain Snake province has been converted to agriculture whereas almost 30 percent (3.9 million acres) of the Columbia Plateau has been converted to agriculture. Eastside mixed conifer forest conversion to agriculture is most pronounced in the Mountain Columbia (about 45 percent). These changes are best illustrated in Figure IV.B.6 where the largest increases in agricultural acreage are in the Columbia Plateau and the Mountain Snake provinces. Given the large conversions to agriculture in these provinces, it is not surprising that this is where there was the largest reduction in shrub steppe acres. The province analysis also indicates shrub steppe acres did not decrease in all provinces and actually increased in five provinces (e.g., Mountain Snake) along with agriculture. Subbasin analyses in these provinces should address the reasons for these increases in shrub steppe. Eastside conifer forest increases at the basin level can be attributed to provinces on the west slope of the Rocky Mountains (e.g., Mountain Snake) but not all provinces had increases in this wildlife habitat type. A decrease in acres of this wildlife habitat type occurred in the Upper Snake and Columbia Plateau.

Alternatives

Columbia Basin Scale Analysis

Wildlife habitat types estimated by Vail et al. 2001 (Figure IV.B.7) clearly show a loss of over 10 million acres of the agriculture wildlife habitat type in the future under all three alternatives. Alternative 2, which addresses dam removal, reduces the agriculture habitat slightly less than the other two alternatives that do not propose dam removal. Alternative 6 reduces the agriculture habitat slightly more than Alternative 5 (Table IV.B.1), a slight increase in eastside conifer forest is approximately equal for each alternative. The decrease in shrub steppe is slightly greater in Alternative 2 than the other two alternatives.

Province Scale Analysis

The changes in wildlife habitat types are similar for each alternative (generally less than 10 percent difference between each alternative for each wildlife habitat type). Given this similarity among alternatives, the province scale analysis focuses on one alternative with the knowledge that trends discussed apply to all alternatives. Alternative 2 shows that the changes in the agriculture wildlife habitat type are quite different for each province (Figure IV.B.8). One province, Blue Mountain, showed a 651-acre increase and the other nine provinces showed decreases. The decreases varied from 3 to 4.6 million acres in the Upper Snake and Columbia Plateau to about 11 thousand acres in the Columbia Gorge. The changes in

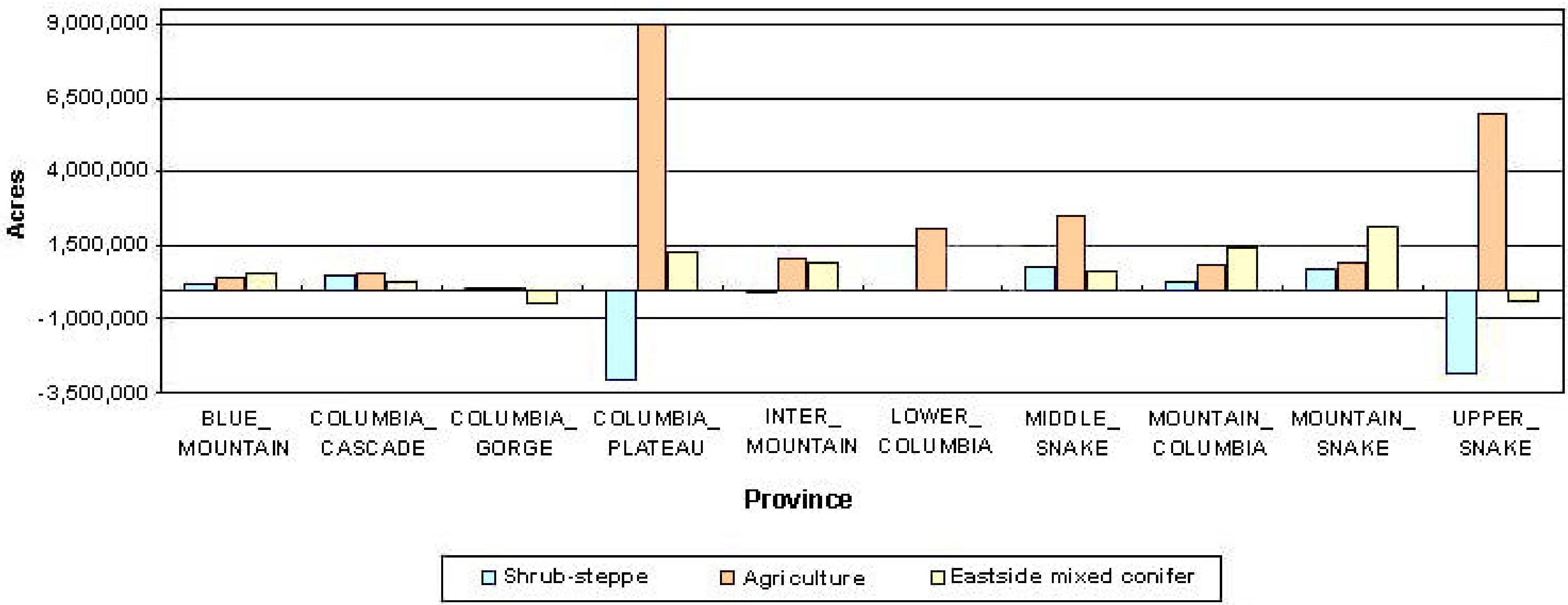


Figure IV.B.6 Change in acres of three wildlife-habitat types in each province from historic to current conditions. These three habitat types are presented as examples of the changes in the many aquatic and terrestrial habitat types in the provinces. Most of the increase in the agriculture habitat type has occurred in the Columiba Plateau and Upper Snake provinces.

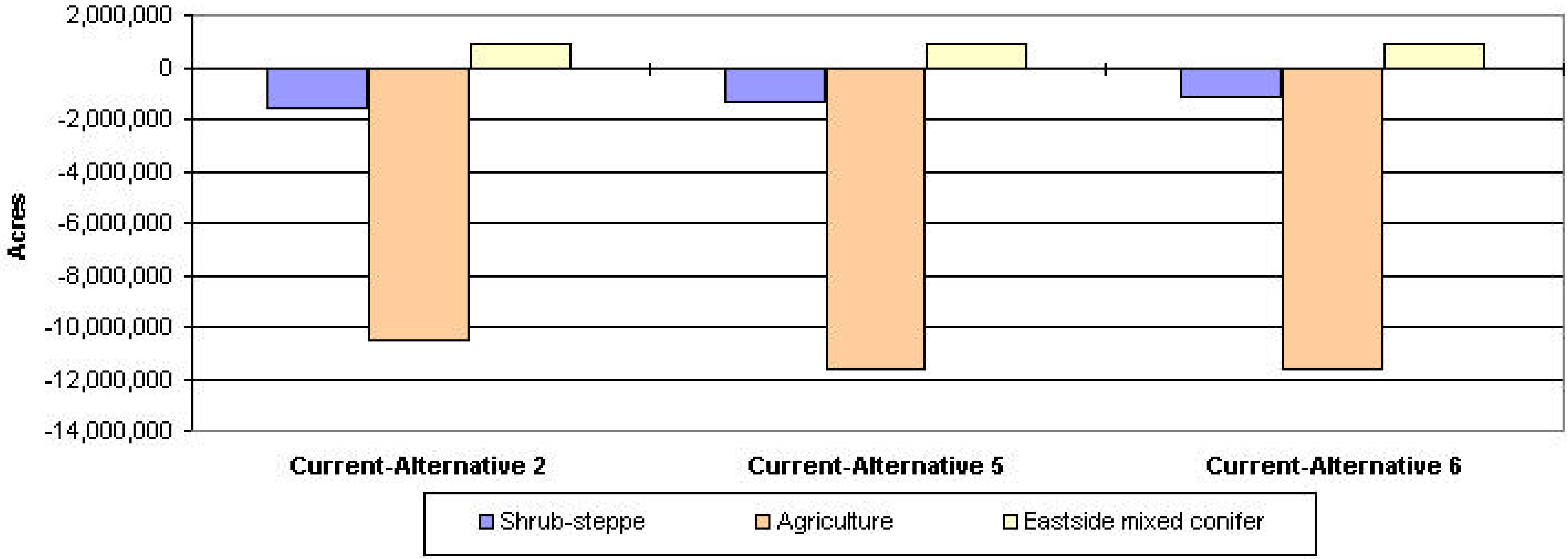


Figure IV.B.7 Change in acres of three wildlife-habitat types in the U.S. portion of the Columbia Basin from current to alternatives 2, 5, and 6 conditions. These three habitat types are presented as examples of the proposed changes for all the aquatic and terrestrial (non-marine) habitat types in the basin. All alternatives propose to reduce the agriculture habitat type by 10 to 12 million acres.

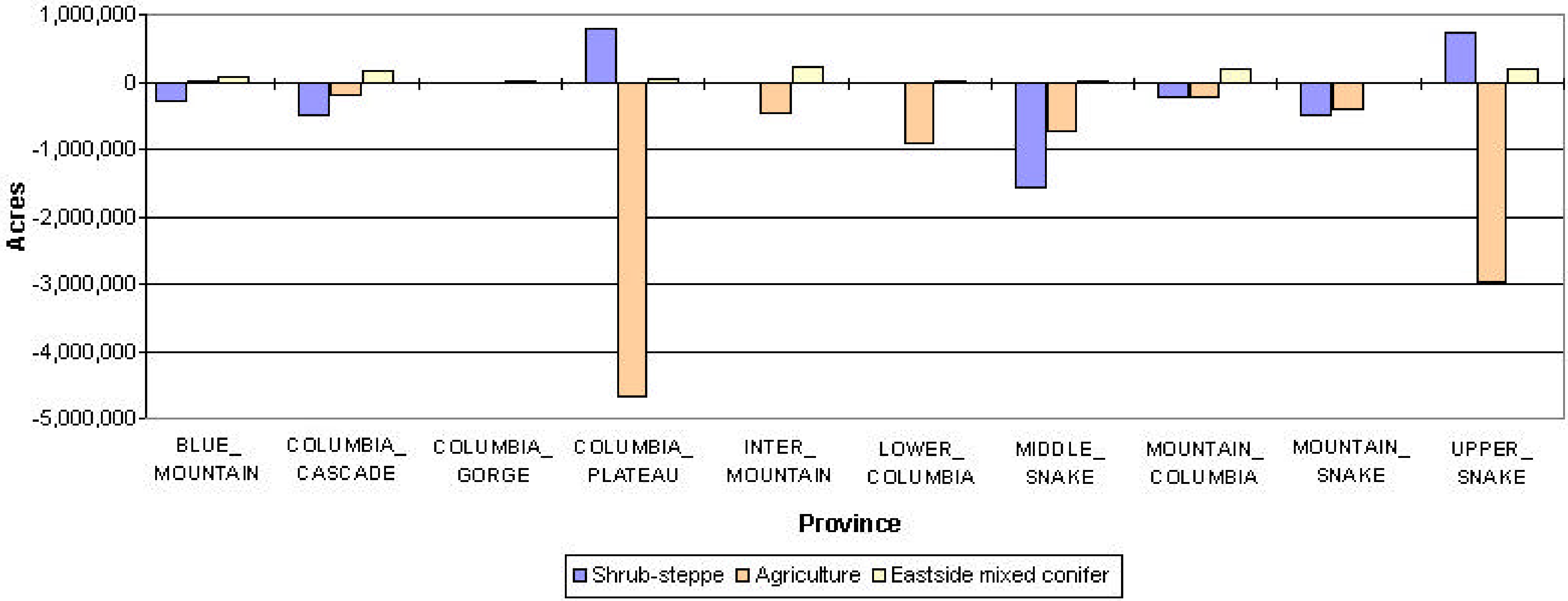


Figure IV.B.8 Change in acres of three wildlife-habitat types in each province from current to alternative 2 conditions. These three habitat types are presented as examples of the proposed changes in the terrestrial and aquatic (non-marine) habitat types in the provinces. Most of the reduction in agricutlre is proposed for the Columbia Plateau and Upper Snake provinces.

shrub steppe also varied across the provinces with increases in the Columbia Plateau and Upper Snake provinces. The largest decrease (1.6 million acres) in the shrub steppe habitat was in the Middle Snake. Decreases in other provinces were less than half a million acres. Eastside conifer forest increased in nine of the ten provinces. The largest gain, 209 thousand acres, was in the Inter Mountain province. One province, the Mountain Snake, had a slight (13 thousand acre) decrease.

Biological Performance

Biological performance for the black bear and the bald eagle were assessed using a Habitat Condition Index (HCI) to estimate capacity (see Methods). As discussed in Methods, necessary fine-scale data on riparian and aquatic habitats were not available for calculating an HCI for the American beaver. HCI results for the black bear and the bald eagle were calculated for each 6-HUC (in the range of the species) and are presented here in three formats: HCI maps, cumulative integrated capacity curves, and HCI change maps. 6-HUC information was aggregated at two levels for analysis: the basin and province. Two types of presentation are illustrated for the species level analysis. The black bear analysis is very general, and utilizes HCI maps and cumulative integrated capacity curves. The bald eagle analysis relies on HCI maps, change maps, and histograms.

The HCI maps plot an HCI value for each 6-HUC. The highest HCI values are represented as dark green and the shade of green lightens as the HCI values decrease with white equivalent to zero. White 6-HUCs represent areas outside the range of the species. Change maps have been prepared to illustrate where the greatest and least changes are expected. Dark red shows the greatest negative changes while the pink and white 6-HUCs illustrate the least negative change. Dark blue shows the greatest positive change while the light blue shows the least positive change. This analysis is especially good for alerting managers to possible problem areas for proposed alternatives.

Black Bear

HCI calculations for historic wildlife capacity are shown on the HCI maps as dark green areas (Figure IV.B.9) where one would expect black bear to have been abundant in the 1850s. For example, the Cascade Range from central Oregon to Canada and the western front range of the Rocky Mountains in Idaho and Montana show the darkest green 6-HUCs. Areas where bears have never been abundant such as southeastern Oregon and southern Idaho are white. The current wildlife capacity (Figure IV.B.10) shows less (than historic) dark green in the above areas and noticeable

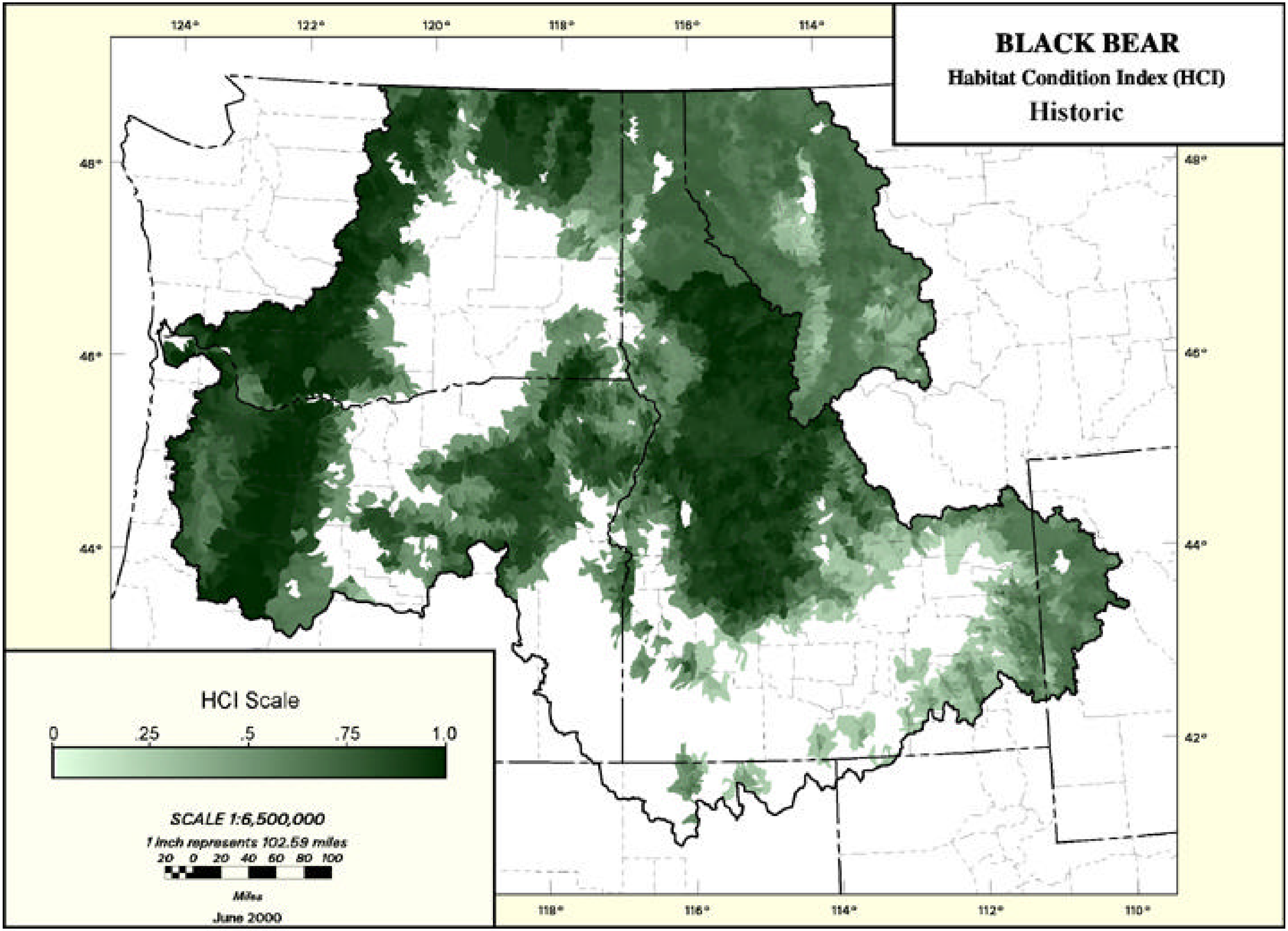


Figure IV.B.9 Bear habitat capacity as measured by a habitat condition index (HCI) for each 6-HUC illustrates historic bear habitat (dark shaded 6-HUCs) in the Cascade Range, the Wallowa Mountains and the front-range of the Rocky Mountains.

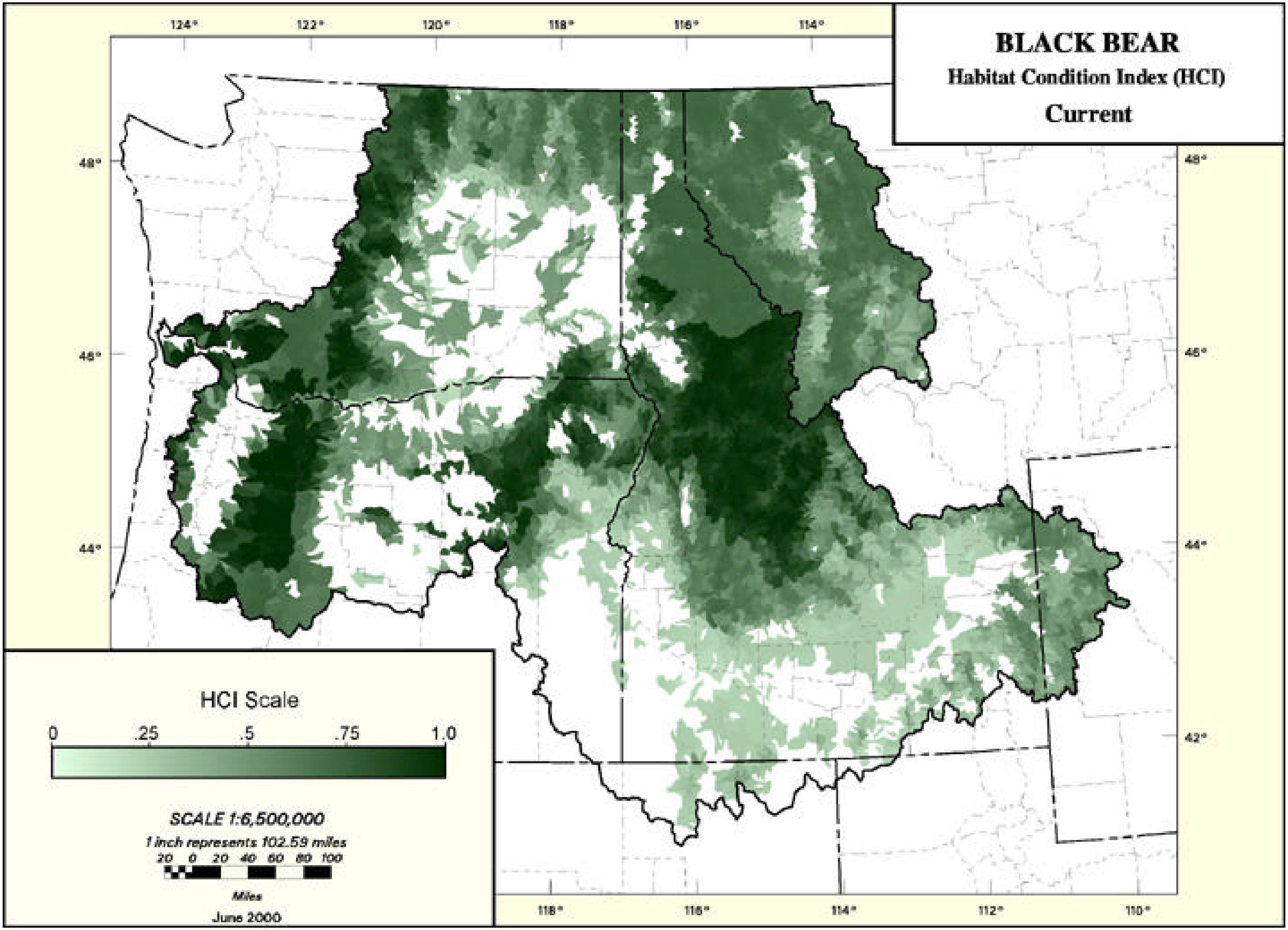


Figure IV.B.10 Bear habitat capacity as measured by a habitat condition index (HCI) for each 6-HUC illustrates current bear habitat is absent (white 6-HUCs) from large areas such as the Willamette Valley and reduced in value in areas such as the North Cascades and the front range of the Rocky Mountains.

absence of bears in populated and agricultural areas (e.g., Willamette Valley.) This is best illustrated in a comparison of the cumulative integrated capacity curves for historic and current wildlife habitat types (Figures IV.B.11 and IV.B.12). The historic curve shows 1000 6-HUCs with a 0.92 (or greater) HCI whereas the current curve shows a general reduction in HCI value with 1000 6-HUCs valued at 0.87 (or greater) HCI.

All three alternatives resulted in HCI maps that are similar and hence are not illustrated. Little change was observed at the basin scale between alternatives due to the relatively small amount of proposed change in forested wildlife habitats. A comparison between current black bear HCI and the alternatives is also slight and difficult to detect with HCI maps at the basin level. Cumulative integrated capacity curves illustrate the subtle differences between current (Figure IV.B.12) and the alternatives (Figure IV.B.13), represented as Alternative 6. The alternatives show a small increase in higher value 6-HUCs (probably due to an increase in carcasses in 75 6-HUCs) but a larger increase in lower value 6-HUCs (i.e., below 0.4 HCI). This indicates that the alternatives could have a positive impact on lower quality black bear habitat. The positive impact illustrated in the cumulative integrated capacity curves is likely due to the projected reduction in roading. The HCI assessment method (i.e., the literature) gives considerable emphasis to the negative influence of roads on black bear.

As one considers the results of the black bear analysis it is important to remember the coarse scale of the analysis and not rely on the results for decision making regarding fish and wildlife recovery. Of greater importance is the result that indicates little is being done to enhance black bear habitat in forested environments and possible consequences of such an alternative strategy for fish. For example, this result might stimulate a fisheries biologist to ask if there will there be adequate forests to produce large woody debris for future aquatic habitat improvements. If as a result of this analysis the alternative is modified to include strategies in forested environments, the fish biologists might coordinate the location (i.e., landscape) for these activities to provide the most benefit for fish as well as higher quality bear habitat. In addition, managers at the subbasin scale of analysis should be aware that decisions to benefit fish while beneficial for bear in some places could be detrimental for bear in other places. Forest structure data that may be available for subbasin analyses (especially in stringers through shrub-steppe habitats) will likely be important for examining potential benefits for fish as well as bear.

Fish and wildlife interaction is a key interest of the framework analysis. The black bear HCI analysis includes the fish carcass variable that allows a simple but important interaction between fish distribution and black bear

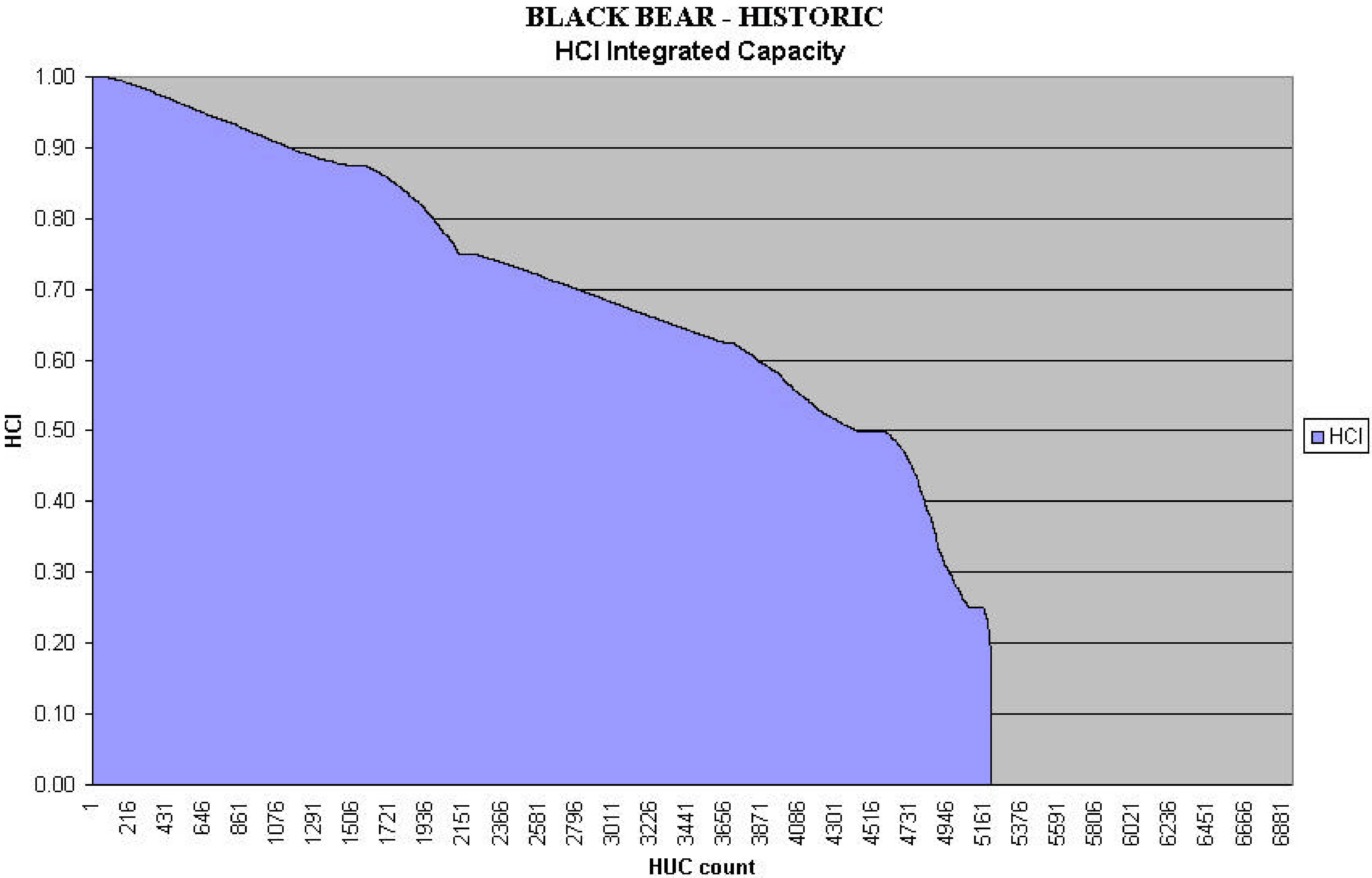


Figure IV.B.11 Historic habitat condition indices (HCIs) for black bear, represented in a cumulative format, are higher than current values. For example, 1000 historic 6-HUCs have a HCI value 0.92 (or greater) compared to 1000 current 6-HUCs that have an HCI value of 0.87 (or greater).

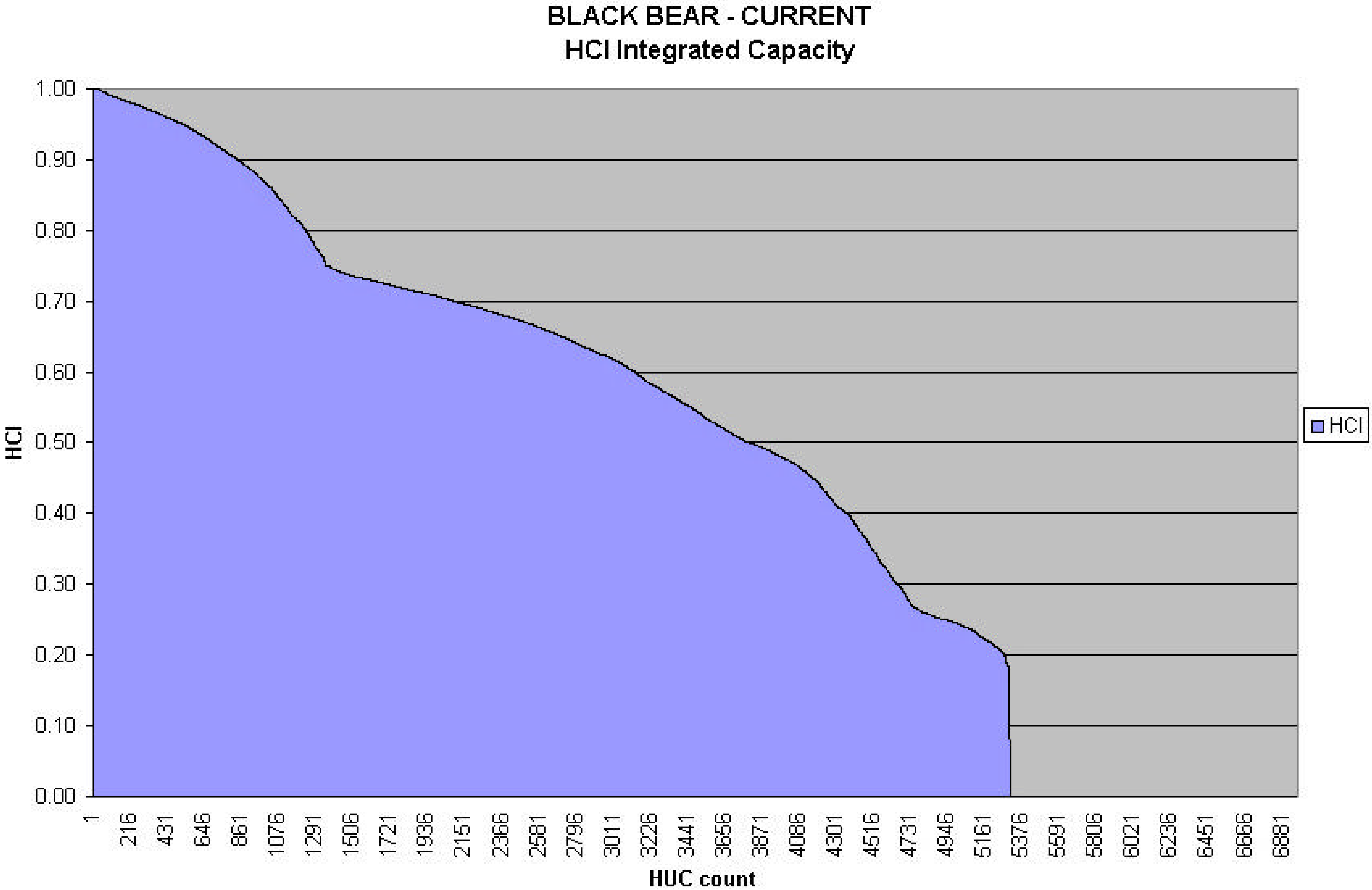


Figure IV.B.12 Current habitat condition indices (HCIs) for black bear, represented in a cumulative format, are lower than historic values. For example, 1000 current 6-HUCs have an HCI value of 0.87 (or greater) compared to 1000 historic 6-HUCs that have an HCI value of 0.92 (or greater).

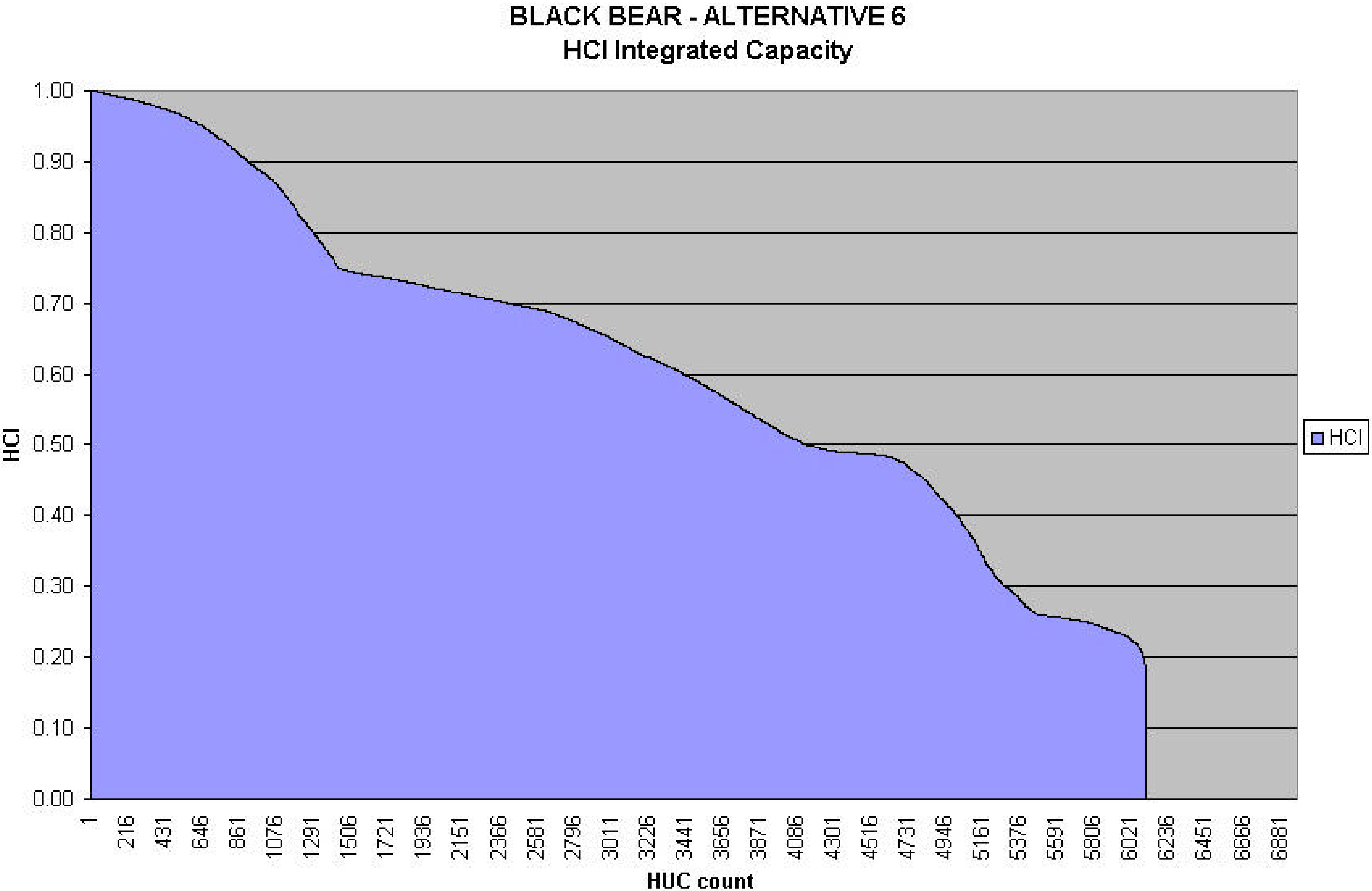


Figure IV.B.13 Alternative habitat condition indices (HCIs) for black bear, represented in a cumulative format, are higher than current but generally not as high as historic values.

habitat value. The importance of fish carcass data can be further examined at the subbasin scale by expanding the carcass variable to include carcass abundance (versus presence or absence in the current HCI analysis) and seasonal use across the landscape.

Bald Eagle

The bald eagle analysis is a little more detailed that the black bear analysis and illustrates how species-specific data might be presented in a more quantitative format. The use of data in Table IV.B.1 and histograms helps to identify areas where alternatives might have a negative influence on this threatened species.

Historic Habitat for Bald Eagle

Columbia Basin and Province Scale Analyses

HCI calculations for the historic wildlife capacity show few dark green 6-HUCs and relatively few 6-HUCs with low (i.e., 0.10) HCI values (Figure IV.B.14). Some of this is due to the large areas of shrub steppe (poor bald eagle habitat). Another explanation is the general lack of fine scale information on wetlands, especially narrow riparian wetlands, from the 1850s. For example, much of the narrow (i.e., less than a kilometer wide) riparian stringer wetlands that were likely present in historic conditions are under-represented at a coarse-mapping resolution of 1 kilometer. Areas along major rivers such as the Willamette and Snake are probably accurately represented on the historic map but few of these areas have high HCIs. The linear nature of suitable wildlife habitat for the bald eagle is not conducive to averaging across provinces for either historic or current times. Instead, the analysis focuses on change in distribution and percent of 6-HUCs increasing or decreasing in HCI value from historic to current.

Current Habitat for Bald Eagle

Columbia Basin Scale Analysis

The current wildlife capacity for the bald eagle (Figure IV.B.15) shows more dark green 6-HUCs (than Historic) and a wider distribution of colored 6-HUCs. For example, the Columbia Plateau and north-central Oregon are mostly lighter shades of green. The cumulative integrated capacity curves for the historic (Figure IV.B.16) and current (Figure IV.B.17) clearly illustrate the above points. The historic curve is truncated showing less than half of the 6-HUCs occupied by bald eagles, while the current curve (Figure IV.B.17) extends to the right showing more 6-HUCs occupied and more HCI values between 0.25 and 0.80. Approximately 56 percent of the 6-HUCs showed in increase in HCI from historic to current.

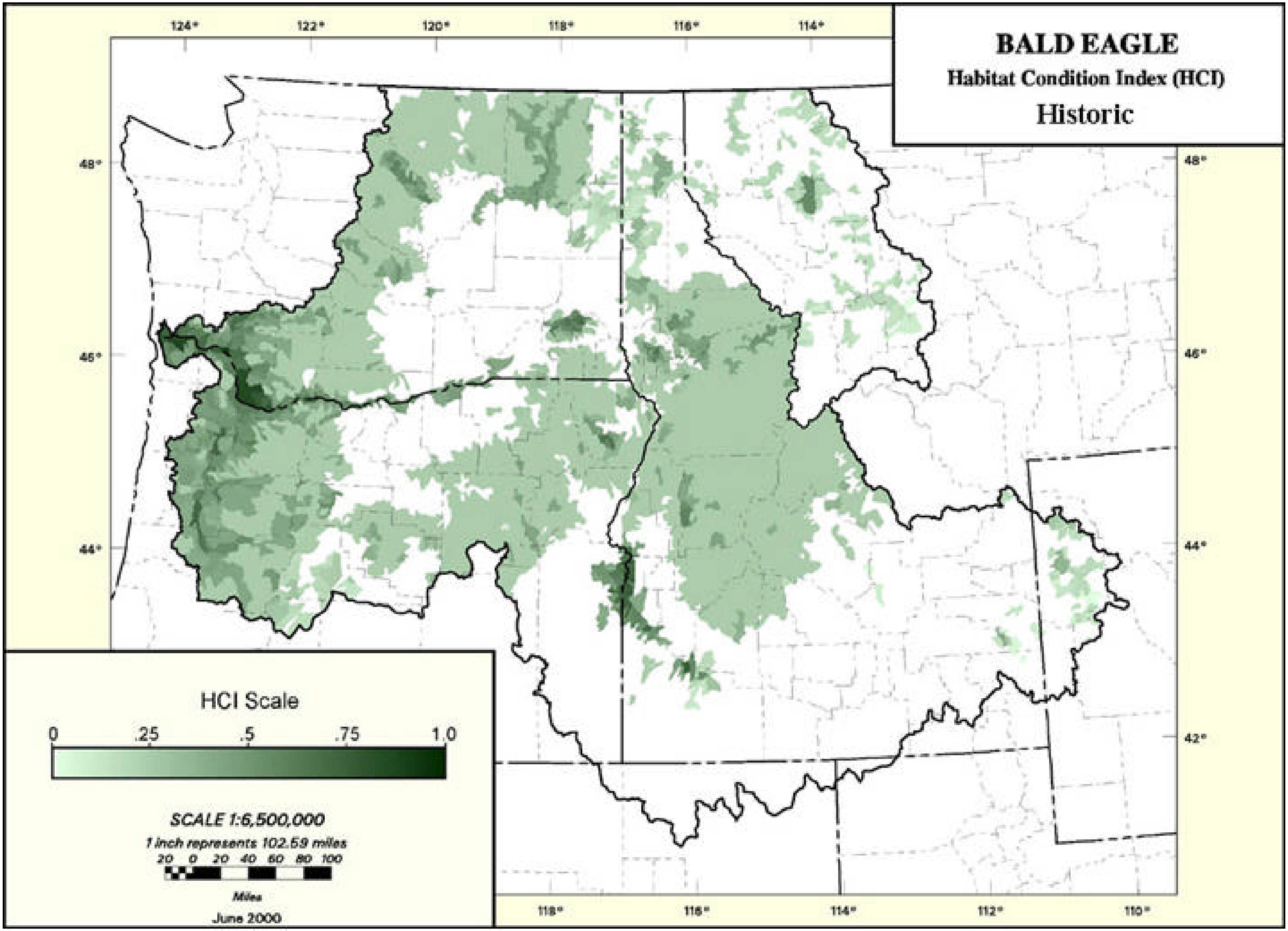


Figure IV.B.14 Historic bald eagle habitat capacity as measured by a habitat condition index (HCI) for each 6-HUC illustrates (dark shaded 6-HUCs) bald eagle habitat in the Lower Columbia and the Middle Snake Provinces.

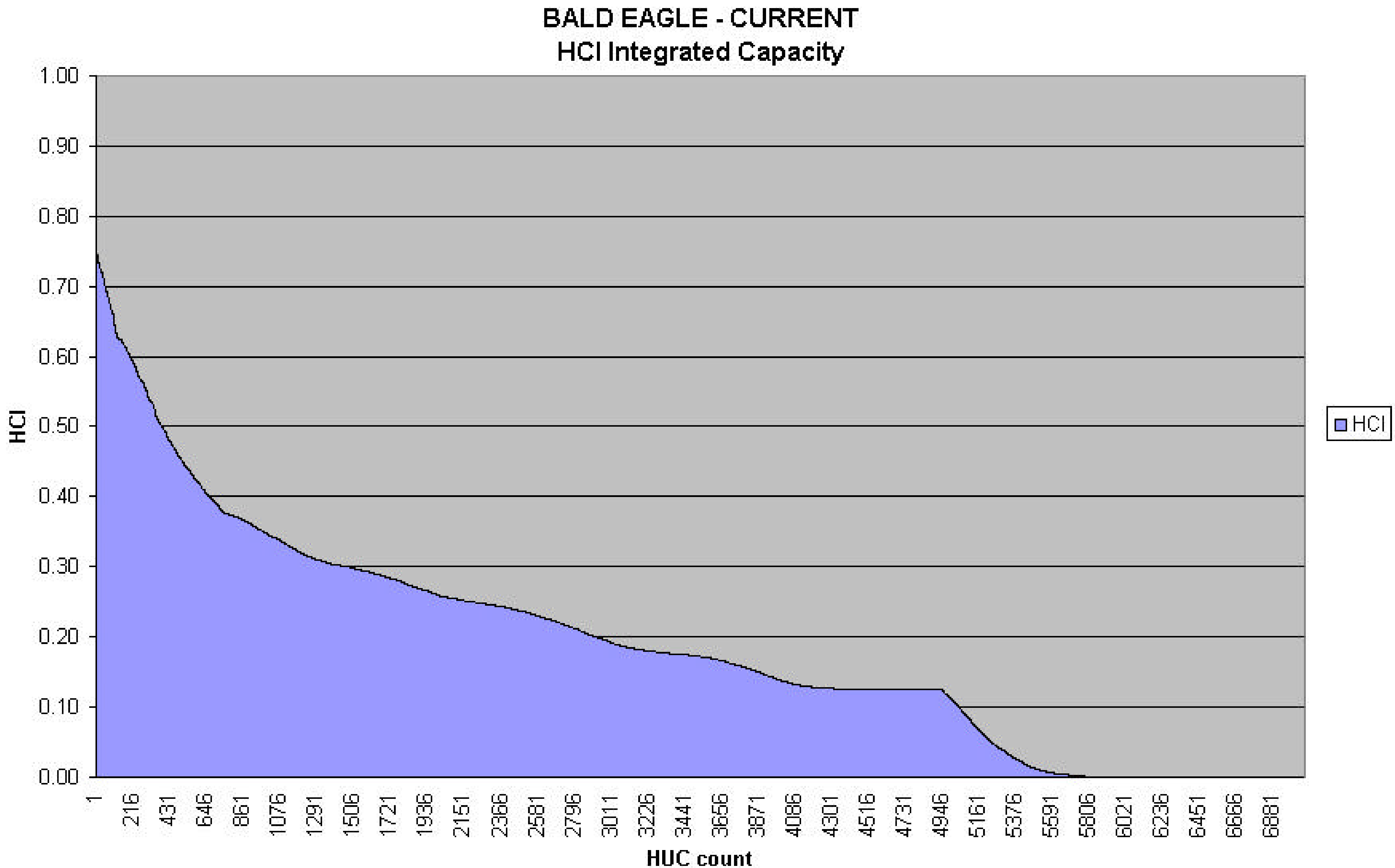


Figure IV.B.15 Current bald eagle habitat capacity as measured by a habitat condition index (HCI) for each 6-HUC illustrates (dark shaded 6-HUCs) bald eagle habitat in the Lower Columbia, Upper Snake and the Columbia Plateau Provinces. There was much less bald eagle habitat in the Upper Snake and Columbia Plateau Provinces during historic conditions compared to current conditions.

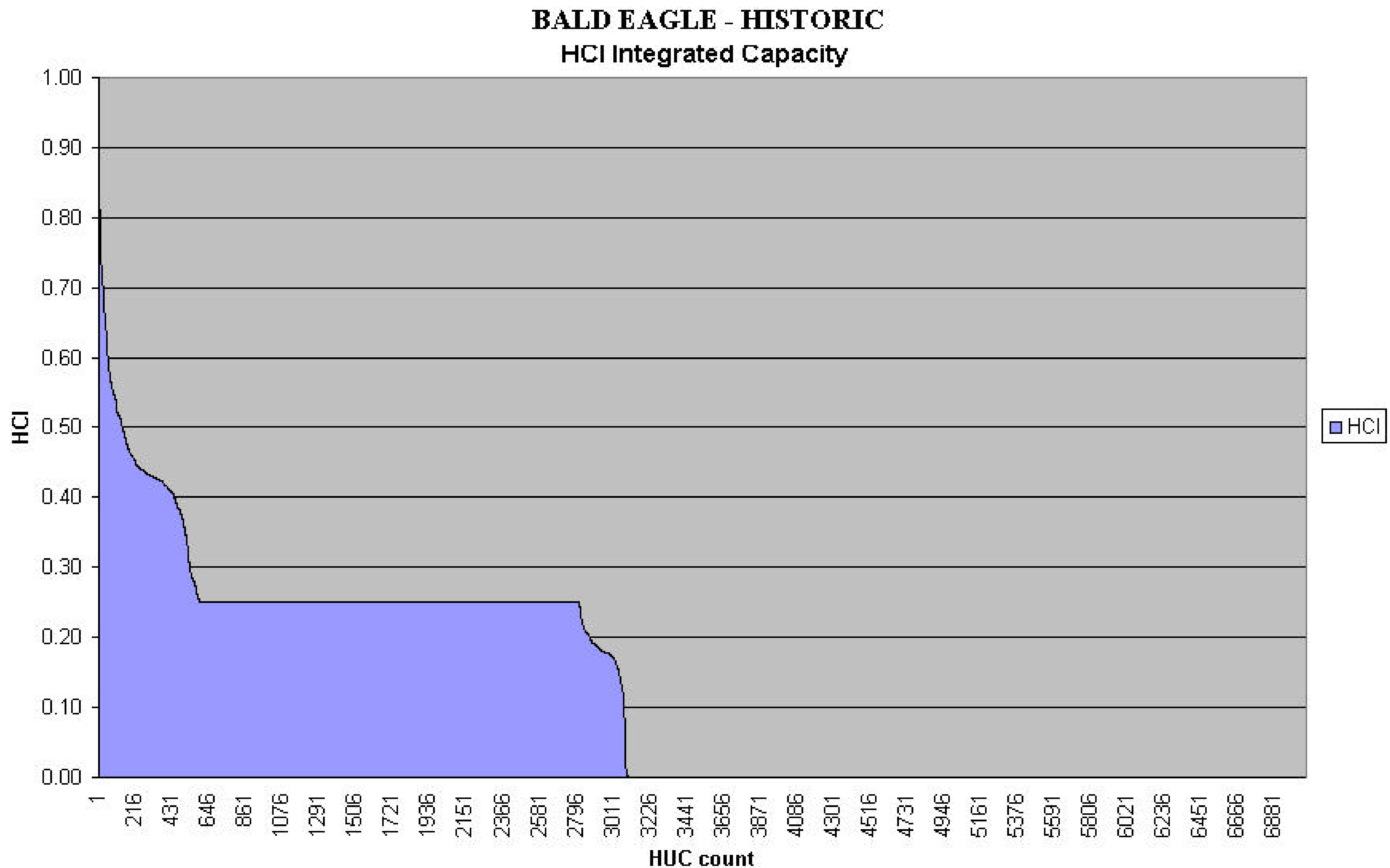


Figure IV.B.16 Historic habitat condition indices (HCIs) for the bald eagle, represented in a cumulative format, are lower than current values.

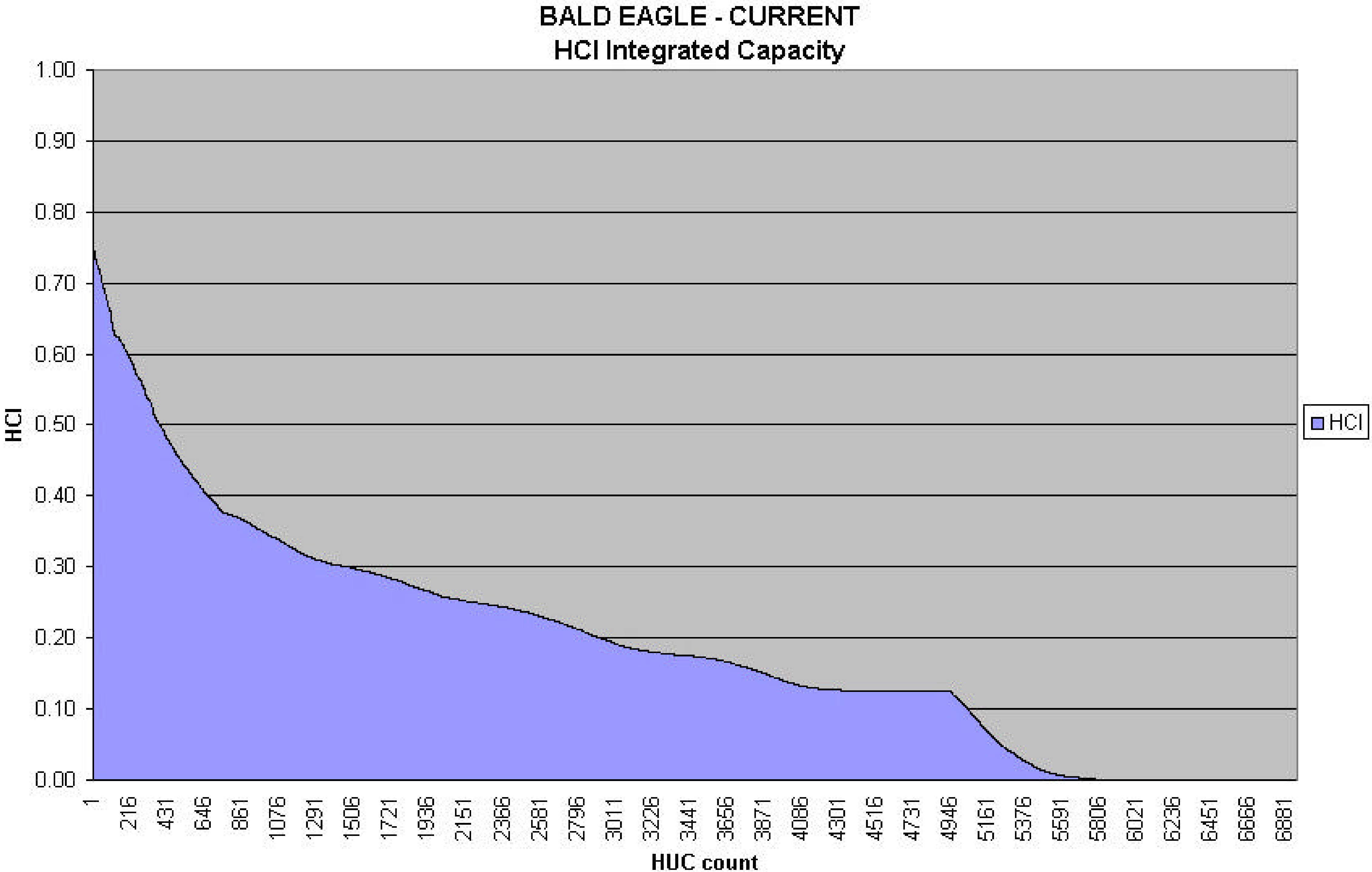


Figure IV.B.17 Current habitat condition indices (HCIs) for bald eagle, represented in a cumulative format, are higher than historic values. There are about 3000 current 6-HUCs with low (below 0.20) HCI values compared to no historic 6-HUCs with low values. The low values for current conditions are likely due to a finer resolution of wetland/riparian wildlife-habitat types in the current wildlife-habitat type map compared to the coarse resolution in the hisotoric map that does not depict narrow stringers of riparian habitat.

During the same period about 30 percent of the 6-HUCs showed a decrease.

Province Scale Analysis

The percent positive change in HCI for each province from historic to current condition was above 75 percent for the Columbia Cascade, Mountain Columbia and Upper Snake (Figure IV.B.18). All of the other provinces showed some moderate positive percent changes. Each province also showed some 6-HUCs with negative changes. The three provinces that showed the most positive percent change also showed the least negative change. The province with the largest negative percent change was the Columbia Gorge (77 percent) followed by the Blue Mountain, Inter Mountain, Lower Columbia, and Mountain Snake, which were all around -60 percent.

Alternatives: Future Habitat for Bald Eagle

Columbia Basin Scale Analysis

HCI maps produced for the three alternatives are very similar. Figure IV.B.19 indicates all three alternatives showed 29 percent positive and 47 percent negative change for current to alternative conditions. In addition there is a larger percent change for current to alternatives than there was for historic to current. Thus it appears that the alternatives could potentially have a negative influence on bald eagles across the basin.

A closer look at the difference between Alternative 2 and the current map using a change detection map (Figure IV.B.20) shows where the negative influences might occur.

Province Scale Analysis

The change map (Figure IV.B.20) illustrates changes in HCI values for each 6-HUC and only the lower 25 percent and the upper 25 percent of change detected is plotted as red (negative) or blue (positive). The changes illustrated are small but indicate concentrations of red in the Columbia Plateau, the Willamette (Lower Columbia province) and Snake (Upper Snake province) Rivers. Much of the red color crosses province and subbasin boundaries and as a consequence efforts to address areas of potential concern need to be coordinated among the managers. Dark blue areas are interspersed across the basin with slightly higher occurrence along the Cascade Range (Mountain Columbia, Figure IV.B.21). Light blue is also interspersed across the basin with slightly higher occurrence along the front range of the Rocky Mountains. The reason for the possible negative influence of alternatives on bald eagles could be due to a number of factors such as the coarse scale of the data (i.e., wetland / riparian

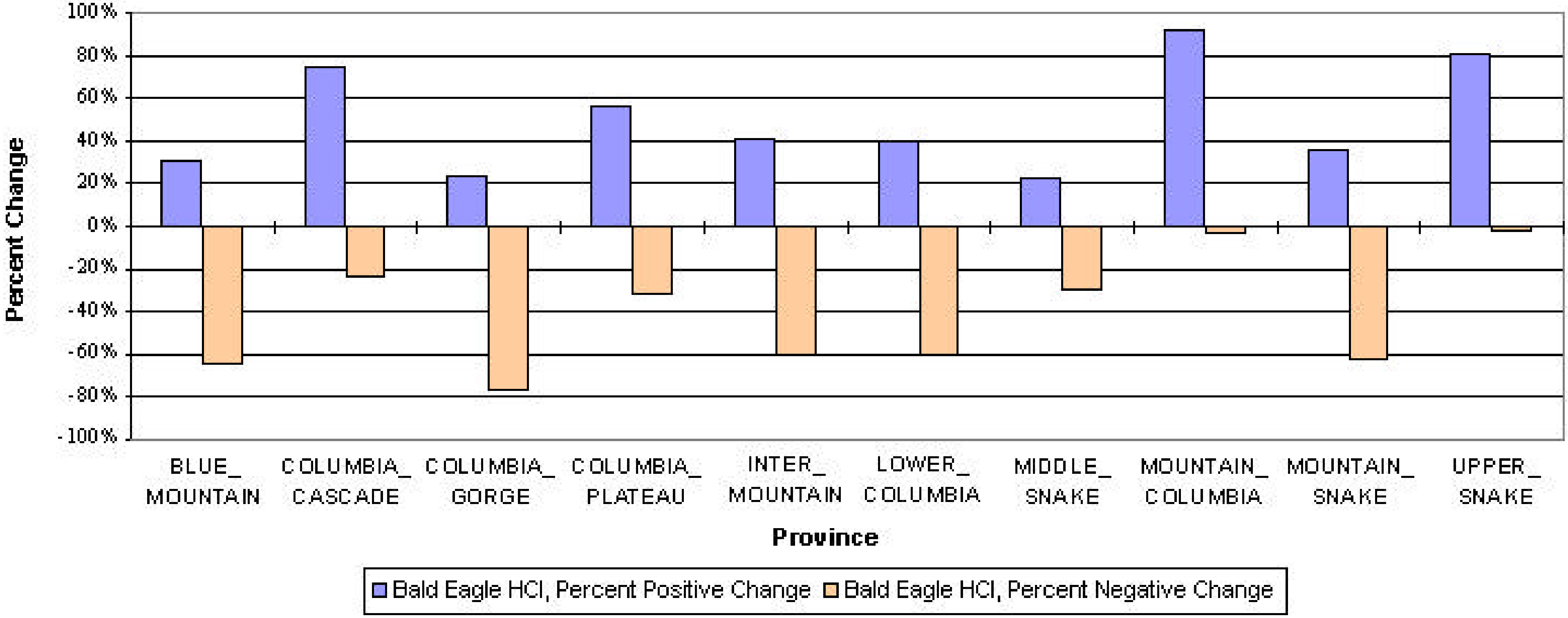


Figure IV.B.18 Percent change in bald eagle habitat condition index (HCI) in each province from historic to current condtions. Percent change is calculated by dividing the number of 6-HUC's that show a negative change or a positive change by the total number of 6-HUCs in each province. Positive and negative changes do not always add up to 100% because some 6-HUCs (less than 20%) show no change (Table IV.B.1). Many of the changes (positive and negative) are slight (less than 1%) and may or may not be of consequence to the bald eagle. The main point is to alert land managers in those provinces with the largest negative changes in bald eagle habitat.

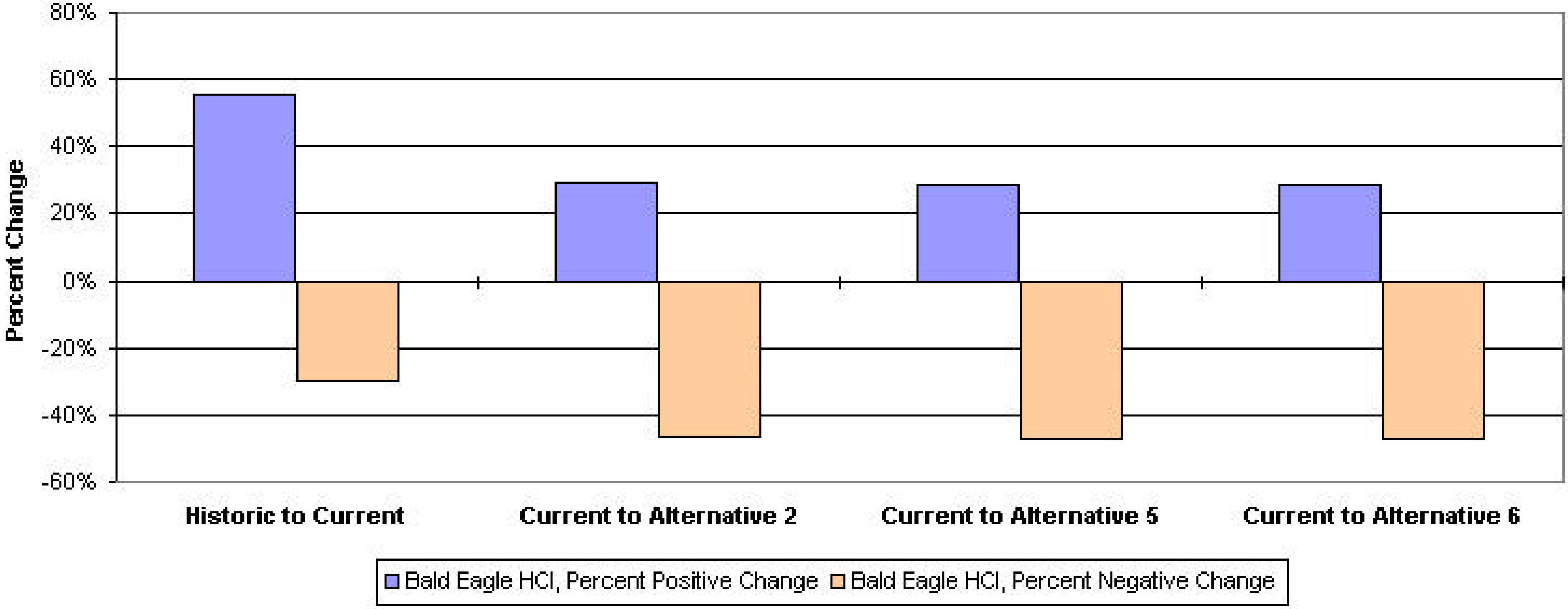


Figure IV.B.19 Percent change in bald eagle HCI in the U.S. portion of the Columbia Basin from historic to current conditions and from current to alternatives 2, 5, and 6 conditions. Percent change in bald eagle habitat condition index (HCI) is calculated by dividing the number of 6-HUCs that show a negative change or a positive change by the total number of 6-HUCs (less than 15 percent) show no change (Table IV.A.1). Many of the changes (positive or negative) are slight (less than 1%) and may or may not be of consequence to the bald eagle. The main point is to alert land managers that actions to recover fish may negatively influence some species of wildlife.

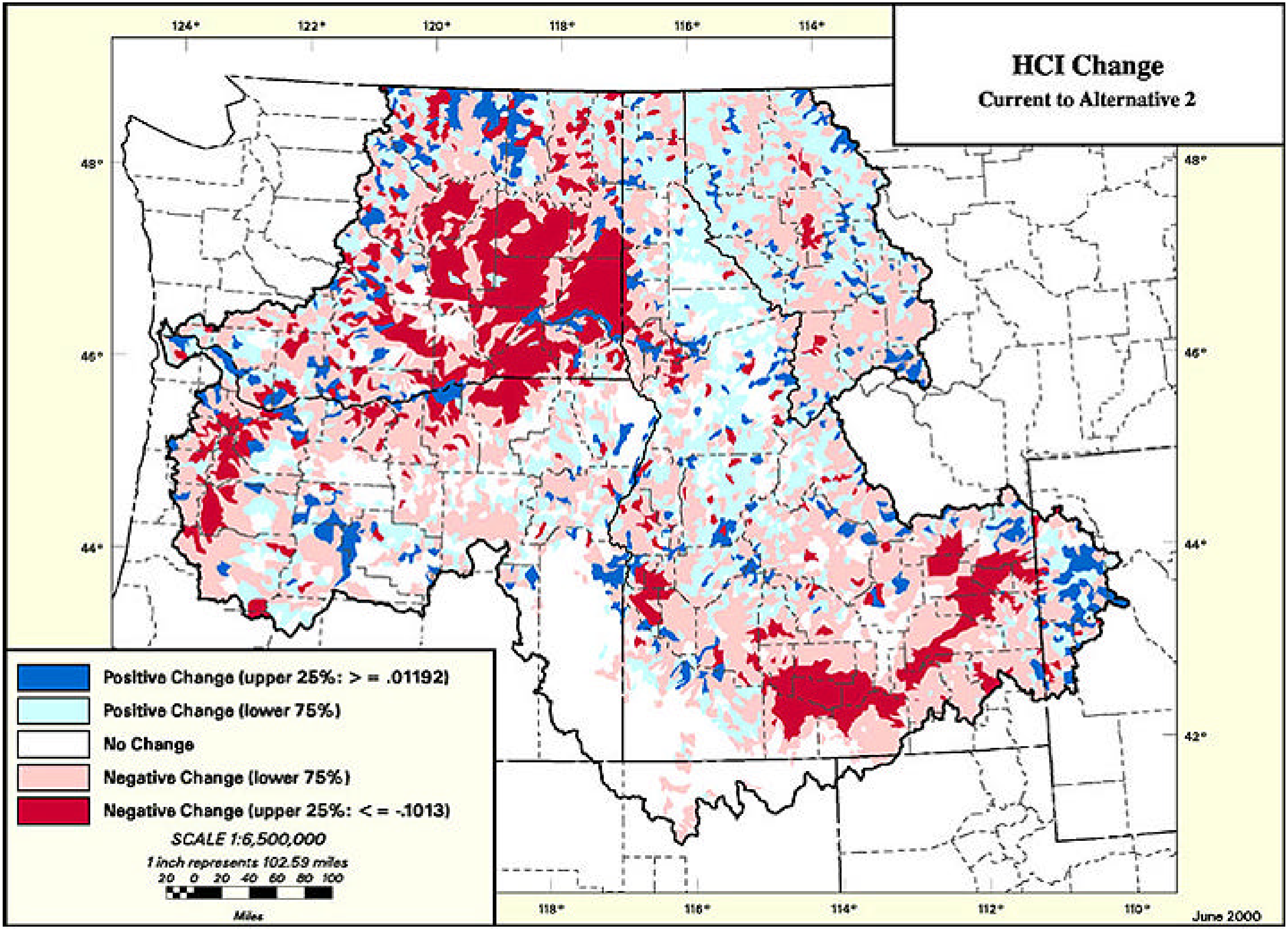


Figure IV.B.20 Percent change of total functional diversity (TFD) for wildlife in each province from current to alternative 2 conditions. Percent change in TFD is calculated by dividing the number of 6-HUC's that show a negative change or a positive change by the total number of 6-HUCs in each province. The percent of 6-HUCs showig an increase in TFD varies between 50% and 90% or similar to the maginitude and range of negative changes between historic and current. Thsi indicates all or most of the TFD can be recovered without returning all wildlife-habitat types to historic conditions.

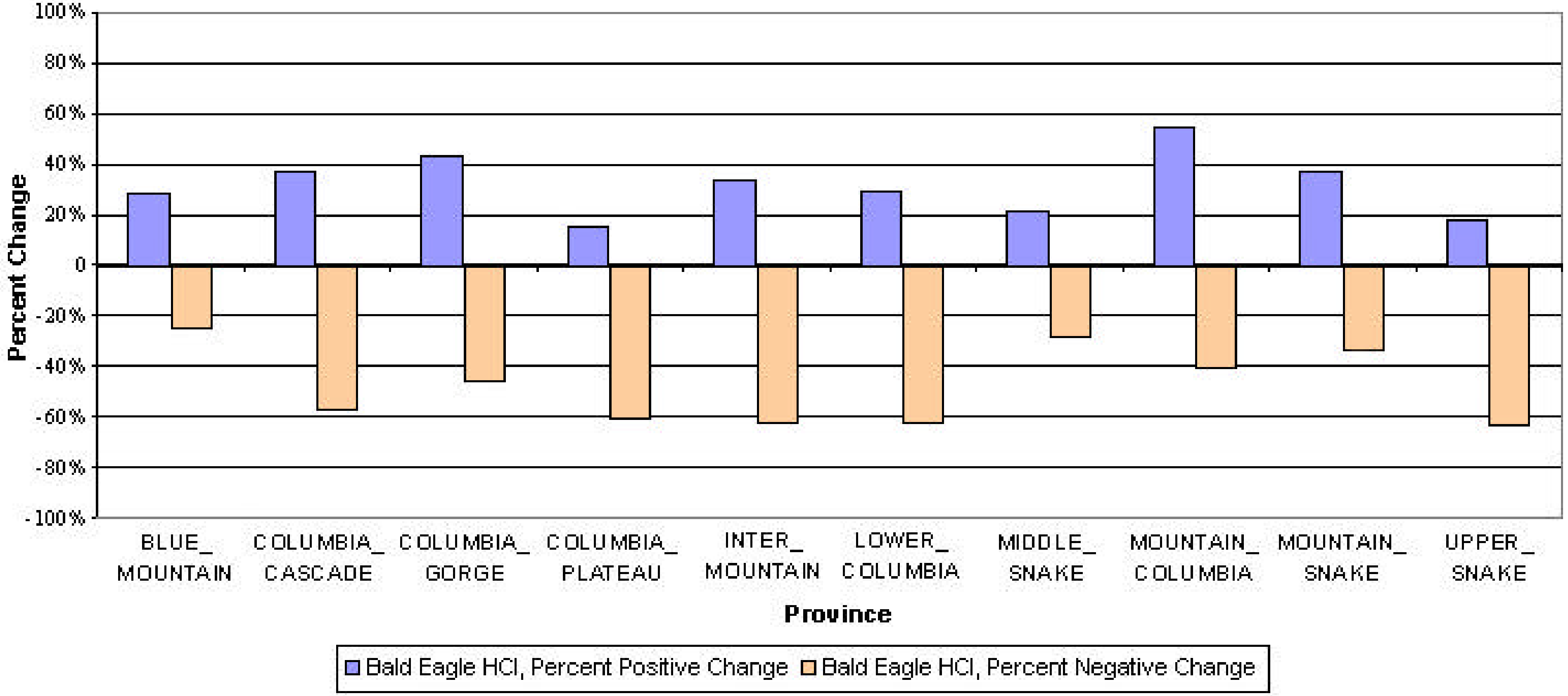


Figure IV.B.21 Percent change in bald eagle habitat condition index (HCI) in each province from current to alternative 2 conditions. Results for alternatives 5 and 6 are slightly different from alternative 2, but the alternative 2 results are generally representative of the other two alternatives. Percent change in bald eagle HCI is calculated by dividing the number of 6-HUC's that showed a negative change or a positive change by the total number of 6-HUC (about 24 percent) show no change between current and alterntive 2 conditions. Many of the changes (positive and negative) are slight (less than 1%) and may or may not be of consequence to the bald eagle. The main point is to alert land managers that actions to recover fish may have a negative consequence for the bald eagle in over 40 percent of the 6-HUCs in the basin.

stringers being under represented or the emphasis on feeding habitat versus breeding habitat since nest site information was not available for the whole basin) or the conversion of agriculture to shrub steppe (which is not associated with bald eagle use.)

The most important result is that the concept of possible negative influences on bald eagles needs to be carried into the Multi-Species Framework analyses at the subbasin level of the hierarchical analysis. Finer scale and more complete data (e.g., nest locations) at the subbasin level will provide better insight into possible negative influences for the bald eagle as well as wildlife in general. For example, the sandhill crane is associated with farmed fields especially during migration through the Basin. They forage in wetlands associated with agricultural fields and eat grains that remain in stubble fields. Loss of these agricultural and associated resources, without mitigative compensation, could be particularly harsh for species such as the sandhill crane whose numbers have been declining in recent years. Mitigation should not only consider the loss of habitat for species such as the crane but also the interim loss of wetland and riparian habitats that have established with contemporary management. Thus biological objectives for alternatives should also include interim biological objectives (especially for rare wildlife habitats) that reflect the time to implement strategies as well as the relationship to adjacent management areas (Palik et al. 2000).

American Beaver

The American beaver was selected as a species to assess because of the obvious (Schlosser and Kallemeyn 2000) association with aquatic ecosystems as well as fish diversity and abundance. An HCI assessment of the American beaver included 3 components: physical condition, cover, and food. Data collection for this species was problematic and thus the assessment met with failure. This was because beaver is linked to small (as well as large) streams in headwater areas of the Columbia Basin, and their streams and associated riparian environments were not mappable at the scale of this assessment. This is where the cycle of dam building and dam decay influence hydraulic and fish habitat diversity. In the headwater areas of the basin, these processes occur at a relatively fine scale compared to the coarse scale used for whole basin analyses. After months of searching and trial runs, we found that there was no consistent habitat data for the upper portions of most 6-HUCs. For example, gradient (low gradient is an important habitat element for beaver) data was available only for the main channels of rivers such as the John Day. While beaver occur in these main channels their habitat is usually a bank den rather than the dam and lodge habitat in low gradient headwater wetland complexes. Consequently the gradient for main stems was only good for assessing bank denning, which was not particularly related to dam building and fish habitat diversity. We tried to develop indices for headwater gradient such as "sinuosity index" or miles of stream per square mile of the 6-HUC. In all cases, data were either not available or if available they were in a format significantly different from other portions of the basin. For this and other reasons, we concluded that the beaver HCI analyses, unlike the bear analyses, are fine-scale dependent.

We encourage subbasin managers to retain the beaver as an evaluation species and to seek the finer-scale data necessary to evaluate beaver habitat quality. As beaver analyses are made at the subbasin and watershed scales, these analyses can be aggregated up to the subbasin and province scales. See Appendix F for the beaver habitat assessment method for HCI developed by the EWG.

RESULTS - FISH AND WILDLIFE INTEGRATION

This section of the Results addresses fish; it is organized as follows:

Integrated Assessments of Fish and Wildlife Populations and Ecological Functions

This section presents the results of the integrated assessments of fish and wildlife populations and ecological functions. As shown in Figure IV.C.1 in Methods, we focused on specific interactions between habitats and populations, and between fish and wildlife.

The results of the analyses for fish and wildlife interaction also include the Ecosystem Functions Analyses. The functions analyses presented in this report build, in part, on the work compiled by Cederholm et al. (2000) who identified ecological relationships between Pacific salmon and wildlife. In this section, we first briefly review the fish and wildlife relationships presented and functional questions asked in Cederholm et al. (2000.) Our analysis suggests how functional assessments might be continued at the subbasin scale by relating specific management activities to specific habitat elements that occur within each wildlife habitat type (see Appendix K).

Influence of Habitats on Populations and Functions

One result pertains to the influence of habitats (including KECs) on populations of fish and wildlife.

<u>Influence of Fish Habitats and KECs on Fish Populations – Use of EDT</u>

For fish, this was analyzed by using the EDT model to determine how the array of fish habitats potentially influence fish populations. Results are presented in the Fish-Results section.

Influence of Wildlife Habitats and KECs on Wildlife Populations and Functions – Use of SHP.

For wildlife, we analyzed the influence of wildlife habitats and KECs on wildlife populations and KEFs by using the SHP database to determine (1) how wildlife habitats, terrestrial vegetation structural conditions (structural or successional stages of wildlife habitats), and KECs ("habitat elements" in the SHP database) influence the presence of or habitat value for wildlife species, and then (2) the arrays of KEFs associated with those wildlife species.

At the broad scale of this assessment, we could map and analyze only gross changes – that is, only changes in amount or types—of wildlife habitats. Changes in vegetation structural conditions and in KECs, which are finer-scale elements of habitats, could not be mapped and analyzed at the broad scale. They will need to be analyzed at the next finer scale of resolution, such as in a subbasin assessment, because there are no consistently mapped, broad-scale GIS data on these conditions for the entire Basin.

Results of the broad-scale influence of wildlife habitats on wildlife species were brought into the functional analyses to determine how gross changes in historic and future amounts and types of wildlife habitats might affect wildlife species and thence their arrays of KEFs. Results suggest that some wildlife communities have undergone major changes since historic time, particularly with the loss of native shrub steppe, conversion to agriculture, and increase in Eastside mixed conifer forest (Figure IV.B.5) with concomitant changes in associated wildlife species and functions. See previous section for details.

Influence of Fish Habitats and KECs on Wildlife Populations

One way to think about integrating management of salmon and wildlife is to determine what wildlife species would benefit from providing habitat for salmon. We asked this question by first listing the habitat elements associated with salmon (Wildlife Methods) and then querying the wildlife database to determine which wildlife species use each of those habitat elements. At least some of the 74 types of wildlife habitat elements are used by various life stages of chinook salmon (Wildlife Methods). A number of wildlife species are also associated with each of these habitat elements. Some examples are shown in Figure IV.C.15. For example, one habitat element related to chinook salmon is "open water in rivers or streams." Some 107 wildlife species are associated with this habitat element, and 26 of these wildlife species have a strong or recurrent relationship with salmon as feeders on one or more salmon life stages. Many wildlife species are also associated with the salmon habitat elements of open water in lakes and ponds, oxbows, water depth, beaver and muskrat activity, water velocity, pools in rivers, and others.

The results of the analyses to address the influence of fish habitats and fish KECs on wildlife populations include the HCI method where output from the EDT fish analyses served as input to the American black bear HCI analysis (presented above). This resulted in an increase in HCI values for American black bear that occurred in the 75 subwatersheds that would have salmon reintroduced as a result of improving fish runs.

The SHP database suggests that many wildlife species are associated with KECs affecting fish. For example, throughout the Columbia River Basin, 133 wildlife species are influenced by water characteristics, including 16 herps influenced by levels of dissolved oxygen, 66 wildlife species influenced by water depth, 17 species by water temperature, 36 species by water velocity, and so on. Some 203 wildlife species are associated with rivers and streams, including 17 species positively associated with cobble or gravel stream substrates, and 12 species with coarse woody debris in streams or rivers. Also, seven wildlife species associate with stream riffles, and at least some 69 wildlife species are affected by seasonal flooding of open water. Many other such associations are described by the database for freshwater as well as coastal and marine KECs and wildlife species.

It is clear that managing for habitat for fish, including salmon, can positively influence a wide array of wildlife species as well. The SHP databases provide a means by which such wildlife species can be listed for specific wildlife habitats and Basin-wide.

KECs (Habitat Elements) Shared by Fish and Wildlife

Some 74 categories and subcategories of wildlife KECs are shared between fish and wildlife. It may be of interest to managers to know which KECs these are, in order to know which wildlife species may be influenced (mostly positively) by managing KECs for fish species, and which fish KECs can influence the most number of wildlife species. Further, the SHP database can be used to generate lists of wildlife species associated with each of these KECs or combinations thereof.

Among wildlife species associated with KECs shared with fish, the most number of wildlife species (>100 species) are associated with lakes, ponds, and reservoirs; open water zones of lakes; riverine wetlands; and open water zones of rivers (Figure IV.C.2). This holds for species of wildlife associated with these KECs, as well as those wildlife species that also have a strong or recurrent relationship with salmon (that is, that commonly feed on salmon).

Influence of Populations on Themselves

The fish-wildlife interaction Figure IV.C.1 also depicts that at least some populations of fish or wildlife might have some feedback or density-dependent influences. We included density-dependency for the wildlife populations models for American black bear and bald eagle. This was done through estimating the factor "percent key habitat" which uses an HCI method. Percent key habitat, in turn, is one of the variables used to calculate carrying capacity.

For fish, density-dependence was considered as part of the Beverton-Holt formulation in the EDT model. Specifically, density-dependence was considered in the EDT model runs for Chinook. This was done by calculating P/C (production/capacity), which is a density-dependence factor in aggregate population modeling.

Density dependent relations, however, were not used in the functional analysis of fish and wildlife KEFs, because these were categorical relations, not population, demographic, or rate models.

Influence of Populations on Other Populations

The direct influence of populations of fish on populations of wildlife, or vice versa, were major interactions between fish and wildlife assessed for this report. In part, this is because such interactions are direct, mostly represented by predation or feeding, and have been studied or at least categorized in greater detail than many of the other fish-wildlife interactions discussed here.

The two major direct population interactions we evaluated were the influence of fish populations on wildlife populations, and the influence of wildlife populations on fish populations.

Influence of Fish Populations on Wildlife Populations

We evaluated the influence of fish populations on wildlife populations by reference to the major report by Cederholm et al. (2000), who explored salmon as prey for wildlife.

According to the SHP database, some 605 species of terrestrial or marine amphibians, reptiles, birds, and mammals currently or historically occur in Washington and Oregon. According to the Cederholm et al. report, of these 605 species, some 137 have a positive feeding relation with salmon. The 137 species include nine wildlife species with a strong consistent relation (the wildlife species is supported by salmon), 59 with a recurrent relation (regular but not necessarily essential use of salmon), 25 with an indirect relation (important but indirect use of salmon, such as feeding on insects occurring on salmon carcasses), and 64 with a rare relation (use salmon but only in a minor diet role). Figure IV.C.3 depicts these associations by each salmon life stage. Some wildlife species have more than one type of relation and may use more than one salmon life stage.

There are 88 wildlife species that have what Cederholm et al. (2000) called a routine relation with salmon (combining strong consistent, recurrent, and indirect relations); these include two amphibian species, one reptile, 60 birds, and 25 mammals (including eight marine mammals). An additional 62 wildlife species have an unknown relation with salmon, and with further study some of these species might exhibit some relation.

Across the salmon life stages and all degrees of use, some 23 wildlife species use the incubation stage, 50 species use the freshwater rearing stage, 64 species use the saltwater stage, 16 species use the spawning stage, and 110 species use the carcass stage. Figure IV.C.4 illustrates the number of strong or recurrent relationships by salmon life stages. At least 41 wildlife species aggregate at salmon congregations (Cederholm et al. 2000).

The wildlife species attracted to the various salmon life stages in turn perform specific key ecological functions (KEFs) or roles in their environment that could affect the presence, distribution, and abundance of environmental factors for, or populations of, other fish and wildlife species (Wildlife Methods). Understanding how salmon influence the broader functional web of the ecosystems in which they reside is an important facet of ecosystem management, particularly in regard to determining how salmon management can affect broader ecosystem functions affecting sustainability, productivity, and biodiversity. To urge managers to think functionally,

Cederholm et al. (2000) suggested the following questions:

- In what way does providing for salmon also provide for a wider array of ecological functions of wildlife species associated with salmon?
- What are those functions?
- How do different kinds of salmon-wildlife relations, and different salmon life stages, provide for an array of ecological functions?

They concluded that salmon provide a causal basis for a wide variety of wildlife species that in turn perform a surprisingly broad array of ecological functions. Those functions cross many types of habitats including, and extending well beyond, the salmon-bearing aquatic systems per se.

Among the many kinds of ecological functions provided by wildlife that are associated with salmon are some that are provided more or less uniquely by each salmon life stage. The ecological wildlife functions that are unique to each salmon life stage are as follows.

- Wildlife that use the *incubation stage* of salmon include species that are secondary cavity users or that are primary excavators of small ground burrows that are used by other wildlife species.
- The *saltwater rearing stage* of salmon provides uniquely for wildlife that create aerial or aquatic structures used by other wildlife species.

- The *spawning stage* of salmon provides uniquely for wildlife that are also spermivores (seed-eaters), grazers, frugivores (fruit-eaters), root-feeders, and bark, cambium or tree bole feeders; for wildlife that might control other vertebrate populations through predation, that create feeding opportunities for other wildlife species, that are primary cavity or large ground-burrow excavators, or secondary ground runway users; or that can kill standing trees (creating snags) and fragment standing and down wood (adding to soil organic matter).
- The *carcass stage* of salmon provides uniquely for fungivores (fungi-eaters), for insectivorous wildlife that might control some insect populations, and for wildlife that serve as interspecific hosts for avian nest parasites (principally the brown-headed cowbird).
- The *freshwater rearing stage* of salmon, although providing for many wildlife species and their associated ecological roles, does not necessarily provide for any unique wildlife KEF categories.

The patterns of fish-wildlife functional relations suggest that, most or all salmon life stages contribute to providing for the full array of all wildlife ecological functions; no one (or two, or three) salmon life stage provides for all functions. Also note the unique wildlife ecological functions provided by spawning and carcass stages, which may be truncated with purely hatchery-raised fish.

The brief review of Cederholm et al. (2000) asks: in what way does providing for salmon also provide for a wider array of ecological functions of wildlife associated with salmon? The Ecosystem Functional Analyses conducted for the framework address this question by assessing ecological functional redundancy for wildlife as a result of the three proposed Alternatives that provide for salmon. The functional redundancy analysis is outlined and the results for the Alternatives are presented below. Details of these analyses are available upon request from the framework office. Functional redundancy was evaluated basin-wide by showing the change in the weighted value of wildlife habitat type from one Alternative to another. Specifically, the amount of wildlife habitat that changed from one Alternative to another was displayed using a matrix that showed the number of wildlife species associated with each Key Ecological Function by wildlife-habitat type. The total amount of change in functional redundancy for each Alternative is mapped in a geographic information system (GIS).

Maps illustrating changes from historic and current conditions were created to assess the amount of change from historic or current conditions by alternative. Historic condition has sometimes been defined as normative condition. Figure IV.C.5 shows the total change (across all KEFs) in functional diversity (number of KEF categories weighted by the number of species performing each KEF) between historic and current conditions. To depict the various alternative's total change in functional diversity using historic conditions as a baseline, see Figure IV.C.6, Figure IV.C.7, and Figure IV.C.8. Alternatives that have been assessed using current conditions as a baseline can be seen in Figure IV.C.9, Figure IV.C.10, and Figure IV.C.11.

A few selected key ecological functions (KEFS) for wildlife were also evaluated to see how they might be influenced by each set of alternatives. Three KEFs that were chosen were: transportation of viable seeds, spores, plants or animals; primary cavity excavator; and physically affects (improves) soil structure, aeration typically by digging. Because of space, all 51 maps are not presented here, but three maps illustrate the potential of doing such an evaluation (see Figure IV.C.12, Figure IV.C.13, and Figure IV.C.14) that show change in historic to current conditions for each KEF.

Salmon would have the ability to interact with wildlife in areas where there is either an overlap in the use of aquatic KECs or where salmon occur or aggregate. Figure IV.C.15 gives an example of aquatic KECs where overlapping uses may occur. Further, Figure IV.C.16 shows an example of chinook salmon KEFs that potentially can influence wildlife. Of these functions, eating aquatic and terrestrial invertebrates, and carrier and transmitter of vertebrate diseases, may have the greatest potential for demonstrating cause-and-effect relationships regarding how fish can influence wildlife.

Overall, results of this analysis suggest that providing KECs for salmon benefits a wide array of wildlife species as well. Of course, individual wildlife species also use other KECs, but the analysis suggests than there is an economy to be gained by integrating habitat requirements for fish and wildlife.

Further, one can identify which management activities or strategies can affect each habitat element. In this way, one can determine how proposed land management activities under a specific planning alternative, for example, can affect habitat elements and thereby affect both salmon and wildlife associated with those elements. Figure IV.C.17 shows the schematic of how these relationships exist with the different data sets.

One example of this concept is, if Alternative 5 called for a strategy to enhance wildlife habitat by changing the operational aspects of road maintenance and road use, then the SHP database could be queried to determine the array of habitat elements, and thence the wildlife species that use these habitat elements, that could be affected by such a management activity. Results show that 17 habitat elements could be affected by this management activity. Upon further re-evaluation, we could look at two habitat elements that affect both fish and wildlife, such as beaver/muskrat activity and water pollution. Querying the SHP database on these habitat elements, we would find the former habitat element, has 50 wildlife species associated with it that in turn perform 61 KEFs, and the latter habitat element has 21 wildlife species associated with it that in turn perform 35 KEFs. Reviewing each KEF and species would then give a manager an idea of which wildlife species that might be involved and which ecological function(s) might be influenced from performing such a management activity.

Additional influences of fish on wildlife can be characterized by transfer of parasites or disease among species, particularly from fish to amphibians, mammals, and other species.

Fish-amphibian interactions. – Little has been written in regards to fish interacting with amphibians. Hence, personal contacts were made with several wildlife biologists who are currently working with amphibians. Two biologists, Deanne Olson (Forest Service, PNW, Corvallis, OR) and Charlie Crisafulli, (Forest Service, Gifford Pinchot Forest, Vancouver, WA) gave some insight in regards to amphibians potentially affected from hatchery fish via inoculation of several fungus forms. For instance, Olson stated, "*Saprolegnia ferax* fungus is common in fish hatcheries and it also infects native freshwater fishes (i.e., trout spp). Amphibian eggs, especially those of *Bufo* species, are especially susceptible to *Saprolegnia* fungal infections. Having communal oviposition and explosive breeding, an infection has been known to cause complete loss of a year's recruitment at a site."

The spores of *Saprolegnia ferax* appear to settle in the substrate at an oviposition site, and quickly infect the eggs oviposited there year after year (the toads often use traditional microsites for oviposition) (Kiesecker and Blaustein 1997). It has been suggested that fish stocking could have increased the incidence of this fungus, but there are no "before" data on fungi. UV-B radiation and *Saprolegnia* are synergistic in that UV appears to make the eggs more vulnerable to infection (Kiesecker 1997, Kiesecker and Blaustein 1995).

Fish-mammal interactions. – In the Pacific Northwest, the common fluke *Nanophyetus salmincola* is an intestinal parasite of canids, felids, raccoons, and humans, and is relatively harmless. This fluke, however, can be a vector for the rickettsial organism, which is usually fatal to canines. This fluke is associated with "salmon poisoning" in dogs, although it is a slight misconception to say that salmon poison canids because dogs contract this disease from eating salmon that carry the *Nanophyetus* larvae. Normally, this fluke lives within the intestines and does not cause any sickness. But when the bacterium *Neorickettsia helminthoeca* occurs inside the fluke, the fluke can carry a rickettsial organism that causes the salmon poisoning. Symptoms of salmon poisoning include high fever, appetite loss, or depression and are almost always fatal to dogs, foxes, and coyotes (Disease Lab Manual, Univ. of Montana, 1980).

Another effect that fish can have on wildlife is with the transfer of tapeworms, although most tapeworms infect mostly dogs when they ingest fleas or non-aquatic animals. However, in the case of the tapeworm *Diphyllobothrium latum*, canids become infected by eating a fish that is infected with larval tapeworms. *Diphyllobothrium* adults can grow up to 30 feet in length. Their eggs are released into water through the feces of an infected dog, fox, mink, or even bear. The eggs are ingested by copepods, which are eaten by small fish. *Diphyllobothrium* larvae live within the muscles of fish and are passed up the food chain from fish to fish until they are eaten by a mammal, where they mature in the digestive system and lay eggs that are passed through the feces (American Animal Hospital Association, Columbia Animal Hospital, Columbia, MD, 2000).

Fish-other species interactions. – As for fish influencing other wildlife, as with birds and reptiles, this interaction primarily pertains to predator-prey relationships. That is, certain fish species are known to be opportunistic and will on occasion prey upon some wildlife species. An example would be northern pike eating a dipper or an aquatic snake. Also, some fish will eat amphibians, their eggs and larvae if an opportunity presents itself.

Influence of Wildlife Populations on Fish Populations

In some instances, direct predation of wildlife on fish can influence fish populations. This has been the concern for least terns and sea lions feeding on salmon in the mouth of the Columbia River.

Influence of Populations on Habitats and KECs

Influence of Fish Populations and KEFs on Fish Habitats and KECs

This interaction was not explicitly analyzed in this report. It may prove useful, however, to consider at a finer spatial scale of resolution, such as when considering introductions of fish species into systems containing other fish species.

Influence of Wildlife Populations and KEFs on Fish Habitats and KECs

We intended to use output from the American beaver HCI analysis as input to the fish EDT analysis but, as mentioned in the section on Wildlife Methods, this attempt was not possible due to lack of data on beaver habitat at the scale of our analysis. We did create a prototype Bayesian belief network model, however, that illustrates the potential of this approach (Figure IV.C.18).

In this hypothetical example, three management alternatives or strategies are shown influencing habitats for American beaver and other wildlife species that, in turn, provide the KEF of creating aquatic structures such as by damming or building lodges in waterways (other such species can include nutria or muskrat, for example). These wildlife KEFs in turn can modify the values of aquatic KECs important to salmon and other fish. As depicted in Figure IV.C.18, such aquatic KECs can include, for example, the degree of embeddedness (the extent that larger cobbles or gravel are surrounded by or covered by fine sediment), temperature spatial variation (the extent of water temperature variation within the stream reach as influenced by inputs of groundwater), monthly average minimum width of the wetted channel, and daily variation in stream flow level. In this way, wildlife KEFs can be explicitly and quantitatively linked to fish habitats (KECs) and then, by modifying those habitat values in the EDT fish population model, to fish populations. Figure IV.C.18 also illustrates how the value of salmon can be included explicitly in the model, so that the economic or social cost or benefit of the wildlife KEFs on salmon production, and the optimal management decision, can be explicitly determined.

In summary, such an approach can be further developed from this framework to clearly depict alternative management activities, their influence on wildlife (and fish) habitats and KECs, the modifying influence of wildlife KEFs on fish habitats, and the resulting fish population response and associated social values. Further, such a construct can be used to help determine the optimal set of management decisions to maximize salmon value. Through sensitivity analysis, it can also show which factors have the greatest influence on fish, thereby helping prioritize monitoring or management of those factors.

RESULTS - IMPLICATIONS OF FINDINGS

This report has provided a framework for assessing selected species of fish and wildlife with regard to various management actions, conducting an integrated fish-wildlife and aquatic-terrestrial assessment of ecological assemblages, and determining effects on ecological functions of fish and wildlife communities. We have based our work on accepted and published ecological theory, and the models and databases we have used have undergone extensive review. However, much remains to be empirically validated. For example, many of the assumptions concerning the functional assessments – such as the value of functional redundancy (number of species with the same general ecological roles) in providing greater ecosystem stability and resilience to undue perturbations – remain to be tested in many ecological communities throughout the Columbia Basin.

As well, this report has made good progress toward explicitly addressing the recommendations in the report "Return to the River 2000: Restoration of salmonid fishes in the Columbia River ecosystem" (Independent Scientific Group 2000). Their recommendations included: address the basin and landscape, address the coupling of species to their associated ecosystem, address multiple species of native fish and wildlife, address the entire life cycle, address ecological functions of salmon and other species, build on a conceptual foundation of ecologically-based Scientific Principles, and work from a set of linked visions, goals, and objectives. We have worked toward meeting these recommendations.

The major lessons and concepts to be taken from our report include:

1. <u>Major historic changes</u>. – The USA portion of the Columbia Basin has undergone major change, since early historic times, that has resulted in the declining distribution and abundance of some native fish and wildlife species and habitats. Our results are consistent with other findings (Covington et al. 1994, Covington and Moore 1994, DellaSala et al. 1995, Hessburg 1993, Hessburg et al. 2000, Jensen and Bourgeron 1994, Quigley et al. 1996).

2. <u>Extending the paradigm</u>. – Our work has extended these previous analyses by providing integrated fish-wildlife assessments and functional analyses. More specifically, we have: (1) expanded the wildlife habitat map and the SHP wildlife database to the entire USA portion of the

Columbia Basin (and our Canadian colleagues are expanding these to include the Canadian portion of the Basin); (2) linked the theory and application of fish and wildlife population models as a basis for a transdisciplinary analysis (sensu Regier 1978); and (3) developed an assessment procedure to link management activities to habitats, KECs, fish and wildlife populations, and integrated ecological functions.

We address several levels of ecological systems: populations, species assemblages, communities, and ecosystems. The EDT and HCI modeling address populations. The SHP databases address wildlife species assemblages. The functional analyses address species and community functions. All of these combined address ecosystem conditions.

3. Predicting management influences and cumulative effects. – The current and potential future influences of management activities and land-use planning on fish and wildlife populations, communities, and ecosystems are difficult to predict precisely. Such influences are sometimes difficult to separate from complicating factors and background natural variations inherent in such systems. However, we provide a framework by which such influences can be analyzed in a repeatable and testable fashion by using specific models (e.g., the EDT model, Figure IV.A.4, IV.A.5) and databases (e.g., the SHP database Figure IV.C.17).

The influence of cumulative effects can be addressed in the Framework process by at least two techniques. The first involves conducting functional analyses to assess effects of multiple management changes on fish and wildlife species' habitats, and thus on the species and their ecological roles (key ecological functions). In turn, results can be interpreted as influencing positively, neutrally, or negatively the functional aspects of the ecosystem. The second involves the step-up process where the combination of management actions for a small focused area (e.g., 6-HUC) can be combined with the management actions from other small areas to assess the cumulative effects of management actions over larger areas. For some species and habitats (e.g., beaver and headwater aquatic systems), the step-up assessment is necessary.

4. Testable hypotheses. – We suggest that local (e.g., watershed) and global (e.g., Columbia Basin) influences predicted from these models and databases can constitute a set of testable management hypotheses that can be generated in a repeatable, scientific manner. Through monitoring and adaptive management studies, the models and databases, and selected predictions of ecological ramifications of management effects, can be studied empirically. Results can be used to re-evaluate goals and questions, to formulate new hypotheses to be tested with modified management, as needed and to refine the models and data.

5. Toward a step-down process. – The Assessment Framework we present in this report can be used in a step-down process to evaluate potential management influences in smaller areas, namely subbasins and eventually watersheds and 6-HUCs. In this manner, subbasin and watershed managers can evaluate effects of alternative management activities on fish and wildlife species and communities (including ecological functions). This would help determine the most effective or most desirable sets of management activities to reach clearly stated resource management objectives for a given subbasin. Also, the Framework allows for a step-up process where aggregations of subbasins and stochastic data developed at the lower levels can be evaluated at the higher province and basin levels to assure that management actions are compatible and, to prioritize which subbasin might need the most immediate management attention.

6. Managing under uncertain outcomes. – There will always be uncertainty in predicting the future. We advise that users of this document, and of any subsequent refinement of our analysis methods and findings, understand the sets of assumptions we discussed previously. Uncertainty in outcomes can be stated as spreads of potential outcomes, such as expressed by ranges of values, confidence intervals, etc. Uncertainty in outcomes does not mean lack of scientific understanding of the systems, and thus that “anything goes” in terms of management. Rather, such uncertainty may mean that selected response variables of the system – selected species, ecological functions, or measures of community composition or performance – might be monitored over time to better determine whether the populations, communities, and ecosystems are changing as predicated by objectives, goals, and visions. Then, management activities, as well as models and databases, can be re-evaluated and amended as needed, in a true adaptive management framework.

RESEARCH, MONITORING, AND EVALUATION

We propose a way to monitor biological outcomes to track progress toward meeting basin and province goals. The role of research in this process is also addFressed. The following topics are covered:

- Conceptual Overview with Example
- Three Levels of Monitoring
  - Implementation Monitoring
  - Effectiveness Monitoring
  - Validation Monitoring
- Role of Independent Science Advisory Board
- Discussion and Elaboration on the Use of Biological Objectives

Conceptual Overview with Example

The portion of the analytical framework pertaining to setting biological objectives (Figure V.1) links the strategies to the vision. When strategies accomplish the biological objectives the vision will be achieved. Biological objectives are described in terms of attributes that characterize the ecological system and that comprise input to the EDT fish model. Output from the EDT fish model describes biological performance, in other words, productivity and abundance of the populations of interest. Unfortunately, because of variability and response delays, it may take several decades before a meaningful change in biological performance is detected empirically (Lichatowich and Cramer 1979).

Fortunately, changes in the environmental attributes often can be detected more quickly than can changes in population response. The reliability of the environmental attributes as indicators of progress toward biological performance objectives depends upon the veracity of the rules used to estimate the latter.

Environmental attributes describe the landscape at various scales of time and space. To the extent that the EDT expert system, as embodied in the rules (Bio-rules), is a valid representation of the relationship between the population of interest and its environment, the environmental attributes predict the biological performance response. A monitoring plan devised to (1) track the status of environmental attributes over time, and (2)

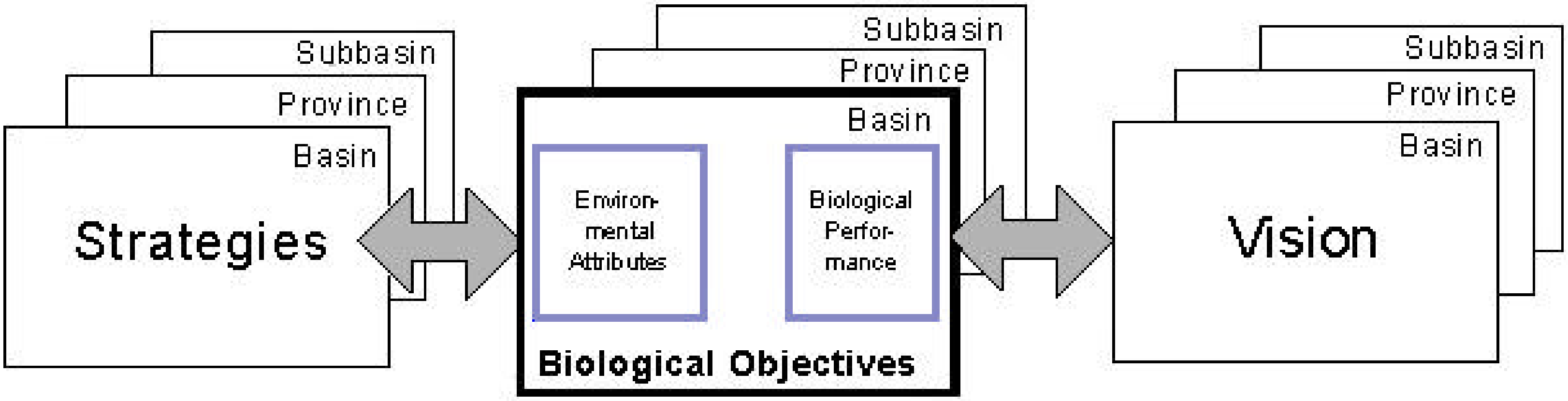


Figure V.1 Framework components.

determine the veracity of the EDT rules, is therefore a potentially very useful way to assess the degree to which an environmental attribute is moving toward the desired level of the biological objective, in the short term.

The Bio-rules are not site specific. They are applicable across the full landscape and at all levels in the spatial temporal hierarchy. Bio-rules are hypotheses about how the population will respond to its environment (e.g., Figure V.2). Some of these hypotheses are based on results of past studies, and others are based on expert opinions. In some cases, the uncertainty about the rule or hypothesis has an important effect on predicting the expected outcome of an action. Hypotheses that are critical to outcomes, that are uncertain, and that lend themselves to resolution through research, should be considered as priorities for future studies. The Bio-Rules are a set of hypotheses that can be tested through research, whereas the environmental attributes—which vary over time and space—are parameters of the ecosystem that could be measured in a monitoring program.

Three Levels of Monitoring

Adaptive monitoring is comprised of three levels: implementation, effectiveness, and validation. These levels are discussed below, relative to the Multi-Species Framework structure and the EDT method.

Implementation Monitoring

Implementation monitoring is used to ensure that strategies and treatments are implemented in accord with stated management standards and guidelines. It is used to determine if the basic management directives are correctly followed.

Effectiveness Monitoring

This type of monitoring is used to evaluate the validity of the Bio-rules developed for estimating how a species will respond to changing environmental attributes. In short, this monitoring intends to confirm that the implemented strategy is having the predicted effect on the targeted environmental attribute. If not, then the Bio-rules will need to be changed to better fit the monitoring data. It is also used to determine if mid-course corrections to these strategies are needed due to the ineffectiveness of the strategy, changing environmental conditions, or real-world limitations (local species extinction, etc.).

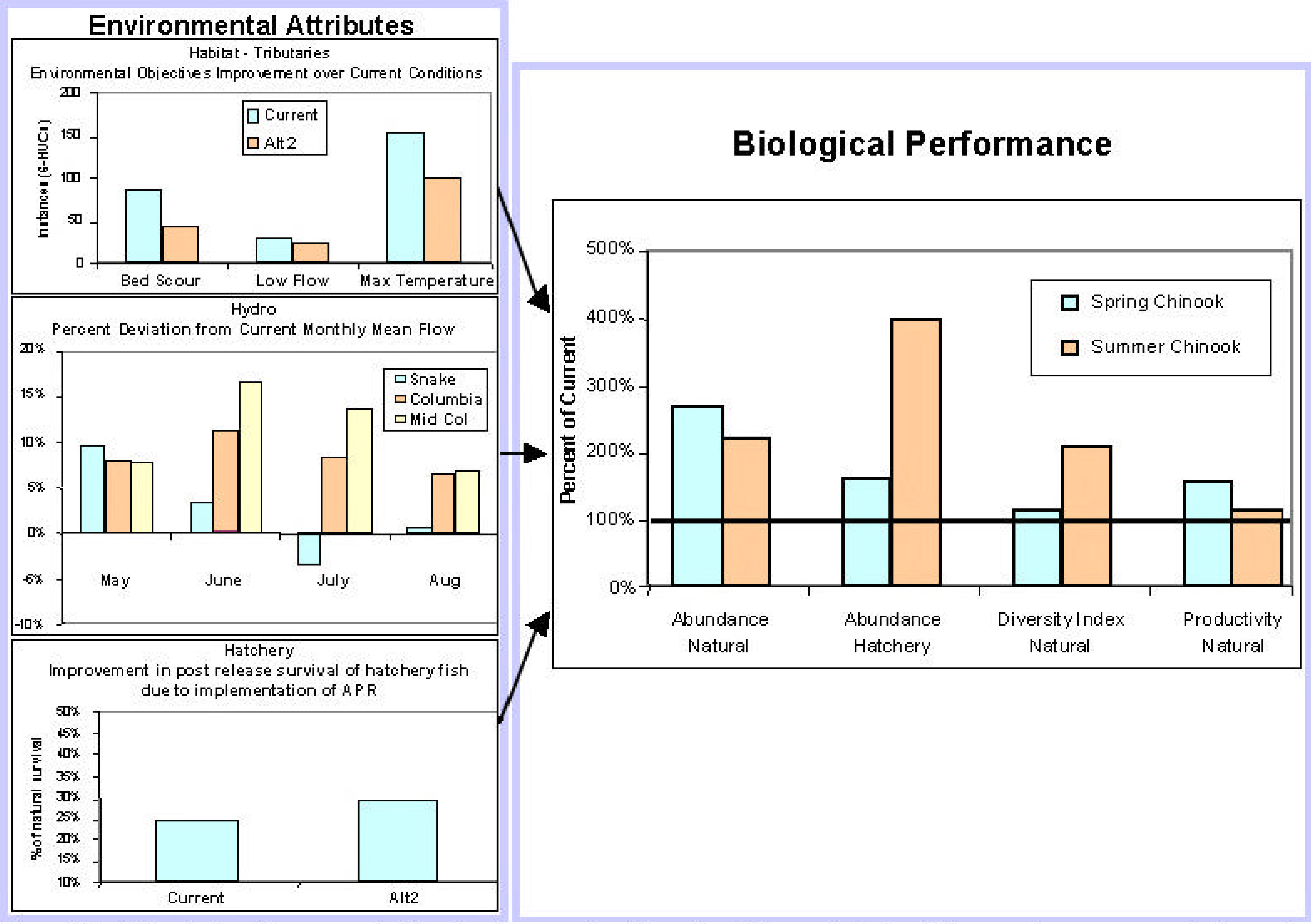


Figure V.2 Biological performance of chinook salmon under Alternative 5 (Cascade Columbia) computer as a percent of current, using the Bio-Rules. The solid line prepresents Current Values.

An additional goal of effectiveness monitoring is to distinguish treatment effects from other environmental variations or perturbations. This is achieved by using two different types of effectiveness monitoring: active and passive. Active monitoring refers to the classic experiment whereby a scientist manipulates environmental variables to determine effects on species performance. In passive monitoring the scientist simply tracks (through measurement or literature) a set of physical or biological variables over time in an attempt to detect major changes in the environment or scientific understanding of how the environment works. Examples of active and passive monitoring would be the testing of a new fish passage facility and the tracking of ocean conditions, respectively.

Validation Monitoring

Validation monitoring is used to confirm that as environmental attributes change, fish and wildlife populations respond as predicted by the EDT and or HCI models. In other words, validation monitoring tests the validity of the basic, underlying scientific assumptions, and tracks trends in population performance measures that imply that goals are being achieved. This might entail statistical trend analyses. Examples of this type of performance measure for salmon include adult returns, juvenile production, and harvest levels. In general, these are the types of data that can be used by policy makers to describe program effectiveness and progress to the general public, and to determine the veracity of the underlying assumptions used in the modeling process.

Role of Independent Science Advisory Board

A Scientific Advisory Board could be very useful to advise on multiple facets of the Council's plan. This board could be responsible for providing advice in the following areas:

1. review and approve the Bio-rules used to predict effects of different strategies on environmental attributes,
2. review and approve the rules used to predict the effects that changes in environmental attributes have on fish and wildlife performance,
3. change these Bio-rules,
4. develop performance measures,
5. select strategies for implementation,
6. evaluate the effectiveness of the implemented strategies,
7. review and approve province plans,

8. change strategies and program direction, and
9. develop and implement the Council's Monitoring and Evaluation program.

Discussion and Elaboration on the Use of Biological Objectives

We propose to define biological objectives based on management goals and on the amount that environmental attribute(s) must be changed to meet the goals. The amount of change required to meet a goal also depends on the set of Bio-rules used in the EDT model. The Bio-rules should be states as testable, explicit hypotheses. The hypotheses are derived from the scientific literature, research studies, and specific analyses using statistical or modeling tools. Examples of such tools potentially include h-VSP developed by the National Marine Fisheries Service, and the models developed within PATH. EDT could be used to evaluate subbasin plans for their contribution to the larger scale (province and basin) vision and biological objectives.

The Council could use EDT to set biological objectives to describe the environmental changes needed within a province to meet the overall goals. Subbasin plans could then detail the strategies and actions needed to make these changes across the province.

The biological objectives could also provide the basis for a regional monitoring and research and evaluation effort. When adopted, the biological objectives could be based on a set of working hypotheses contained within EDT. These could be tested and refined through research and evaluation that could lead to revision of the objectives at some future point. The biological objectives themselves could be measurable attributes that would provide a way to define progress and to track change through a monitoring program.

Our knowledge base about how management actions affect fish and wildlife is, and probably always will be, incomplete. Hence any action plan devised to meet a specified set of goals should be based on a working hypothesis, namely that the actions will result in specific, measurable environmental changes that, in turn, will help meet the goals. The biological rules of the EDT analysis explain the rationale behind the working hypotheses. The EDT analysis translates observable habitat conditions into abundance, productivity, and life history diversity potential for selected target species (e.g. chinook salmon).

EDT characterizes habitat in the basin in regard to some 45 environmental attributes that are described at the 6-HUC level. These attributes are related through Bio-rules (hypotheses) that are used to estimate life-stage survival. Integration of these life stage survivals across the life history trajectory of the target species (e.g., chinook salmon) provides an estimate of the abundance, productivity, and life history diversity of the species as a result of the habitat conditions.

Biological objectives would be based on three characterizations of the environment derived from the EDT hypotheses: (1) the Current Potential, (2) the adopted alternative, and (3) the Historic Potential. These characterizations would be developed at the basin and province scales based on information gathered at the 6-HUC level. The Current Potential describes the abundance, productivity and life history diversity of target species based on the habitat conditions, as they exist and on our knowledge represented in the Bio-rules. The Historic Potential is roughly equivalent to the historical condition and is a depiction of the basin and province based on regional climate, geology, and other parameters without the influence of large-scale human activities. It can be used as a reference point to describe change. The characterization of the adopted alternative will show how current environment would move toward the potential based on a set of management actions. The idea of the biological objectives is to use the environmental attributes to characterize this projected movement of the environment from the Current Potential to that of the adopted alternative, in the direction of the Historical Potential.

Figure V.3 provides on example of how this movement might be accomplished. The figure shows three types of biological objectives that could be developed. The first is a set of attributes describing aquatic habitats, the second describes terrestrial habitat types, and the third describes biological performance using the abundance of three fish species as indicators. EDT would be used to describe the current state of the parameter (abundance, productivity, or life history diversity) based on the rules embedded within the EDT model, the potential for the parameter, and the target value associated with an alternative (or the adopted alternative). The biological objective describes the amount of change needed in the attribute within a province. Change is measured relative to the current state and in the direction of the potential or goal.

The figure suggests several parameters that could form biological objectives. While likely candidates, they are intended to demonstrate the concept and are not by any means exhaustive or complete. However, we propose that objectives have explicit criteria. We suggest that they could be:

- readily measurable,
- intuitive,

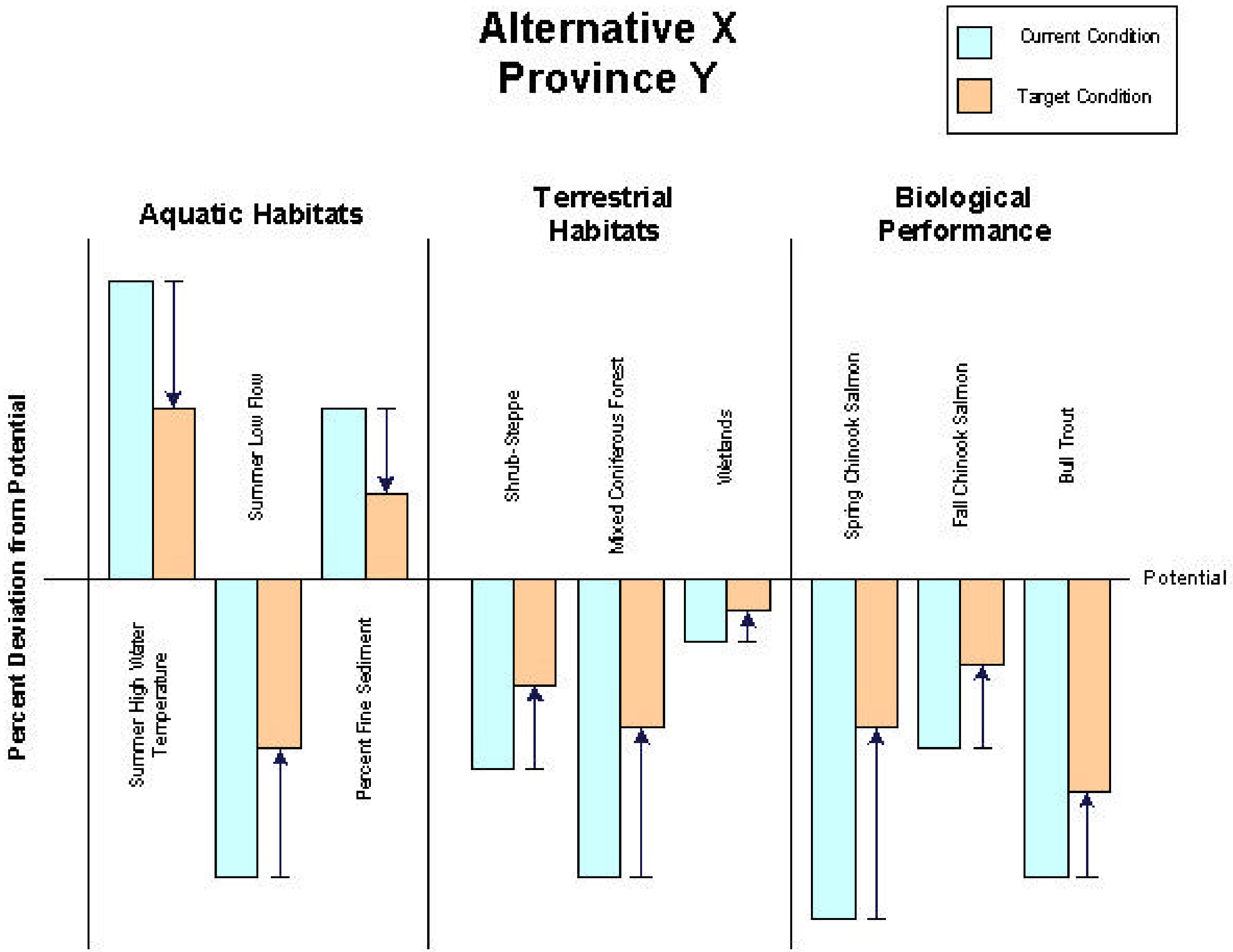


Figure V.3 The concept of biological objectives defined for environmental attributes as well as for biological performance.

- capable of providing clear direction to smaller scale planning,
- effective in representing needed conditions,
- integrative across many human activities.

It may be useful to define biological objectives as emergent properties of the ecosystem that would be the target of a monitoring program. They would be qualities that we can readily observe or measure such as temperature, flow, or numbers of fish. Ecological processes and function that are the underlying mechanisms determining emergent properties are the basis for the rules that are contained within EDT. These would be based on research and on other tools such as the NMFS h-VSP analysis or the models developed by PATH and Species-Habitat Project (SHP). The rules (hypotheses) would be tested and refined by research and evaluation. Examples include survival rates, trophic relationships, ecological redundancy, and the like. Many of these are measurable only under controlled circumstances such as those in a research program. Once understood, they would lead to better rules within EDT but would not need to be routinely monitored (there may be exceptions to this such as some survival rates).

Monitoring Aquatic habitats. While all of the attributes used within EDT might be important, it is likely that a smaller subset could be identified that would most influence many other attributes and that would be most influenced by management actions. Figure V.3 shows three candidate attributes: summer low flow, summer high temperature, and the percent fine sediment. The figure summarizes the results of a single alternative (e.g., the adopted alternative) for a single province. The bars show the deviation of the province with regard to each attribute relative to the potential for the province. Those on the left of each group show the current deviation of the province while those on the right show the target situation for an alternative or for the adopted alternative. The arrows refer to the biological objectives: the amount of change in an attribute within a province needed to meet the program goal based on the set of hypotheses within the EDT model.

Monitoring Terrestrial Habitats. Terrestrial habitats and aquatic habitats are often described in different terms, reflecting different scientific traditions and perspectives. While the two sides are converging, differences remain that should be reflected in the biological objectives. Terrestrial biologists generally refer to habitat types that are described on the basis of vegetational coverages rather than on the habitat attributes that are used for aquatic habitats. EDT is being adapted to provide a uniform structure to describe both aquatic and terrestrial habitats. Figure

V.3 demonstrates how terrestrial habitat types could be handled in much the same way as the aquatic habitat attributes. Again, the potential, current, and target habitats could be displayed to derive a biological objective as the change in a habitat type (e.g. shrub-steppe) within a province in the direction of the potential.

Monitoring Biological Performance. This refers to measures of abundance, productivity, and diversity of specific species. These are calculated within EDT on the basis of the Bio-rules and the habitat conditions. For many, these are the *bottom line* for performance of the program and are often directly translatable into the values and qualities referred to in the goal for the basin. EDT could be used to set biological objectives for the program in terms of biological performance that could be expected *if* the other objectives are met and *if* the rules or hypotheses within the model effectively represent the behavior of the Columbia River ecosystem. In many ways, these biological objectives serve as the final check on how accurately we can depict and predict the behavior of the system. These measures are meaningful only over relatively long time frames and are the result of complex and imperfectly understood ecological processes. Hence, while important, they may be less revealing about program effectiveness in the short term, relative to other parameters such as the habitat attributes.

Some measures of biological performance may be derived using other methods; for example, the responsible federal agencies may define criteria for delisting species listed under the Endangered Species Act. These could be incorporated and used as objectives. It is likely that the same procedure for monitoring and evaluation using EDT as the analytical framework could be used to track progress toward ESA recovery goals.

At the province level, the biological objectives would guide development of finer-scale objectives and strategies (management actions) at the subbasin level. For example, if the biological objective for a province were to reduce average water temperatures in late summer by 25 percent, the job at the subbasin level would be to devise a set of strategies to achieve this in the most biologically effective manner at the lowest cost while keeping with local values and so on. The objectives would not be prescriptive because the Council has no regulatory authority. Instead, the Council could be saying that it would fund actions that are consistent with the goal of changing conditions within a province as described by the biological objectives.

The biological objectives thus provide measurable attributes to track progress. Summer low flow, summer high water temperature, and fine sediments are relatively easily measured. Following adoption of the program, these, and perhaps others, could be monitored to update the

EDT analysis. Periodically, a formal updating could occur to define progress. The five-year life of the Council's Fish and Wildlife program stipulated in the Northwest Power Act provides a natural point to assess progress as well as the need to refine the biological objectives. The abundance of specific fish and wildlife populations (including their status relative to ESA delisting criteria) could be related to the biological objective to track progress as well. The rules within EDT that are the basis for derivation of the biological objectives would be the subject of evaluation efforts following adoption of a program. As better information is developed, the formal updating of the analysis could indicate the need to revise and update the biological objectives.

Several lines of modeling and assessment may prove fruitful in the near-term. Analyses of fish and wildlife interactions could explore the use of Bayesian belief network (BBN) models as an alternative to the HCI species habitat capacity models. The models may be used to assess habitat quality as well as proportional contributions for various species in functional diversity and redundancy analyses. Since USDA Forest Service has developed BBN models for many of the vertebrate species (fish and wildlife) in the basin (Raphael et al, 2001, Marcot et al, 2001), the Framework process could greatly benefit by coordinating modeling efforts with USDA Forest Service. The Ecological Work Group will also focus on applied aspects of the HCI, BBN, and KEF analyses by posing management hypotheses about which ecological functions may be in jeopardy if the wildlife species that perform such a function(s) are not maintained (Cederholm et al. 2000). Hypothesis-testing to assess management activities will be greatly facilitated by current efforts to integrate Framework Strategies with WHR management activities. Such work could quickly link management activities to KEF attributes for fish and wildlife using simple queries in the WHR database. The theoretical basis for the Framework methodology also provides for input of finer scale data to supplement the WHR database as one moves down the landscape hierarchy into the subbasin and watershed scales.

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GLOSSARY

6-HUC: HUCs (hydrologic unit codes) are a standard hydrological classification system. There are some 7,500 HUC-6s within the U.S. portion of the Columbia River basin.

actual flows: Flows as modified by upstream regulation and diversion.

adiabatic mixing: A meteorological event sometimes called Chinook winds. This occurs when a cold front is warmed due to changes in air pressure.

Alternative 2: A combination of strategies that include breeching five hydroelectric projects, improved hatcheries, and equal emphasis on improving tributary habitat on public and private land. Alternative 2 places equal effort in improving habitat on private and public lands.

Alternative 5: A combination of strategies that do not include breeching but propose increasing spring and summer mainstem flows, improving hatcheries, and emphasis on improving tributary habitat on public lands. Alternative 5 emphasizes habitat actions on public lands over private lands.

Alternative 6: A combination of strategies that do not include breeching but propose increasing juvenile transportation, reducing spring flows, increasing summer flows, improving hatcheries and emphasis on improving tributary habitat on public lands. Alternative 6 requires the same amount of effort as Alternative 5 does for public lands but significantly less on public lands.

Bayesian belief network (BBN): A model that depicts the probability of events or conditions based on causal relations such as between habitats and species; uses a form of Bayesian statistics.

Beverton-Holt model: A generally accepted stock-recruitment model that can be used to determine harvest and stock size for semelparous species such as Pacific salmon.

Beverton-Holt formulation: see Beverton-Holt functions

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

biodiversity: the variety of life and its processes; includes components of structure, function, and process of species, communities, ecosystems, and other levels of biological organization

biodiversity, productivity, and resource-use sustainability (BPS): three potential goals for managing for ecological integrity under ecosystem management.

Biological Objectives: Target levels set by the Framework process for: numbers of individuals (fish or wildlife population sizes), amount of habitat types and attributes, and functional attributes.

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

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

Bio-Rules: 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.

carcass stage: The final stage of a salmon life when the animal dies.

Closely Associated: Wildlife habitat types or structural conditions that play an essential need in supporting a wildlife species in its overall maintenance and viability; as used in the SHP database.

community: The array of species, and their ecological interactions, existing in a particular environment and geographic area.

community richness: An EDT Level 2 ecological attribute referring to the number of species in a particular area.

confidence rating: An evaluation of the overall strength of scientific evidence that describes wildlife habitat relationships.

CRiSP Model 4: The Columbia River Salmon Passage model used for the Columbia River mainstem. It calculates fish survival and movement through the hydroelectric system. EDT used some of the data sets developed for this model.

current condition: see Current Potential

Current Potential: The likely array of aquatic and terrestrial environmental conditions over the most recent decade, as depicted at a relatively coarse level of geographic resolution.

Ecological Work Group: A group within the Framework process responsible for scientific analysis of the policy alternatives

Evolutionary Significant Unit (ESU): A combination of Distinct Population Segments that are collectively protected by the Endangered Species Act.

ecosystem: The set of species and biological communities, including all biotic and abiotic factors and their interactions, existing in a particular environment and geographic area.

EDT approach: A science-based approach to formalizing and analyzing actions to improve the sustainability and production of migratory salmon. The approach integrates the quality and quantity of habitat across the salmon life cycle. It estimates the ability of the environment to support a population in terms of abundance, productivity, and life history diversity.

effectiveness: The extent that an attribute might be expected to change under a strategy.

effectiveness monitoring: Determining the degree to which the biological system responds to management activities as expected.

embeddedness: Degree to which large particles (boulders, rubble, gravel) are surrounded or covered by fine sediment, usually measured in classes according to percent coverage.

environmental attributes: Conditions in the environment that are used by EDT to evaluate the quality of habitat. They can be abiotic (water temperature) or biotic (i.e., community diversity).

Fall redistribution: An early-fall movement of yearling salmon into new territory in the freshwater environment.

Framework strategies: Strategies are actions that might be implemented to manage a watershed; strategy blocks are suites of actions that comprise an alternative.

freshwater rearing stage: The salmon life history stage following fry colonization. Fish are largely stationary and activities are mainly focused on feeding and growth.

functional analysis: The name given to our evaluation of the ecological roles of fish and wildlife.

functional attributes: Categories of key ecological functions.

functional richness: The number of categories of key ecological functions present in a particular biological community.

functional web: The array of key ecological functions and the various species performed by them, in a community, along with ecological links among species and between species and their habitats.

Future Potential: Conditions in the basin assuming alternative management strategies have been implemented. These strategies predict changes in attributes that have the potential to improve salmon performance over the next 100 years.

Generally Associated: Habitat types or structural conditions that play a supportive role for a species overall maintenance and viability; as used in the SHP database.

habitat attributes: See key environmental correlates (KECs); term used in the SHP wildlife database; refers to specific substrates and other aspects of a species' environment at spatial scales of resolution finer than those of habitat types and vegetation structural conditions.

habitat capacity: Habitat quality times habitat area, similar to the Habitat Unit in the Habitat Evaluation Procedure.

Habitat Condition Index (HCI): The Framework term used for habitat capacity in the wildlife analyses.

historic condition: See Historic Potential.

Historic Potential: Conditions in the basin that likely existed about 150 years ago (prior to non-native human influences).

HUC: Hydrologic unit code; refers to a strictly hierarchical mapping of water containment units conducted by US Geological Survey. Levels in the hierarchy are denoted by numbers, including the following: 4-HUC = subbasin, 5-HUC = watershed; 6-HUC = subwatershed.

h-VSP analysis: A viable salmon population model that includes habitat conditions. This model, once used by the National Marine Fisheries Service, has been superceded by more recent habitat-based salmon population models.

ICBEMP: Interior Columbia Basin Ecosystem Management Project; of USDI Bureau of Land Management and USDA Forest Service.

incubation stage: The period of the salmon life cycle from egg fertilization until hatching.

intensity: Framework intensity scores indicate the extent of implementation for management strategies; intensity scores modify effectiveness ratings by specifying full or reduced effectiveness.

interstitial space: The space between the material (e.g., sand, gravel, cobbles) that comprise the spawning substrate in streams.

juvenile migration timing: The time during the salmon life cycle when juvenile fish either redistribute into fresh water or start their movement to the ocean.

key ecological functions (KEF): The major ecological roles played by a species in its ecosystem.

key environmental correlate (KEC): An aspect of a species' environment finer in scale than major vegetation or habitat type; includes specific habitat substrates and also non-habitat aspects of a species' environment, such as noise, effects of other species, etc.

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.

life history pattern: a collection of similar trajectories, as applied in the EDT analytical model.

management activities: In the SHP wildlife database, refers to a set of general categories of management actions that might influence habitats for wildlife; extended to fish in this report.

Manning's equation: A formulation used by hydrologists to assess sheer forces in rivers. This report used this equation to determine the wetted channel width.

Moderate worldview: An intermediate world view that reflects likely outcomes when only a portion of the assumptions in the Technical Optimistic and Technical Pessimistic world views actually occur.

Multi-Species Framework: A process conceived by the Northwest Power Planning Council to analyze strategic choices associated with fish and wildlife recovery in the Columbia Basin.

natural stream flow: Flow without consideration of any upstream diversion or regulation.

nutrient load: A Level 1 Environmental Attribute used by EDT. Denotes the monthly concentration of nutrients such as nitrate and phosphorous.

ocean type: The portion of a salmon population that moves to the ocean in their first year of life.

original source: The reference or study that is the source of empirical data.

PATH: Plan for Analyzing and Testing Hypotheses. The PATH members use a variety of modeling tools to address questions related to salmon recovery in the Columbia Basin.

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.

population productivity: A term used by fish biologists to express the growth rate of a population. This term does not address density dependence.

population: The set of interbreeding organisms of a particular species existing in a particular area.

potential future performance: see Future Potential

Present: The habitat types or structural conditions provides marginal support to a species overall maintenance and viability; as used in the SHP database.

productivity: see Population Productivity.

redd construction: The process of making a spawning nest in the gravel bed of a river by salmon or steelhead.

Resident fish: Fish that spend their entire life cycle in freshwater. For program purposes, resident fish include landlocked anadromous fish (e.g., white sturgeon, kokanee and coho), as well as traditionally defined resident fish species.

Ricker model: A density-dependent population model developed by fisheries biologist W.E. Ricker to describe the relationship between recruits and spawners or total offspring for various population sizes.

Ricker recruitment curves: Graphical representations of the results/outputs (e.g., recruitment function) from a Ricker model.

runoff: Defines the amount of flow generated from each 6-HUC unit into the stream network; runoff was estimated from the Distributed Hydrologic Soils Vegetation Model (DHSVM).

saltwater rearing stage: The portion of a salmon life cycle when they live in the ocean.

sediment load: A Level 1 environmental attribute considered in the EDT modeling process. It refers to the mean monthly concentration of fine sediments in the water.

sinuosity: The amount of bending, winding and curving in a stream or river.

sinuosity index: A category used to describe the degree a stream bends, winds or curves.

spawning stage: The portion of a salmon life cycle when fish release and fertilize eggs

species assemblage: The set of species occurring in a particular area without regard to their ecological interactions (see Community).

Species Habitat Project (SHP) database: A database on wildlife in Oregon and Washington, from the Species-Habitat Project (Johnson and O'Neil 2001).

Spring dispersal: Refers to the initial movement of fry during the spring months.

Spring-Fall dispersal: Refers to the combined movement in the spring and subsequent redistribution movements of salmon that remain in fresh water for one year.

stream type: The portion of a salmon population that remains in fresh water for a year.

survival landscape: A conceptual term used by EDT modelers to convey the idea that salmon survival and abundance is influenced by a mix of environmental attributes that varies depending on where the fish occurs in the basin. This report considers each 6-HUC to be a survival landscape.

sustainability: The ability to maintain diversity, productivity, resilience to stress, health, renewability, and/or yields of desired values, resources, uses, products, or services from an ecosystem while also maintaining the integrity of the ecosystem over time.

Technology Optimistic worldview: Assumes that strategies for fish recovery that emphasize technology will be successful.

Technology Pessimistic worldview: Assumes that strategies for fish recovery that do not emphasize technology will be successful.

The All-Hs: Habitat, Hydro, Harvest and Hatcheries.

total functional diversity: The full array of all categories of key ecological functions (KEFs) of wildlife species in a particular area or community, along with the relative redundancy (number of species) of each KEF category.

trajectories: Multiple pathways generated by a Trajectory Generator module, in the EDT analytical model.

Trajectory Generator module: Component of EDT software that creates a life history pathway (i.e., trajectory) that a single fish will follow. Many trajectories are generated for each EDT analysis.

translation examples: Formulas and functions used by the Ecological Work Group to convert Level 2 ecological attributes to Level 3 biological performance.

validation monitoring: Monitoring studies that seek to test the major underlying assumptions about how a biological system operates.

water temperatures: Level 2 ecological attributes used in the EDT modeling process. The temperature of water is evaluated as a daily maximum, a daily minimum and as surface water is influenced by inputs of ground water.

water velocity: A measure of how fast water flows. Natural flow is an EDT Level 1 environmental attribute.

wildlife habitat relationships (WHR): General term referring to species-specific depictions of habitats and environmental features that influence the distribution and abundance of wildlife species.

wildlife population performance: Measured by the Habitat Condition Index that addresses habitat capacity.

worldview: A concept describing how a biological system operates that used in this report to assess uncertainty of the fish results for each of the three alternatives analyzed.

The EDT Method

August 1999 - Draft

Mobrand Biometrics, Inc.

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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.

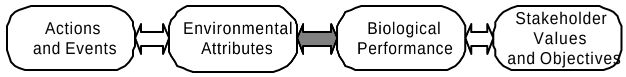

Figure 1. The EDT framework.

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.

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[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 <u>not</u> 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.

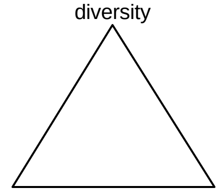

Figure 2. Elements of biological performance.

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).

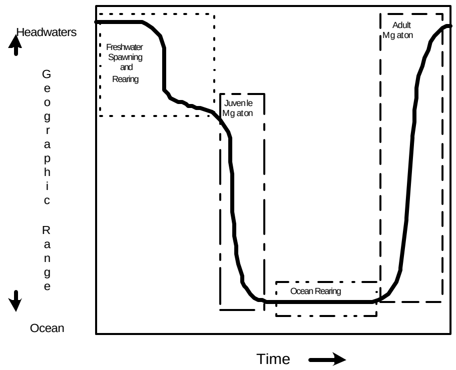

Figure 3. The concept of a life history trajectory across the “space-time landscape.”

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.

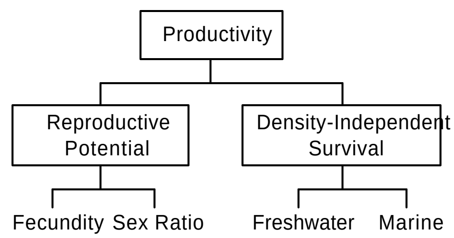

Figure 4. Components of productivity.

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).

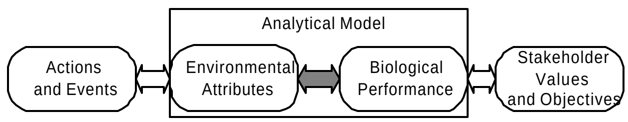

Figure 5. The analytical model in the context of the conceptual framework.

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.

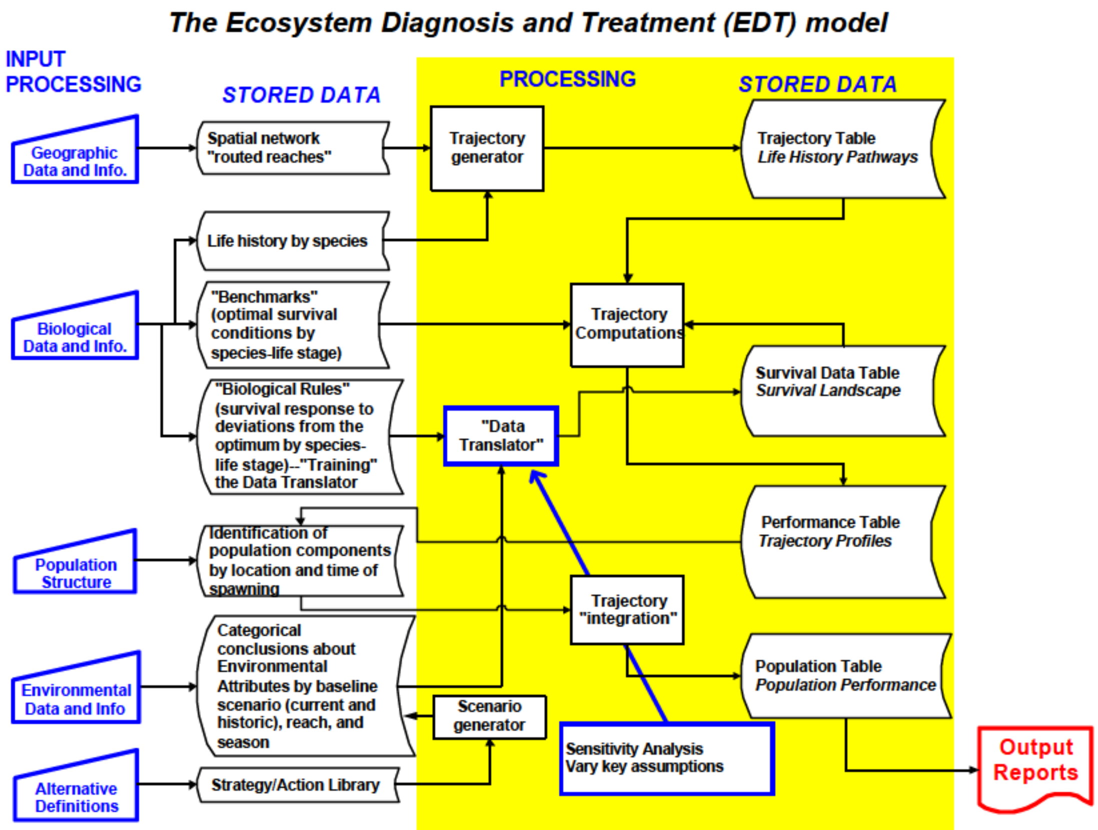

Figure 6. Overview of the EDT analytical approach.

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:

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

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, *{ tÎT }*, 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-1

Level 2 Environmental Attributes

Level 2 Environmental Attributes are a standardized set of attributes for characterizing the environment, or ecosystem, as it affects the performance of various species. The attributes described here were selected to be applied to fish species, and in particular to salmonid species. Other attributes may need to be added to analyze performance for other aquatic species within freshwater.

This section provides a brief description for each of the 45 environmental attributes used to characterize the freshwater environment. Each of the 45 attributes is defined and described with regard to its ecological role, some of the factors affecting its condition, and its general importance to salmonid fishes of the Pacific Northwest. These descriptions should be helpful to individuals reviewing the Level 2 attribute values and in understanding the role of these attributes within the rules. Also, this section will be useful in the process of updating Level 2 information through the **Assessment Review** that the Northwest Power Planning Council is initiating in mid 2000.

The attributes are presented in alphabetical order.

Alkalinity

Definition/Usage

Alkalinity of water (at moderate flows)

Importance and Role

Alkalinity is broadly correlated with the productive capacity of streams, with respect to both primary production and fish production. The correlation between alkalinity and fish production is believed to be due to the role alkalinity plays in the production of food organisms.

Categorical Conclusions

Index 0	Index 1	Index 2	Index 3	Index 4
Very low (average value typically would be 0-5 mg/l)	Moderately low (average value typically would be 5-25 mg/l)	Moderately high (average value typically would be 25-50 mg/l)	High (average value typically would be 50-150 mg/l)	High (average value typically would be 150-250 mg/l)

* *Where an index value is associated with a range, the integer value is assumed for modeling to be the midpoint. Index values can be identified as non-integers to represent the lower or upper ends of a range.*

Factors Affecting Attribute/Guidelines

Because of the variability that can occur in alkalinity data and the incompleteness of available data for this data, a measure of alkalinity is sought for broad ecological regions only. Alkalinity is highly correlated with water yield in watersheds, being lowest in high runoff areas.

In general, alkalinity on the west side of the Cascades will fall into index levels 1 and 2. Therefore, Index 1 or 2 should be prevalent for the Westside unless evidence indicates otherwise. While alkalinity is generally higher on the east than the west side of the Cascades, it can vary widely in relation to runoff patterns, proximity to the Cascade crest, and local geology. In general, Index 3 and 4 should be prevalent in the mid and lower portions of subbasins on the east side of the Cascade crest but lower as the crest is approached.

Special Instructions for New Input or Updates

In general, this attribute should be treated as a low priority. Default values premised on the pattern described above can be applied. When the attribute is explicitly addressed, all months should be rated the same. Conditions under moderate flows should be considered.

Effect on Level 3 Biological Metrics

Alkalinity affects the Level 3 attributes Food and Competition (as a modifying attribute associated with food fish food production) and, in turn, affects 1) the maximum density that can be attained by the end of rearing life stages and 2) resultant species productivity.

References/Sources

Importance and Role: Hynes (1970) and Ptolemy (1993).

Factors Affecting: Hynes (1970) and Ptolemy (1993).

Bed Scour

Definition/Usage

Average depth and frequency of scour on small-cobble/gravel riffles during high flow events. The term "frequent" indicates at least one event every 1-2 years. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1991): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 7 inch diameter), large cobble (7 to 11.9 inch diameter), boulder (>11.9 inch diameter).

Importance and Role

The channel bed is a substrate used by aquatic organisms as a foothold, as a site to deposit or incubate eggs, and as a refuge from floods. The substrate can be extremely active biologically. The disruption of the particles comprising the upper layer of the substrate can therefore have a profound effect on survival and production of species that rely on this area of a stream. In particular, scour of bed materials during high flows can affect the survival of incubating salmonid eggs and overwintering juveniles located there. It can also affect the production of aquatic insects within streams.

Categorical Conclusions

Index 0	Index 1	Index 2	Index 3	Index 4
Pool tailouts and riffles very stable, characteristic of conditions prevailing in largely spring fed streams.	Infrequent scour, averaging depths < 10 cm	Frequent scour, averaging depths < 10 cm	Frequent scour, averaging depths > 10 cm and < 25 cm	Frequent scour, averaging depths exceeding 25 cm

**** Where an index value is associated with a range, the integer value is assumed for modeling to be the midpoint. Index values can be identified as non-integers to represent the lower or upper ends of a range.***

Factors Affecting Attribute/Guidelines

Depth of bed scour in natural conditions is affected by discharge level and geomorphic conditions. Bed scour is generally assumed to occur when discharge reaches bankfull, which typically occurs every 1-2 years under pristine conditions. Some bed mobility occurs at stages below bankfull, but widespread bed mobility commonly occurs at a stage near bankfull. Steep and low-gradient channels, however, fundamentally differ in the extent of bed mobility and the depth of scour during typical bed-mobilizing events (Montgomery et al. 1999).

Bankfull flows generally mobilize the streambed across the entire channel. The average thickness of the layer in active transport is related to the bedload transport rate, which is determined by the magnitude and duration of the peak discharge.

Increased bedload transport rate in a stream reach may result from increases in peak flow or sediment supply—both of which may be caused by various land use activities. Channel straightening, diking, and closure of side channels can also increase bedload transport rate in a channel.

Bed scour within microhabitats of main channels may differ from surrounding areas due to localized conditions. For example, gravels impounded behind log jams may decrease local channel gradient enough to reduce bed scour. Elimination of such microhabitats may prevent spawning fish from spawning at sites relatively protected from significant bed scour. Side channels may also experience less bed scour than main channel areas.

Anadromous salmonids typically bury their eggs 15-20+ cm below the channel bed, whereas smaller resident and anadromous trout bury eggs at shallower depths, typically 5-10 cm (DeVries 1997; Montgomery et al. 1999). Larger females generally dig deeper redds than smaller fish do, and egg survival to emergence is inversely related to the depth of scour between time of spawning and fry emergence.

Montgomery et al. (1996) reported that chum salmon bury their eggs just below scour depths during bankfull flow. This suggests that the average depth of scour in many rivers of the Pacific Northwest prior to watershed development must have been less than this depth. It is likely that average scour depths have increased to greater than these levels in rivers where extensive watershed development has occurred.

In general, therefore, Index values 2-3 (<10 cm - ~17 cm scour depths) should be assumed for unconfined reaches of most streams within the region in pristine conditions during bankfull stage. For tightly confined reaches, Index values should be greater; values in the range 3-4 (~17 cm - >25 cm) are suggested.

Special Instructions for New Input or Updates

This attribute is considered as a high priority for rating.

It is necessary to rate only for the month when bed scour would likely be highest. Other months will be inferred using modeling techniques within the database by applying an appropriate flow pattern for the watershed of interest.

Effect on Leve1 3 Biological Metrics

This attribute affects the Level 3 attribute Channel Stability and, in turn, affects resultant species productivity. The effects generally occur in the egg incubation and inactive life stages, though they can occur in the rearing life stages for certain species as well.

References/Sources

Definition/Usage: Platts et al. (1983) and Gordon et al. (1992)

Importance and Role: DeVries (1997), Gordon et al. (1992), Montgomery et al. (1996), and Montgomery et al. (1999).

Factors Affecting: Gordon et al. (1992), Lisle (1989), Montgomery and Buffington (1993), Montgomery et al. (1996), and Montgomery et al. (1999).

Benthos Diversity and Production

Definition/Usage

Measure of the diversity and production of the benthic community.

Importance and Role

Benthic organisms in flowing waters comprise an important component of the diet of many fish species, particularly of juvenile salmonids. Food supply in turn can affect the survival of rearing fishes, as well as the maximum densities that can be achieved by these species within key habitats.

Categorical Conclusions:

Index 0	Index 1	Index 2	Index 3	Index 4
Macroinvertebrates abundant; multiple species of families Emphemeroptera, Plecoptera, and Trichoptera are present.	Intermediate	Macroinvertebrates common or abundant but 1-2 families among Emphemeroptera, Plecoptera, and Trichoptera are not present.	Intermediate	Macroinvertebrates are present only at extremely low densities and/or biomass.

Factors Affecting Attribute/Guidelines

The categorical conclusions employed for benthos diversity and production assume that biological impairment of the benthic community may be indicated by the absence of generally pollution-sensitive macroinvertebrate taxa such as Emphemeroptera, Plecoptera, and Tricoptera (EPT).

The EPT is highly sensitive to dissolved oxygen, resulting largely from the combination of temperature and nutrient loading. Benthos production and diversity will be at the lowest possible level under conditions of super enrichment and high temperature. Deleterious effects are assumed to drop sharply with reductions in enrichment levels. The EPT can generally be assumed to be highest possible under conditions of no nutrient loading because dissolved oxygen is normally at or near saturation in the absence of enrichment in the Pacific Northwest.

A suggested guideline is given below that corresponds closely with that for dissolved oxygen (see guideline for *Dissolved Oxygen*); both guidelines are based on water temperature and nutrient enrichment (see guideline for *Nutrient Enrichment*).

Benthos Index Value Lookup Table

Nutrient enrichment index value	Mean monthly water temperature (°C)				
	≤10	>10 and ≤12	>10 and ≤12	>10 and ≤12	>20
0	0	0	0	0	0

1	0	0	1	1	1
2	0	0	2	2	2
3	2	2	2	3	3
4	2	2	3	3	4

Other attributes besides nutrient enrichment and water temperature are known to have significant effects on benthos production and diversity, such as fine sediment loading, riparian function, and toxic substances.

Special Instructions for New Input or Updates

In general, this attribute should be treated as a low priority for rating. There is generally no need to rate this attribute for the region unless unusual conditions are present. Default values built from the temperature and oxygen attributes can be formulated within the database.

When the attribute is explicitly addressed, all months can be rated the same.

Effect on Leve1 3 Biological Metrics

This attribute affects the Level 3 attribute Food, and in turn, affects 1) the maximum density that can be attained by the end of rearing life stages and 2) resultant species productivity.

References/Sources

Importance and Role: Chapman (1966) and Hynes (1970).

Factors Affecting: Allan (1995), Hynes (1960), and Plafkin et al. (1989).

Channel Width - Month Maximum Width (ft)

Definition/Usage

Average width of the wetted channel during high flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels.

Importance and Role

The wetted width of the channel helps define the quantity of wetted area available as habitat for riverine species.

Categorical Conclusions

Index 0	Index 1	Index 2	Index 3	Index 4
< 15 ft	> 15 ft and < 60 ft	> 60 ft and < 100 ft	> 100 ft and 360 ft	> 360 ft

** Where an index value is associated with a range, the integer value is assumed for modeling to be the midpoint. Index values can be identified as non-integers to represent the lower or upper ends of a range.*

Factors Affecting Attribute/Guidelines

The width of the wetted channel, except in confined reaches, is normally related to discharge.

If width data are not available for the reach of interest, conclusions can be based on personal knowledge of the area. In some cases, a better characterization of flow may exist than channel width. Here, an estimate of width (in feet) can be obtained from flow (cfs) data using an equation formulated for streams in Western Washington from Johnson et al. (1988) as follows:

$$Width = a * CFS^b$$

Where a = 4.58 and b = 0.566

Similarly, a relationship can be applied to streams on the eastside of the Cascade crest using an equation given in Johnson et al. (1988) as follows:

$$Width = a * CFS^b$$

Where a = 10.03 and b = 0.435

The equation for the westside is based on data collected at 154 sites from a variety of rivers and tributaries in Western Washington. The eastside equation was developed with data from sites in the Wenatchee River system; this system contains a high degree of semi- or fully confined reaches. Presumably, therefore the eastside equation should be applied to systems that contain a higher amount of confined reaches.

Special Instructions for New Input or Updates

Channel width – month maximum width (ft) is to be rated for the month when average flow tends to be highest. This month will typically be during some part of March-June east of the Cascade crest and during December or January on the westside. A flow pattern can be applied to extrapolate from the high and low months to all remaining months.

In assigning values to this attribute, it is essential to recognize that channel width here is average wetted width during the month, *not bankfull width*. Individuals assigning widths to reaches are encouraged to be as specific as possible (i.e., assign width to the foot if possible). If only the categorical conclusion is designated (e.g., an index value of 2), then it will be assumed that the midpoint of the range is most applicable (though an index value will flag this assumption as being bounded by considerable uncertainty).

Effect on Leve1 3 Biological Metrics

This attribute is used to estimate the wetted surface area of channel reaches in different months of the year. Percentages of key habitat for different life stages for the species of interest is then applied to wetted surface area to estimate quantities of key habitat at for each life stage.

References/Sources

<u>Factors Affecting</u>: Johnson et al. (1988).

Channel Width - Month Minimum Width (ft)

Definition/Usage

Average width of the wetted channel during low flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels.

Importance and Role

The wetted width of the channel helps define the quantity of wetted area available to be used as habitat by riverine species.

Categorical Conclusions

Index 0	Index 1	Index 2	Index 3	Index 4
< 15 ft	> 15 ft and < 60 ft	> 60 ft and < 100 ft	> 100 ft and 360 ft	> 360 ft

** Where an index value is associated with a range, the integer value is assumed for modeling to be the midpoint. Index values can be identified as non-integers to represent the lower or upper ends of a range.*

Factors Affecting Attribute/Guidelines

The width of the wetted channel, except in confined reaches, is normally related to discharge.

If width data are not available for the reach of interest, conclusions can be based on personal knowledge of the area. In some cases, a better characterization of flow may exist than channel width. Here, an estimate of width (in feet) can be obtained from flow (cfs) data using an equation formulated for streams in Western Washington from Johnson et al. (1988) as follows:

$$Width = a * CFS^b$$

Where a = 4.58 and b = 0.566

Similarly, a relationship can be applied to streams on the eastside of the Cascade crest using an equation given in Johnson et al. (1988) as follows:

$$Width = a * CFS^b$$

Where a = 10.03 and b = 0.435

The equation for the westside is based on data collected at 154 sites from a variety of rivers and tributaries in Western Washington. The eastside equation was developed with data from sites in the Wenatchee River system; this system contains a high degree of semi- or fully confined reaches. Presumably, therefore the eastside equation should be applied to systems that contain a higher amount of confined reaches.

Special Instructions for New Input or Updates

Channel width – month minimum width (ft) is to be rated for the month when average flow tends to be lowest. This month will typically be during late summer or early fall on both sides of the Cascade crest. A flow pattern can be applied to extrapolate from the high and low months to all remaining months.

Individuals assigning widths to reaches are encouraged to be as specific as possible (i.e., assign width to the foot if possible). If only the categorical conclusion is designated (e.g., an index value of 2), then it will be assumed that the midpoint of the range is most applicable (though an index value will flag this assumption as being bounded by considerable uncertainty).

Effect on Leve1 3 Biological Metrics

This attribute is used to estimate the wetted surface area of channel reaches in different months of the year. Percentages of key habitat for different life stages for the species of interest is then applied to wetted surface area to estimate quantities of key habitat at for each life stage. This attribute is also used to group certain Biological Rules (Level 2 to Level 3 translation rules) by size of stream.

References/Sources

Factors Affecting: Johnson et al. (1988).

Confinement – Natural

Definition/Usage

The extent that the valley floodplain of the reach is confined by natural features—determined as the ratio between the width of the valley floodplain and the bankfull channel width. *Note: this attribute addresses the natural (pristine) state of valley confinement only. The extent that reaches are confined by hydromodifications (e.g., diking) is addressed under a separate attribute.*

Importance and Role

Channel confinement affects habitat-forming processes and, hence, the occurrence of different types of fish habitats within the stream network. Extent of confinement also affects water velocity and flood storage capacity of the floodplain, and, consequently it can strongly influence bed stability and potential for scour.

Categorical Conclusions

Index 0	Index 1	Index 2	Index 3	Index 4
Reach mostly unconfined by natural features -- Average valley width > 4 channel widths.	Reach comprised approximately equally of unconfined and moderately confined sections.	Reach mostly moderately confined by natural features -- Average valley width 2 - 4 channel widths.	Reach comprised approximately equally of moderately confined and unconfined sections.	Reach mostly confined by natural features -- Average valley width < 2 channel widths.

Factors Affecting Attribute/Guidelines

Channel morphology and response to high flows are influenced by the degree of confinement by valley walls. Unconfined channels typically have relatively wide floodplains, relatively low gradients, and often are areas of alluvial aggradation. In this situation, sediment supply (of a wide range of sizes) exceeds transport capacity of the channel. Steep channels typically are confined by valley walls and shallow bedrock. These channels have relatively low sediment storage capacities and serve as transport reaches, with sediment loads being carried through the reach during high flow events.

Because confined channels have high transport capacities, their substrates containing small cobbles/gravel are typically subject to higher rates of bed scour than are unconfined reaches.

The extent of natural confinement can be determined from topography maps, though some ground truthing may be required. In Western Washington, natural confinement has been determined for many river systems as part of the Salmon and Steelhead Habitat Inventory and Assessment Project.

Special Instructions for New Input or Updates

All months are rated the same for this attribute.

Effect on Leve1 3 Biological Metrics

This attribute affects the Level 3 attributes Flow and Habitat Diversity, which, in turn, affect productivity of certain life stages of salmonids.

References/Sources

Definition/Usage: Schuett-Hames et al. (1994)

Importance and Role: Montgomery and Buffington (1993)

Factors Affecting: Montgomery and Buffington (1993)

Confinement – Hydromodifications

Definition/Usage

The extent that man-made structures within or adjacent to the stream channel constrict flow (as at bridges) or restrict flow access to the stream's floodplain (due to streamside roads, revetments, diking or levees), or the extent that the channel has been ditched or channelized.

Importance and Role

Stream channels are modified to protect adjacent property from streambank erosion and flooding. This is accomplished by eliminating and/or reducing meanders to increase velocity, construction of levees and dikes, and armoring streambanks. These alterations reduce or eliminate (often by blocking access) fish habitat and typically reduce the quality of remaining habitat.

Categorical Conclusions

Index 0	Index 1	Index 2	Index 3	Index 4
The stream channel within the reach is essentially fully connected to its floodplain. Very minor structures may exist in the reach that do not result in flow constriction or restriction. Note: this describes both a natural condition within a naturally unconfined channel as well as the natural condition within a canyon.	Some portion of the stream channel, though less than 10%, is disconnected from its floodplain along one or both banks due to man-made structures or ditching.	More than 10% and less than 40% of the entire length of the stream channel within the reach is disconnected from its floodplain along one or both banks due to man-made structures or ditching.	More than 40% and less than 80% of the entire length of the stream channel within the reach is disconnected from its floodplain along one or both banks due to man-made structures or ditching.	Greater than 80% of the entire length of the stream channel within the reach is disconnected from its floodplain along one or both banks due to man-made structures or ditching.

Factors Affecting Attribute/Guidelines

The assignment of ratings to this attribute is subjective, to be based on a determination of the extent that hydromodifications to the channel within a reach have occurred. Such determination may be wholly or partially a *judgment* based on information available. Types of alterations to the channel corridor that should be considered are dikes, bank armoring, closure of flood relief channels, channel straightening, and channelization.

Special Instructions for New Input or Updates

All months are rated the same for confinement—hydromodifications.

Effect on Leve1 3 Biological Metrics

Confinement—hydromodifications affects the Level 3 attributes Flow and Habitat Diversity, which, in turn, affects productivity of certain life stages of salmonid fishes.

References/Sources

Importance and Role: Beechie et al. (1994), Federal Interagency Stream Restoration Working Group (1998).

Factors Affecting: Federal Interagency Stream Restoration Working Group (1998).

Dissolved Oxygen

Definition/Usage

Average dissolved oxygen within the water column for the specified time interval.

Importance and Role

Dissolved oxygen (DO) is a basic requirement for a healthy aquatic ecosystem. Fish and aquatic insects require DO to survive and carry on life giving functions.

Categorical Conclusions

Index 0	Index 1	Index 2	Index 3	Index 4
> 8 mg/L (allows for all biological functions for salmonids without impairment at temperatures ranging from 0-25 C)	> 6 mg/L and < 8 mg/L (causes initial stress symptoms for some salmonids at temperatures ranging from 0-25 C)	> 4 and < 6 mg/L (stress increased, biological function impaired)	> 3 and < 4 mg/L (growth, food conversion efficiency, swimming performance adversely affected)	< 3 mg/L

** Where an index value is associated with a range, the integer value is assumed for modeling to be the midpoint. Index values can be identified as non-integers to represent the lower or upper ends of a range.*

Factors Affecting Attribute/Guidelines:

DO in unpolluted streams and rivers is usually near saturation; and, under these circumstances, it poses no risk to biological function to species of concern. *Hence index values should be set to 0 when nutrient enrichment is nil for all temperature levels.*

DO can be severely depleted as a result of human activities that introduce nutrients into surface waters. This occurs, for example, when runoff is enriched with fertilizers and animal wastes or from municipal discharges. Nutrient enrichment, consisting of elevated concentrations of phosphates or nitrates, can lead to oxygen depletion when the stream flora increases in biomass followed by death and decomposition of plant material. These conditions are made worse when water temperature increases, due to corresponding increases in rates of plant growth and subsequent decay. Further, oxygen solubility decreases with increasing water temperature. *Index values for DO should be set at 4 when mean monthly water temperatures are high (>20°C) and super enrichment of nutrients occurs. Index values should be reduced corresponding to decreased temperatures or nutrient loading.*

A guideline for the dissolved oxygen index value is given in the Dissolved Oxygen Index Value Lookup Table based on mean monthly water temperature and the Level 2 nutrient enrichment index value (see guideline for *Nutrient Enrichment*).

Dissolved Oxygen Index Value Lookup Table

Nutrient enrichment index value	Mean monthly water temperature (°C)				
	≤10	>10 and ≤12	>12 and ≤16	>16 and ≤20	>20
0	0	0	0	0	0
1	0	0	0	1	1
2	0	1	1	1	2
3	1	1	2	2	3
4	3	3	4	4	4

Special Instructions for New Input or Updates

Rate the month when DO is likely to be lowest, i.e., the month when temperature is highest. Rate only one month. Other months will be inferred from an appropriate seasonal pattern based on temperature.

Effect on Leve1 3 Biological Metrics

The attribute, Dissolved Oxygen, affects the Level 3 attribute, Oxygen, which, in turn, can affect the productivity of any life stage of stream dwelling fishes.

References/Sources

Importance and Role: Hynes (1970).

Factors Affecting: Allan (1995), Federal Interagency Stream Restoration Working Group (1998), and Hynes (1960).

Embeddedness

Definition/Usage

The extent that larger cobbles or gravel are surrounded or covered by fine sediment.

Importance and Role

Juvenile fish will hide in the interstitial spaces in stream substrates, particularly in winter, when the voids are accessible. When these spaces are filled by fine sediment (embedded), the quality of the substrate for hiding cover is diminished, and survival can be reduced. It can also diminish the flow of water into the substrate, thereby affecting oxygenation of incubating eggs buried there. Embeddedness also affects the production of aquatic insects.

Categorical Conclusions

Index 0	Index 1	Index 2	Index 3	Index 4
< 10% of surface covered by fine sediment	> 10 and < 25 % covered by fine sediment	> 25 and < 50 % covered by fine sediment	> 50 and < 90 % covered by fine sediment	> 90% covered by fine sediment

** Where an index value is associated with a range, the integer value is assumed for modeling to be the midpoint. Index values can be identified as non-integers to represent the lower or upper ends of a range.*

Factors Affecting Attribute/Guidelines

Responses to increases in fine sediment load depend on the ability of the channel to transport material relative to sediment supply. Responses can include aggradation, channel widening, bed fining, pool filling, or braiding where the amount of introduced sediment overwhelms local sediment transport capacity. Increased supply of fine sediment to a plane-bed channel is expected to result in either fining of the bed surface or channel aggradation. Pool-riffle channels will undergo aggradation and fining in response to increased sediment load. Increased sediment supply can also result in expansion of the zone of active sediment transport. Although bed scour is expected to increase during high flow under this condition, the extent of embeddedness is expected to increase during lower flows. Hence, at the highest levels of sediment loading, reaches with the least transport capacity (typically lower gradient reaches with slowest water velocities) would result in the highest level of deposition and embeddedness.

Special Instructions for New Input or Updates

All months are to be rated the same for embeddedness. In reality, the extent of embeddedness likely varies in response to scour and fill and times when sediment inputs are greatest. A temporal pattern may need to be applied in a future application.

Effect on Leve1 3 Biological Metrics

Embeddedness affects the Level 3 attribute Sediment and, in turn, species survival of free-swimming fish when strongly associated with the streambed.

References/Sources

Importance and Role: Bjornn et al. (1977), Bjornn and Reiser (1991), Chapman and Bjornn (1969), Cordone and Kelly (1961), and Platts et al. (1983).

Factors Affecting: Montgomery and Buffington (1993).

Fine Sediment Load (intragravel)

Definition/Usage

Percentage of fine sediment within pool-tailouts, glides, and riffles. Fine sediment in this definition refers to the percentage of the substrate composed of particles <0.85 mm in diameter.

Importance and Role

Fine sediment particles within the substrate of pool-tailouts, glides, and riffles can affect the survival of incubating salmonid eggs and alevins by altering oxygen exchange across the organisms and by entombment. Fine sediment can also affect the benthos, both species diversity and production (benthos is rated directly as another attribute, however).

Categorical Conclusions

Index 0	Index 1	Index 2	Index 3	Index 4
< 6% fines < 0.85 mm	> 6% and < 11% fines < 0.85 mm	> 11% and < 18% fines < 0.85 mm	> 18% and < 30% fines < 0.85 mm	> 30% fines < 0.85 mm

** Where an index value is associated with a range, the integer value is assumed for modeling to be the midpoint. Index values can be identified as non-integers to represent the lower or upper ends of a range.*

Factors Affecting Attribute/Guidelines

Levels of fine sediment in salmon spawning areas of unmanaged streams of the Pacific Northwest, British Columbia, and Alaska have been reported to generally range between 6% and 11% (summarized in Peterson et al. 1992). Basin geology and other geomorphic conditions (such as channel slope) can affect percent fines in unmanaged conditions. Some streams in such areas, however, do have fine sediment levels >11%, and, presumably, such situations occur in low slope areas or those with particularly erosive geologic conditions.

All measures of watershed disturbance can affect the amount of intragravel fine sediment. These disturbances can be associated with agriculture (includes grazing), forestry, mining, or urban related. Each of these land use practices contributes major quantities of sediment to streams.

In forested areas, the road system can be a primary contributor; in other cases, slope failures and stream bank erosion are most influential.

On the west side of the Olympic Peninsula, Rittmueller (1986) reported that percent fines ranged from 0.7% in an unlogged basin to 29% in a stream with the highest sediment input coming from heavily used logging roads. Rittmueller found that percent fines increased by 0.15% as percent of watershed clearcut increased by 1%. As road density increased by 1 km/km^2, intragravel fine sediment levels increased by 4.3%. In streams where logging activity exists, road use and road building had ceased or been minimized in recent years, percent fines appeared to have returned to nearly background levels. *It should be noted that these streams would generally have channel slopes >0.5%, and many would have slopes >1%.*

In contrast to Rittmueller's findings, McHenry et al. (1994) suggested that recovery to pre-management levels would be slow for streams draining to the west side of the Strait of Juan de Fuca on the Olympic Peninsula even with road closure. Geology of the area is comprised of sandstones, siltstones and mudstones. Only one of eighteen streams studied was found with percent fines (<0.85 mm) <17%. All streams have been extensively logged over the past century.

The effect of changes in the fine sediment load carried by a stream on the amount of sediment entrained within the upper layer of substrate is related to the ability of the channel to transport material relative to sediment supply. In general, the response of a channel to changes in sediment load are known to depend on sediment transport capacity. Sediment transport capacities are high in high gradient channels, making channel types associated with high slopes more resilient to increased sediment loads. Sediment transport capacity in lower gradient channels (e.g., those <4%) are more easily overwhelmed by increased sediment supply, causing aggradation, channel widening, bed fining, pool filling, or braiding. Thus increased sediment loading should show a much greater response in intragravel fines in low slope than in higher slope reaches.

For many streams, the intragravel fine sediment level may be considered roughly constant over an annual cycle despite periods of scour and fill due to high flows.[1]

Special Instructions for New Input or Updates

All months should be rated the same for fine sediment load (intragravel).[2]

Effect on Leve1 3 Biological Metrics

This attribute affects the Level 3 attribute, Sediment Load and, in turn, affects resultant species productivity in life stages strongly associated with the substrate, particularly during egg incubation.

References/Sources

Importance and Role: Everest et al. (1987), Bjornn and Reiser (1991), and Peterson et al. (1994).

[1] Peterson et al. (1994) reported that fine sediment levels in spring, following winter high flows, approximated those in the fall prior to the advent of high flows in a salmon spawning stream.

[2] This does not necessarily mean that conditions with a salmon egg pocket would experience the same level of fine sediments, particularly over the entire period of incubation. Currently the Biological Rules assume that conditions remain constant in the redd over the entire period, but conditions may actually differ by hydrologic regime, particularly between streams in the high desert (e.g., the John Day subbasin) and those on the west side of the Cascade crest. This matter will be addressed in refining the rules.

Factors Affecting: Rittmueller (1986), Peterson et al. (1992), and Montgomery and Buffington (1993).

Flow – Change in Inter-annual Variability in High Flows

Definition/Usage

A measure of between-year variation in magnitude of high flow levels and/or the extent of change in overall high flow level during a month relative to an undisturbed watershed of comparable size, geology, and geography (or as would have existed in the pristine state).

Importance and Role

Hydrologic patterns of ecologically healthy watersheds in the coastal ecoregion are strongly related to the timing and quantity of flow, characteristics of seasonal water storage, and dynamics of surface-subsurface exchanges.

Changes in the timing and quantity of flow, due to land uses and flow regulation, can affect responses of stream dwelling organisms like salmonids, leading to changes in overall performance of their populations.

Species adapted to disturbance events (such as floods) of intermediate intensity, as occurred in most pristine watersheds of the Pacific Northwest, can be negatively affected by increases in the frequency and magnitude of disturbance. Changes in flow runoff patterns associated with channelization, revetment, and timber harvest can increase both magnitude and frequency of high flow events resulting in increased intensity of disturbance.

Moreover, hydrologic regimes that have been shifted to more stable patterns (i.e., less variation and reduced high flows) can result in loss of habitat quality if channel/habitat forming events occur much less frequently.

Categorical Conclusions

Index 0	Index 1	Index 2	Index 3	Index 4
Pronounced decreases in high flow levels and/or amount of between year variation in high flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest).	Some evidence of decreases in high flow levels and/or amount of between year variation in high flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest)	Typical high flow levels and amount of variation in high flows between years relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest).	Some evidence of increases in high flow levels and/or amount of between year variation in high flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest)	Pronounced increases in high flow levels and/or amount of between year variation in high flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest).

Factors Affecting Attribute/Guidelines

The attribute, Flow—Change in Inter-annual Variability in High Flows, operates in concert with the attribute Hydrologic Flow Regime—Natural. It defines the amount of change that has occurred in between-year variation in high flow or the extent of overall change in high flow as a result of watershed development.

Changes in vegetation cover and land use as a result of watershed development can alter the hydrograph shape, increasing inter-annual high flow variation and peak discharge. Because vegetation cover affects infiltration rates, its removal can cause direct runoff to increase and hydrographs to become more peaked. This is most strongly seen in urban areas, where total runoff and peak discharges are increased relative to the pristine conditions. Depending on the degree of watershed impervious cover, as occurs in urban areas, the annual volume of storm water runoff can increase by 2 to 16 times its predevelopment rate (Schueler 1995).

The index values for this attribute have been scaled to the pristine state, described by Index Value 2. Shifts toward more interannual variability or peak discharge are represented by Index Value 3 and 4, less variability or reduced peaks by values 0 and 1. The latter conditions would be characteristic of reaches subject to moderate or strong

Special Instructions for New Input or Updates

Rate the month when high flow variability (between years) will be greatest. Rate only one month. Other months will be inferred from an appropriate flow pattern for the watershed of interest.

Effect on Leve1 3 Biological Metrics

This attribute affects the Level 3 attributes Flow, which, in turn, affects productivity of certain life stages of salmonids.

References/Sources

Importance and Role: Stanford and Ward (1992).

Factors Affecting: Federal Interagency Stream Restoration Working Group (1998), Gordon et al. (1993), Schueler (1995).

Flow - Changes in Inter-annual Variability in Low Flows

Definition/Usage

A measure of between-year variation in the severity of low flow discharge during a month. Variation in low flows as applied here is relative to an undisturbed watershed of comparable size, geology, and geography (or as would have existed in the pristine state).

Importance and Role

Hydrologic patterns of ecologically healthy watersheds in the coastal ecoregion are strongly related to the timing and quantity of flow, characteristics of seasonal water storage, and dynamics of surface-subsurface exchanges.

Changes in the timing and quantity of flow due to land uses and flow regulation can affect responses of stream dwelling organisms like salmonids, leading to changes in overall performance of their populations.

This attribute defines how low flow (e.g., during late summer) has changed relative to the undisturbed state. Changes are considered in both overall level of flow and between-year variation. Increased variation in low flow or overall reduced low flow can result in survival reduction due to increased exposure or migration difficulties.

Categorical conclusions

Index 0	Index 1	Index 2	Index 3	Index 4
Pronounced increases in low flow levels and between year stability in low flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest). This index level indicates a marked increase in both low flow and stability compared to pristine conditions.	Some evidence of increased low flow levels and between year stability in low flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest). This index level some evidence exists of an increase in both low flow and stability compared to pristine conditions.	Typical low flows and between-year variation in low flows relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest).	Some evidence of reduced low flows and/or between year variation in low flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest).	Pronounced reductions in low flows and/or between year variation in low flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest).

Factors Affecting Attribute/Guidelines

The attribute, Flow—Changes in Inter-annual Variability in Low Flows, operates in concert with the attribute Hydrologic Flow Regime—Natural. It defines the amount of change that has occurred in between-year variation in low flow or the extent of overall change in low flow.

Changes in vegetation cover and land use as a result of watershed development can alter the hydrograph shape, increasing inter-annual low flow variation or decreasing the extreme low flow discharge. Changes in vegetation cover, reduction in the amounts of wetlands, and roads can alter the retention time and pattern of runoff in a watershed, resulting reduced low flows. Interannual variation in low flows may also be increased. Urbanization can result in dramatic reductions in low flows compared to the predevelopment condition. Impervious cover prevents infiltration into the soil, reducing ground water recharge. Consequently, during extended periods without rainfall, baseflow levels are often severely reduced (Simmons and Reynolds 1982).

The index values for this attribute have been scaled to the pristine state, described by Index Value 2. Shifts toward more interannual variability or lower low flow discharge are represented by Index Value 3 and 4, less variability or increased low flows by values 0 and 1.

Rate as 2 the pristine state for all stream reaches. This index value states that inter-annual variation is equal to what would have occurred in the watershed's natural state.

Rate as 3 or 4 the reaches affected by land uses that increase between-year variation in low flow or reduce low flows. Rate as 0 or 1 the reaches subject to flow regulation that act to stabilize low flow or increase them. The latter conditions can lead to increased survival of salmonids in some life stages, at least in the short-term. Over the long-term, habitat-forming disturbance events may be reduced in frequency, leading to degradation of some environmental attributes.

Special Instructions for New Input or Updates

Rate the month when low flow variability (between years) will be greatest. Rate only one month. Other months will be inferred from an appropriate flow pattern for the watershed of interest.

Effect on Leve1 3 Biological Metrics

This attribute affects the Level 3 attributes Flow and Predation[3], which, in turn, affect productivity of certain life stages of salmonids.

References/Sources

Importance and Role: Stanford and Ward (1992)

Factors Affecting: Federal Interagency Stream Restoration Working Group (1998), Gordon et al. (1993), Simmons and Reynolds (1982)

Flow - Intra Daily (diel) Variation

Definition/Usage

Variability in flow level during a daily period. This attribute is informative mainly for regulated rivers or when flow patterns are influenced by storm water runoff.

Importance and Role

Sudden changes in flow associated with flow regulation or storm runoff can result in displacement of rearing juveniles or, in the case of loss of flow, in stranding. Such rapid flow changes can also affect other environmental attributes, like streambank erosion and riparian habitat.

Categorical conclusions

Index 0	Index 1	Index 2	Index 3	Index 4
Essentially no variation in discharge during a 24-hr period. During a month, this condition would characterize most flow patterns not associated with flow ramping by a hydro project or storm-water runoff.	Little variation, on average, in discharge during a 24-hr period--typical of natural runoff pattern during relatively small rainfall storm events.	Moderate variation, on average, in discharge during a 24-hr period--typical of low ramping rate associated with hydro facilities or natural change in discharge associated with an average to above average rainfed freshet.	Some evidence of increased variation in discharge during a 24-hr period compared to natural runoff pattern. This pattern typical of moderate ramping condition associated with flow regulation.	Extreme variation on average over a 24-hr period during month. This pattern typical of severe ramping condition associated with flow regulation or highly urbanized areas.

Factors Affecting Attribute/Guidelines

Most, if not all, pristine basins should be assigned a rating of 0. This rating indicates that the average daily fluctuation in flow over a month is slight. (Note: under pristine conditions, some streams could experience much more variation over a single day, but the average value over a month would be minimal.)

The rating should be applied in consideration of the average expected variation over a month.

Special Instructions for New Input or Updates

Rate the month when diel variation will be greatest. Rate only one month. Other months will be inferred from an appropriate flow pattern for the watershed of interest. In this case, the month will likely occur during power peaking. Any unusual pattern should be noted in the comments.

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[3] The effect of Low Flow on predation is likely incorrect and will probably be adjusted.

Effect on Leve1 3 Biological Metrics

This attribute affects the Level 3 attribute Flow, which , in turn, affects survival of free swimming fish (including emergent fry) or the survival of eggs due to stranding.

References/Sources

Importance and Role: Federal Interagency Stream Restoration Working Group (1998), Gordon et al. (1993)

Factors Affecting: Federal Interagency Stream Restoration Working Group (1998), Gordon et al. (1993)

Flow - Intra-Annual Flow Pattern

Definition/Usage

The average extent of intra-annual flow variation during a month—a measure of a stream's *flashiness* during a season.

Importance and Role

Frequent, significant changes in flow over a relatively short time-period like a month associated with flow regulation or storm runoff can result in displacement of rearing juveniles during high flows, or, in the case of loss of flow, in stranding.

Categorical conclusions

Index 0	Index 1	Index 2	Index 3	Index 4
Pronounced decreases in variation in daily flow during a month (intra-annual) relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest).	Some evidence of decreased variation in daily flow during a month (intra-annual) relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest).	Typical variation in flow variation during a month (intra-annual) in an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest).	Some evidence of increased variation in daily flow during a month (intra-annual) relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest).	Pronounced increases in variation in daily flow during a month (intra-annual) relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine s tate for the watershed of interest).

Factors Affecting Attribute/Guidelines

This attribute is similar to the one that describes diel variation in flow, only in acts on a slightly longer time scale. The extreme on the high end in this attribute would be seen in heavily urbanized watersheds. Less extreme conditions would be found in watersheds with a high amount of vegetation cover removed (e.g., high degree of clearcutting) or high road densities. In heavily urbanized streams, the annual volume of storm water runoff can increase by 2 to 16 times the predevelopment rate; essentially every rainfall event can produce a sharp spike in the hydrograph, resulting in a high degree of flashiness (Schueler 1995).

Rate as 2 the pristine state for all stream reaches. This index value states that within-year variation is equal to what would have occurred in the watershed's natural state.

Rate as 3 or 4 the reaches affected by land uses that increase within-year variation daily flow. Rate as 0 or 1 the reaches that are subject to flow regulation that acts to reduce within-year variation.

Special Instructions for New Input or Updates

Rate the month when intra-annual flow variation is greatest. It is assumed that this variation will be greatest during high runoff months. Rate only one month. Other months will be inferred from an appropriate flow pattern for the watershed of interest.

Effect on Leve1 3 Biological Metrics

This attribute affects the Level 3 attribute Flow and, in turn, principally affects survival of fingerlings during overwintering. It can affect other free-swimming stages also. In addition, it can affect survival from egg to emergence due to redd stranding.

References/Sources:

Importance and Role: Gordon et al. (1993).

Factors Affecting: Federal Interagency Stream Restoration Working Group (1998), Gordon et al. (1993), Schueler (1995)

Predation Risk

Definition/Usage

Level of predation risk on fish species due to presence of top-level carnivores or unusual concentrations of other fish-eating species. This is a classification of per-capita predation risk—in terms of the likelihood, magnitude, and frequency of exposure to potential predators (assuming other habitat factors are constant).

Importance and Role

Human activities can affect concentrations of fish-eating predators relative to conditions that existed prior to Euro-American settlement. In some cases, predator risk has been reduced as some fish-eating species have declined sharply due to human activity. Other activities, such as construction of dams, have concentrated some fish-eating species, like northern pikeminnow, at critical fish passage sites in the Columbia River. These changes in relative concentrations (or effectiveness) may have altered predation risk on salmon species compared to historic levels in some areas.

Categorical Conclusions

Index 0	Index 1	Index 2	Index 3	Index 4
Many or most native predators are depressed or rare, none are greatly increased over natural levels, and there may be some numerical survival advantage to fish as a result compared to historical predator abundance.	Intermediate	Diversity and per-capita abundance of predators exists so that predation risk is at near-natural level and distribution.	Intermediate	Excessive population density or concentrated population of predator species exists due to artifacts of human alteration of the environment (e.g., top-down food web effects, habitat manipulations).

Factors Affecting Attribute/Guidelines

This factor is meant to cover a fairly broad range of types of predation risk, though it largely addresses the *relative concentration or dispersal* of fish-eating predators compared to the pristine state associated with dispersed predators. Situations that are meant to be covered by this attribute are concentrations of birds or pisivores below dams or near juvenile migrant bypasses, and artificially enhanced, concentrations of fish eating species associated with the creation of new habitat (as on Rice Island in the Columbia River), or large concentrations of hatchery smolts at or near release sites. The natural concentrations of pisivores that occurs at the outlet of sockeye producing streams under pristine conditions would also be addressed here.

A rating of 2 is assumed to be the historic condition. In areas where human activity acts to concentrate fish-eating predators, or to increase their effectiveness at prey capture, ratings will increase to 3 or 4. A value of 4 would represent highly unusual conditions likely to result in a dramatic per capita predation risk on salmon species, as might occur below fish bypass facilities associated with some dams.

In areas where human activity has dispersed fish-eating species abundance or reduced their overall population abundance (e.g., where bull trout or Dolly Varden are listed through the ESA), ratings will be reduced to values <2.

It is recognized that the per capita risk of some fish-eating species may be increased over historic levels, while risk associated with other species may be reduced. The assigned ratings should represent an average condition across all species.

Special Instructions for New Input or Updates

A rating of 2 is assumed to be the historic condition. Rationale to be given for assigned ratings should note the fish-eating species that are assumed in the ratings. Consideration should be given to species that prey either on small or large fish (i.e., juvenile or adult salmon).

Rate the month when per capita predation risk is believed to be highest.

Effect on Leve1 3 Biological Metrics

This attribute affects the Level 3 attribute, Predation, and, in turn, affects resultant species productivity.

References/Sources

Importance and Role: Beamesderfer et al. (1996) and Roby et al. (1998)

Factors Affecting: Beamesderfer et al. (1996) and Roby et al. (1998)

Riparian Function

Definition/Usage

A measure of riparian function that has been altered within the reach.

Importance and Role

The riparian zone is characterized by its vegetation—trees, brush, grass, and sedges. This zone and the stream channel are interdependent. The zone comprises those areas near the stream channel that affect the channel and are affected by it. Riparian areas constitute the interface between aquatic and terrestrial ecosystems.

Many of the functional and structural attributes of stream habitat are created and maintained through interaction with the riparian vegetation. Healthy riparian areas dissipate flood energy, moderate drought, store surface waters, recharge groundwater supplies, moderate water temperatures by providing shade, regulate energy inputs, and reduce erosion. These areas also provide large-sized wood structure, which is critical in creating structural diversity and habitat complexity in streams.[4]

Categorical Conclusions:

Index 0	Index 1	Index 2	Index 3	Index 4
Strong linkages with no anthropogenic influences.	>75-90% of functional attributes present (overbank flows, vegetated streambanks, groundwater interactions typically present).	50-75% functional attribute rating-significant loss of riparian functioning-minor channel incision, diminished riparian vegetation structure and inputs etc.	25-50% similarity to natural conditions in functional attributes- many linkages between the stream and its floodplain are severed.	< 25% functional attribute rating: complete severing of floodplain-stream linkages

** Where an index value is associated with a range, the integer value is assumed for modeling to be the midpoint. Index values can be identified as non-integers to represent the lower or upper ends of a range.*

Factors Affecting Attribute/Guidelines

Valley form and channel confinement, including the extent that the channel has been artificially modified, strongly affect the extent and maintenance of the riparian zone. Unconfined channels tend to flood relatively frequently, promoting riparian development. Tightly confined channels, particularly within canyons, have much less opportunity for such development and support much smaller riparian zones.

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[4] Historically large wood was not available in all streams east of the Cascade crest, particularly in the high desert. In those streams, other types of vegetation served some of the same purposes as those afforded by large wood, see text under "Factors Affecting Attribute/Guidelines."

Riparian wetlands are an important component of riparian zones. A wetland is a system that depends on recurrent or constant inundation or saturation at or near the surface of the substrate. Besides providing habitat for fish and wildlife, wetlands provide water storage, sediment trapping, flood damage reduction, water quality improvement/pollution control, and ground water recharge.

Drawing from the Bureau of Land Managment's (BLM) use of the concept, Proper Functioning Condition (PFC), the riparian-wetland area is considered to be proper functioning when adequate vegetation, landform, or large woody debris is present to:

- dissipate stream energy associated with high waterflow, thereby reducing erosion and improving water quality;
- filter sediment, capture bedload, and aid floodplain development;
- improve flood-water retention and ground-water recharge;
- develop root masses that stabilize streambanks against cutting action;
- develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses;
- support greater biodiversity.

The reason the definition of proper function here includes "adequate vegetation, landform, *or* large woody debris" is that not all riparian-wetland areas are created equally. For example, in many areas west of the Cascade crest, large wood must be present to dissipate energy, capture bedload, and aid floodplain development. However, many streams in the high desert do not have the potential or require large wood to dissipate stream energy associated with high streamflows. These streams can dissipate energy through the presence of vegetation such as willows, sedges, and rushes (Prichard 1998).

The BLM's definition of function emphasizes the aspect of stream stability. Other elements of function are also worth noting, however, including: shading and inputs and regulation of energy sources (e.g., litter input) (Spence et al. 1996).

The assignment of ratings to this attribute is subjective, to be based on a *judgment* of the extent that the elements defined above have been diminished by land use. Conclusions are to be based on personal knowledge of the reaches or inferences based on land use. Riparian function within urban areas and agricultural valleys will typically be extremely modified. Grazing practices are also known to severely impair riparian function. Forestry operations, especially using current standards, can result in impaired function, though usually not to the level seen with the other land uses.

Special Instructions for New Input or Updates

All months are rated the same for Riparian Function.

Effect on Leve1 3 Biological Metrics

Riparian Function can affect the Level 3 attributes channel stability, habitat diversity, flow, and harassment, which in turn affects species productivity at certain life stages. Riparian function also affects other environmental conditions like temperature or habitat types. In these cases, however, the linkage is already accounted for in assessing the condition of the Level 3 attribute (here, temperature and key habitat).

References/Sources

Importance and Role: Cederholm et al. (2000), Federal Interagency Stream Restoration Working Group (1998), Leopold (1997), and Spence et al. (1996)

Factors Affecting: Federal Interagency Stream Restoration Working Group (1998), Prichard (1998), and Spence et al. (1996)

Salmon Carcasses

Definition/Usage

Relative abundance of anadromous salmonid carcasses within watershed (e.g., HUC 5 level) that can serve as nutrient sources for many wildlife and fish species.

Importance and Role

Salmon act as an ecological process vector, important in the transport of energy and nutrients between the ocean, estuaries, and freshwater environments. Salmon serve to cycle nutrients between these environments, most notably from the ocean to freshwater, where the carcasses can be the source of large amounts of nutrients to the riparian-stream system. The carcasses provide food to numerous wildlife species, macroinvertebrates, and fish species, including juvenile salmonids.

Categorical Conclusions

Index 0	Index 1	Index 2	Index 3	Index 4
Super abundant -- an average number of carcasses per total miles of main channel habitat >800.	Very abundant -- an average number of carcasses per total miles of main channel habitat >400 and < 800.	Moderately abundant -- an average number of carcasses per total miles of main channel habitat >200 and < 400.	Not abundant -- an average number of carcasses per total miles of main channel habitat >25 and <200.	Very few or none -- an average number of carcasses per total miles of main channel habitat <25.

** Where an index value is associated with a range, the integer value is assumed for modeling to be the midpoint. Index values can be identified as non-integers to represent the lower or upper ends of a range.*

Factors Affecting Attribute/Guidelines

The attribute, Salmon Carcasses, is intended to describe the relative number of salmon carcasses available for nutrient input. It is meant only to be a very rough approximation of an average annual number of carcasses that becomes available to the system. All species of salmon that spawn naturally (including those of hatchery origin) in the system should be considered. The density of carcasses is to represent potential availability only to the sytem.[5]

Special Instructions for New Input or Updates

All months are to be rated the same for Salmon Carcasses.

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[5] The effectiveness that carcasses can be utilized as food is likely related to channel structure (e.g., as provided by wood), flow patterns, and riparian condition. These may need to be incorporated in the biological rules that translate the Salmon Carcass attribute into the Level 3 attribute Food.

Effect on Leve1 3 Biological Metrics

The attribute, Salmon Carcasses, affectd the Level 3 attributes Food and Competition.

References/Sources

Importance and Role: Cederholm et al. (2000)

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APPENDIX B-2

Rules for Translating
Level 2 Environmental Attribute Values
To
Level 3 Biometrics for Chinook Salmon

DRAFT

LARRY'S August 4 DRAFT

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Introduction

This document is an appendix to the report entitled "Columbia River Multi-Species Framework Project Coarse Screening Analysis—Progress Report" Although it can be treated as a stand-alone document for the sake of reviewing the rules presented here, the reader will better understand its conceptual basis and application if it is used as a supplement to the main report.

This document presents the rules used to translate Level 2 Environmental Attribute values into Level 3 Biological Performance Attribute values (biometrics) for chinook salmon. We applied these rules in the EDT analysis of Columbia River chinook presented in the main report. We are currently developing comparable rule sets for bull trout, steelhead trout, coho salmon, and chum salmon. A similar process has been applied for analyzing performance measures for selected species of wildlife in the Columbia Basin.

The rules have been developed for use within the Multi-Species Framework, which provides a structure for relating the performance of different species to the environmental (or ecological) conditions in which they live. Data and information used in the Framework are organized through the Ecological Information Structure (Figure 1). The purpose of the Information Structure is to identify and organize hypotheses—or assumptions—about the environment, key ecological functions, and biological performance for the species being analyzed. It serves to document the rationale for how well management actions are expected to move the ecosystem closer to achieving the vision (goals) for the basin. EDT is an analytical method that emphasizes the need for having explicit operating hypotheses on which to base management decisions.

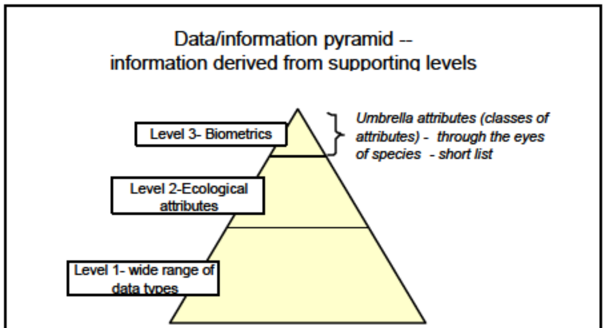

Figure 2.

The Information Structure and associated data categories are defined at three levels of organization (Figures 1). Levels 1 and 2 together characterize the environment, or ecosystem, as it can be described by data of different types. It is assumed that this characterization provides all of the necessary information about the environment needed to analyze biological performance as a consequence of the effects of environment. The Level 3 category is also a characterization of the environment, but "through the eyes of the species" being analyzed. This category describes biological performance in relation to the state of the ecosystem described by the Level 2 Environmental Attributes. Together, the three levels of data/information can be thought of as a data pyramid, with Levels 2 and 3 built upon their next lower level (Figure 2).

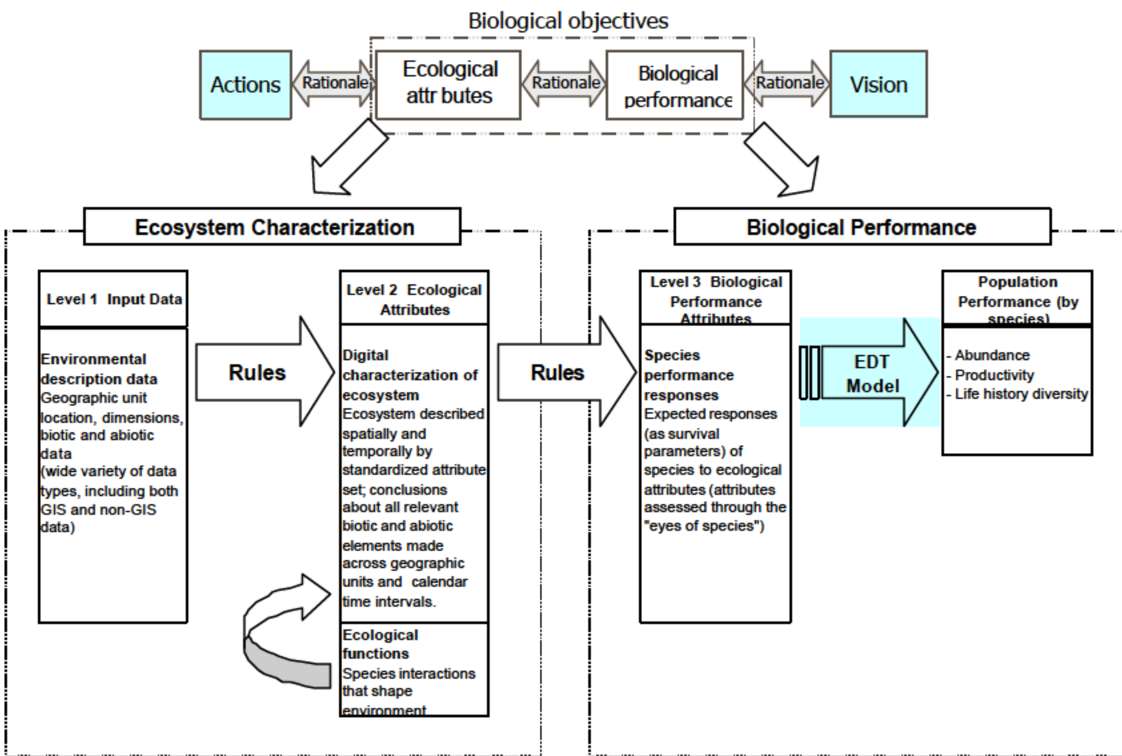

Figure 1. Ecological Information Structure.

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The Information Structure provides a way of summarizing and synthesizing a wide range of environmental input data (referred to as Level 1 input data) into a standardized set of environmental attributes (Table 1). These attributes, called Level 2 Environmental Attributes, represent a sort of digital characterization of the ecosystem. They describe the condition of the environment (both abiotic and biotic elements) encountered by various species. In concept, a set of Level 2 Environmental attributes can be described for analyzing any species.

The rules presented in this document are used to translate this characterization of the ecosystem expressed in the Level 2 attributes into survival-related performance measures for a single species, chinook salmon. They describe our assumptions about how environmental conditions affect these performance measures, or biometrics, for chinook salmon. These biometrics are also defined through a set of attributes, called Biological Performance Attributes (Table 3), which act as sort of "umbrella attributes" that group similar Level 2 environmental attributes together. In this case, however, the Biological Performance Attributes are assessed "through the eyes of the species" and define species sensitivity to one or more Level 2 Environmental Attributes. Level 3 biometrics are life-stage specific for the species of interest; chinook salmon life stages are defined in Table 3.

At this time, we have only developed rules for relating environmental conditions to chinook performance within freshwater. Consequently, Level 2 Environmental Attributes have only been defined to date for freshwater environments only, not for estuarine or marine environments. Interest exists among different entities to undertake a similar process for developing attributes and rules for estuarine and marine environments but to date no effort to do so has been initiated.

The rules presented here should be considered provisional—they are currently under review and refinements are expected. Moreover, we believe the rules should periodically be reviewed and refined through an on-going process as new information or understanding becomes available. We suggest that some type of formal process be established for this purpose. We think the rules should be a primary focus of attention by scientists with different expertise, providing the region with a common "state-of-understanding" about the effects of different attributes on species survival by life stage. Uncertainty about the rules will always exist to some extent, but when described it can help identify research needs, particularly for those attributes found to be most critical to species performance in the region.

The main body of this document is organized into two parts following the Introduction. Part I, "Rule Derivation, Structure and Presentation Format", describes how the rules were derived and structured, along with an explanation of the format for presentation. Part II provides the rules.

Four appendices are included to this document. Appendix 1 gives a description of the Level 2 Environmental Attributes. Each of the 45 attributes is defined and described with regard to its ecological role, some of the factors affecting its condition, and its general importance to salmonid fishes of the Pacific Northwest. This material will be helpful to individuals reviewing the Level 2 attribute values and for gaining an understanding of the role of these attributes within the rules. Also, the material will be useful in the process of updating Level 2 information through the **Assessment Review** that the Northwest Power Planning Council is initiating in mid 2000.

Appendices 2-4 consist of tables referenced in the section "Rule Derivation, Structure and Presentation Format."

Table 1. Level 2 Environmental Attributes. All attributes except length can be treated as categorical.

Name	Definition
Alkalinity	Alkalinity of water (conductivity can be used as a surrogate) (at moderate flows)
Bed scour	Average depth and frequency of scour on small-cobble/gravel riffles during high flow events. Frequent indicates at least one event every 1-2 years. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et a. (1991): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 7 inch diameter), large cobble (7 to 11.9 inch diameter), boulder (>11.9 inch diameter).
Benthos diversity and production	Measure of the diversity and production of the benthos community.
Channel length	Length of the primary channel contained with the stream reach -- Note: this attribute will not be given by a categories but rather will be a point estimate. Length of channel is given for the main channel only--multiple channels do not add length.
Channel width - month maximum width (ft)	Average width of the wetted channel during peak flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.
Channel width - month minimum width (ft	Average width of the wetted channel. If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.
Confinement - Hydromodifications	The extent that man-made structures within or adjacent to the stream channel constrict flow (as at bridges) or restrict flow access to the stream's floodplain (due to streamside roads, revetments, diking or levees) or the extent that the channel has been ditched or channelized.
Confinement - natural	The extent that the valley floodplain of the reach is confined by natural features. It is determined as the ratio between the width of the valley floodplain and the bankful channel width. Note: this attribute addresses the natural (pristine) state of valley confinement only.
Dissolved oxygen	Average dissolved oxygen within the water column for the specified time interval.
Embeddedness	The extent that larger cobbles or gravel are surrounded by or covered by fine sediment.
Fine sediment	Percentage of fine sediment within pool-tailouts and riffles.
Fish community richness	Measure of the richness of the fish community (no. of fish taxa).

Name	Definition
Fish pathogens	The presence of pathogenic organisms (relative abundance and species present) having potential for affecting survival of stream fishes.
Fish species introductions	Extent of introductions of exotic fish species in the vicinity of the stream reaches under consideration.
Flow - change in interannual variability in high flows	A measure of between year variation in magnitude of high flow levels and/or the extent of change in overall high flow level during a month relative to an undisturbed watershed of comparable size, geology, and geography (or as would have existed in the pristine state).
Flow - changes in interannual variability in low flows	A measure of between year variation in the severity of low flow discharge during a month. Variation in low flows as applied here is relative to an undisturbed watershed of comparable size, geology, and geography (or as would have existed in the pristine state).
Flow - Intra daily (diel) variation	Varibility in flow level during a daily period. This attribute is informative mainly for regulated rivers or when flow patterns are influenced by storm water runoff.
Flow - intra-annual flow pattern	The average extent of intra-annual flow variation during a month -- a measure of a stream's "flashiness" during a season.
Gradient	Average gradient of the main channel of the reach over its entire length.
Habitat type - backwater pools	Percentage of the wetted channel surface area comprising backwater pools.
Habitat type - beaver ponds	Percentage of the wetted channel surface area comprising beaver ponds. Note: these are pools located in the main or side channels, not part of off-channel habitat.
Habitat type - large cobble/boulder riffles	Percentage of the wetted channel surface area comprising large cobble/boulder riffles.
Habitat type - off-channel habitat factor	A multiplier used to estimate the amount of off-channel habitat based on the wetted surface area of the all combined in-channel habitat.
Habitat type - pool tailouts/glides	Percentage of the wetted channel surface area comprising pool tailouts and glides.
Habitat type - primary pools	Percentage of the wetted channel surface area comprising pools, excluding beaver ponds.
Habitat type - small cobble/gravel riffles	Percentage of the wetted channel surface area comprising small cobble/gravel riffles.
Harassment	The relative extent of poaching and/or harassment of fish within the stream reach.
Hatchery fish outplants	The magnitude of hatchery fish outplants made into the drainage over the past 10 years.
Hydrologic regime - natural	The natural flow regime within the reach of interest. Flow regime typically refers to the seasonal pattern of flow over a year; here it is inferred by identification of flow sources. This applies to an unregulated river or to the pre-regulation state of a regulated river.
Hydrologic regime - regulated	The change in the natural hydrograph caused by the operation of hydroelectric facilities in a watershed. Definition does not take into

Name	Definition
	account daily flow fluctuations (See Flow-Intra-daily Variation attribute)
Icing	Extent (magnitufe and frequency) of icing events.
Metals - in water column	The extent of dissolved heavy metals within the water column.
Metals/Pollutants - in sediments/soils	The extent of heavy metals and miscellaneous toxic pollutants within the stream sediments and/or soils adjacent to the stream channel
Miscellaneous toxic pollutants - water column	The extent of miscellaneous toxic pollantants (other than heavy metals) within the water column.
Nutrient enrichment	The amount of nutrient enrichment consisting of such items as ammonia, nitrogen, phosphorous.
Obstructions to fish migration	Obstructions to fish passage by physical barriers (not dewatered channels or hinderances to migration caused by pollutants or lack of oxygen).
Predation risk	Level of predation risk on fish species due to presence of top level carnivores or unusual concentrations of other fish eating species. This is a classification of per-capita predation risk, in terms of the likelihood, magnitude and frequency of exposure to potential predators (assuming other habitat factors are constant).
Riparian function	A measure of riparian function that has been altered within the reach.
Salmon Carcasses	Relative abundance of andromous salmonid carcasses within watershed (e.g., HUC 5 level) that can serve as nutrient sources for juvenile salmonid production.
Temperature - daily maximum (by month)	Maximum water temperatures within the stream reach reach during a month.
Temperature - daily minimum (by month)	Minimum water temperatures within the stream reach reach during a month.
Temperature - spatial variation	The extent of water temperature variation within the reach as influenced by inputs of groundwater.
Turbidity	The relative extent of turbidity episodes within the stream reach.
Water withdrawals	The number and relative size of water withdrawals in the stream reach.
Wood	The amount of wood within the reach. Note definition of "large wood" under terms/clarification.

Table 2. Level 3 Biological Performance Attributes (biometrics). The measure of these attributes is in relation to the relative survival or performance of the focus species by life stage. These attributes act as "umbrella attributes", combining the effects of similar Level 2 attributes on the species. Effects measured by these attributes are assessed relative to fully fit individuals when present in optimal environmental conditions.

Attribute	Definition
Channel stability	The effect of stream channel stability (within reach) on the relative survival or performance of the focus species; the extent of channel stability is with respect to its streambed, banks, and its channel shape and location.
Chemicals	The effect of toxic substances or toxic conditions on the relative survival or performance of the focus species. Substances include chemicals and heavy metals. Toxic conditions include low pH.
Competition (with hatchery fish)	The effect of competition with hatchery produced animals on the relative survival or performance of the focus species; competition might be for food or space within the stream reach.
Competition (with other species)	The effect of competition with other species on the relative survival or performance of the focus species; competition might be for food or space.
Flow	The effect of the amount of stream flow, or the the pattern and extent of flow fluctuations, within the stream reach on the relative survival or performance of the focus species. Effects of flow reductions or dewatering due to water withdrawals are to be included as part of this attribute.
Food	The effect of the amount, diversity, and availability of food that can support the focus species on the its relative survival or performance.
Habitat diversity	The effect of the extent of habitat complexity within a stream reach on the relative survival or performance of the focus species.
Harassment	The effect of harassment, poaching, or non-directed harvest (i.e., as can occur through hook and release) on the relative survival or performance of the focus species.
Key habitat	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.
Obstructions	The effect of physical structures impeding movement of the focus species on its relative survival or performance within a stream reach; structures include dams and waterfalls.
Oxygen	The effect of the concentration of dissolved oxygen within the stream reach on the relative survival or performance of the focus species.
Pathogens	The effect of pathogens within the stream reach on the relative survival or performance of the focus species. The life stage when infection occurs is when this effect is accounted for.
Predation	The effect of the relative abundance of predators species on the relative survival or performance of the focus species, apart from

Attribute	Definition
	the influence of the amount of cover habitat used by the focus species.
Salinity	The effect of the concentration of salts within the reach on the relative survival or performance of the focus species.
Sediment load	The effect of the amount of the amount of fine sediment present in, or passing through, the stream reach on the relative survival or performance of the focus species.
Temperature	The effect of water temperature with the the stream reach on the relative survival or performance of the focus species.
Withdrawals (or entrainment)	The effect of entrainment (or injury by screens) at water withdrawal structures within the stream reach on the relative survival or performance of the focus species. This effect does not include dewatering due to water withdrawals, which is covered by the flow attribute.

Table 3. Chinook salmon life stages for analyzing the biological performance of the species. Only life stages relevant to freshwater are shown.

Attribute	Definition
Spawning	Period of active spawning, beginning when fsh move on to spawning beds and initiate redd digging and ending when gametes are released.
Egg incubation	Egg incubation and alevin development; stage begins at the moment of the release of gametes by spawners and ends at fry emergence.
Fry colonization	Fry emergence and initial dispersal; time period is typically very short, beginning at fry emergence and ending when fry begin active feeding associated with a key habitat.
0-age resident rearing	Rearing by age 0 fish that is largely associated with a small "home range"; these fish are generally territorial (note: this behavior typifies the pattern of feeding/rearing by spring chinook in headwater stream reaches).
0-age transient rearing	Rearing by age 0 fish accompanied by directional movement (I.e., these fish do not have home ranges); these fish are non-territorial, though agonistic behavior may still be exhibited (note: this pattern typifies a 0-age fall chinook rearing pattern).
0-age migrant	Directional migration by age 0 fish that tends to be rapid and not strongly associated with feeding/rearing (note: fish displaying strong smolt characteristics typify this life stage).
Inactive	Largely inactive or semi-dormant fish age 0 fish; this behavior is associated with overwintering, when feeding is reduced; fish exhibiting this behavior need to be largely sustained by lipid reserves.
1-age resident rearing	Feeding/rearing by age 1 fish that is associated with a home range; these fish are often territorial.
1-age migrant	Directional migration by age 1 fish that tends to be rapid and not strongly associated with feeding/rearing (note: fish displaying strong smolt characteristics typify this life stage).
Migrant prespawner	Adult fish approaching sexual maturity that are migrating to their natal stream; in the ocean this stage occurs in the final year of marine life, in freshwater feeding has generally ceased.
Holding prespawner	Adult fish approaching sexual maturity that are largely stationary and holding, while en route to their spawning grounds; distance to the spawning grounds from holding sites may be short or long.

Part I - Rule Derivation, Structure and Presentation Format

The purpose of the rules presented here is to translate Level 2 Environmental Attribute values into survival-related performance measures for chinook salmon. The rules are assumptions about how environmental conditions affect these performance measures.

The rules are based on an extensive set of "translation examples" put together by Chris Frissell, with further input obtained from the BioRules Work Group.[1] We reformatted the information from these data sets into the rule sets applied here for chinook salmon, taking into account refinements made through the process in definitions and index values of the Level 2 Environmental Attributes. The rules should be considered as still in a state of development and refinement; further review of the rules will help ensure their adequacy and consistency with up-to-date thinking and research.

The survival-related performance measures, or biometrics, derived by the rules are defined through the Level 3 Biological Performance Attributes. These attributes act as sort of "umbrella attributes" that group similar Level 2 Environmental Attributes together, serving to explicitly define the sensitivity of the species to one or more of the Level 2 attributes through each Level 3 attribute. Whereas 45 Level 2 Environmental Attributes are used to characterize the environment (Table 1), 17 Level 3 Performance Attributes are used in defining biological response to the environment (Table 2).

The Level 3 biometrics are life-stage specific. Therefore, we formulated a rule set for each Level 3 Performance Attribute, one rule for each life stage. With eleven life stages applicable to chinook salmon in freshwater (Table 3), a total of 176 rules are presented (note: rules were not formulated for the Level 3 attribute Salinity, as they were not needed for the current analysis of the freshwater environment[2]). Rules are presented in alphabetical order for Level 3 attributes following this narrative.

The rules fall into two classes, each requiring a different format for presentation. The first class consists of those that address environmental ***quality*** attributes. These attributes directly affect the *productivity* of a population. The second class consists of rules that determine the Level 3 attribute Key Habitat, a measure of habitat ***quantity*** used by the species of interest. This attribute operates in concert with environmental quality attributes to affect the *capacity* of the environment for the species. We describe rule structure and presentation format for each rule class in the following two sections.

Rules for Environmental Quality Attributes

The rules for deriving Level 3 biometrics for attributes associated with environmental quality produce estimates of *relative survival* for a life stage. Life stage relative survival is the proportion of the survival that we assume would occur when environmental quality conditions are optimal for survival over an entire life stage. Thus a relative survival value of 1.0 would be

[1] The BioRules Work Group consisted of Bob Bilby, Pete Bisson, Chris Frissell, Larry Lestelle, and Dale McCullough
[2] As noted in the Introduction, rules presented here address the freshwater environment only

expected to produce the highest (on average) survival that could occur during the life stage having a sterotypical duration for that life stage. In this case, the actual survival for the life stage would be equivalent to what we call the *benchmark survival*.[3] The estimated survival for a life stage, therefore, is simply the product of relative survival and benchmark survival.

The rules are structured in a way to identify the contributions of various Level 2 Environmental Attributes to reducing relative survival from a value of 1.0. More simply, the rules define the *assumed* extent that various Level 2 attributes prevent environmental conditions from being considered optimal for survival.

Each Level 2 Environmental Attribute is indexed to a set of values from 0 to 4, where the range of index values span a spectrum of environmental conditions (see example below for intra-gravel fine sediment). Conditions associated with index values for Level 2 Environmental Attributes are described in Appendix 2. The indexing system allows for both continuous or integer values for the attributes. Integer values were assumed to represent the midpoint of conditions for attributes having a range of conditions associated with one value, as in the sediment example shown.[4]

Example rating definitions for Fine Sediment (intra-gravel fine sediment within pool-tailouts and riffles)

Value	*Value definition*
0	<6% fines <0.85 mm article size
1	>6% and <11% fines 0.85 mm particle size
2	>11% and <18% fines <0.85 mm particle size
3	>11% and <30% fines <0.85 mm particle size
4	>30% fines <0.85 mm particle size

Generally, there is a consistent direction to attribute values, where 0 or low values are often associated with pristine conditions, and higher values tend to occur under managed conditions. This pattern varies for a few attributes, especially those describing stream flow conditions. In this case, a rule often employed a "reset" of the index values in order to create a direction to the values, where low values would tend to represent conditions prior to watershed development.

The rules were formulated by first identifying the specific Level 2 Environmental Attributes that could strongly, moderately, or weakly cause the Level 3 biometric (relative survival) to be reduced below the optimal environmental condition for survival. These Level 2 attributes are referred to as the Primary, Secondary, and Tertiary environmental attributes affecting biological performance, respectively. In all cases, we defined only one Primary Level 2 Environmental Attribute as affecting a single Level 3 Performance Attribute. The Secondary and Tertiary Level 2 attributes were treated as modifiers to the effect of the Primary attribute. More than one

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[3] Benchmark survivals are discussed in more detail in ___________

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

Secondary and Tertiary Level 2 attributes were applied as assumed relevant. The associations between Level 2 and Level 3 attrributes are identified for each life stage in Appendix 3.

We then defined explicit relationships between each Level 2 Environmental Attribute and the Level 3 Performance Attribute for each attribute association listed in Appendix Table 2, as illustrated in Figure 3. As noted earlier, the relationships are based on "translation examples" put together by Chris Frissell, with additional input obtained from the BioRules Work Group, and finally, they were reformatted into their current form consistent with refinements in attribute definitions.

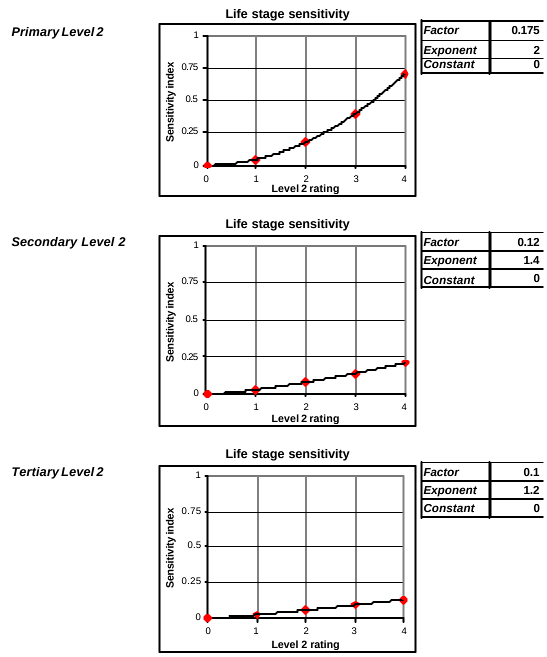


Figure 3. Examples of relationships between Level 2 Environmental Attribute ratings (Primary, Secondary, and Tertiary) and sensitivity indexes for one Level 3 Performance Attribute.

Each relationship used to define sensitivity (*SensitivityIndex*) of a Level 3 attribute to a single Level 2 Environmental Attribute *i* was given the form

$$SensitivityIndex_i = F * \left(\frac{Level2}{4}\right)^E + C$$

where *F* is a factor, *E* is an exponent, *C* is a constant, and *Level2* is the Level 2 Environmental Attribute Index value.

Most relationships were assumed to be strongly curvilinear for Primary Level 2 attributes and some Secondary attributes, having extremely little sensitivity to index values of 1, then rapidly increasing at values >2.

Sensitivity of a Level 3 attribute *j* to all associated Level 2 attributes *i* was then defined by adding the sensitivities for the Primary, Secondary, and Tertiary attributes, and converting the sum to relative survival (*RelSurv*) for the life stage, as seen in the following equation

$$\mathrm{Re}\,lSurv_j = 1 - \left(\sum SensitivityIndex_i\right)^{2\ 7}$$

where the exponent 2.7 is used to shape the function so that low Level 2 attribute index values (e.g., values of 1) added from multiple Level 2 attributes retain a minor effect on relative survival but with rapidly increasing effect as the total sensitivity index increases to higher values. [5]

The foregoing equations produce what might be thought of as *partial* relative survival values because they reflect only the mortality components contributed by each Level 3 Performance Attribute. Relative survival for a life stage *k* due to the combination of all Level 3 Performance Attributes is simply the product of relative survivals associated with each attribute as seen below

$$\mathrm{Re}\,lSurv_k = \prod \mathrm{Re}\,lSurv_j$$

The parameters that define each relationship were manually selected in order to achieve consistency with the "translation examples" noted above, together with updated information from the BioRules Work Group and literature determined to be relevant. In shaping these relationships, we found it useful to compare estimates that could be derived for actual life stage survival (density-independent survival here) to literature values where applicable. Estimated actual life stage survival is simply the product of the derived relative survival and benchmark survival. Benchmark survival values for chinook salmon used in the analysis are provided in Appendix 4.

The format for the presentation of rules for each Level 3 Performance Attribute is explained in Figure 4. For each rule, the Primary, Secondary, and Tertiary Level 2 Environmental Attributes

[5] We have found that the exponent 2 7 produces results consistent with the "translation examples" noted in the text and with a large body of habitat rating values provided to us in earlier studies

are clearly labeled, accompanied by a brief rationale. The rationale is assigned a Level of Proof to indicate the relative amount of evidence supporting how the attribute was applied in the rule. Four levels of proof were assigned (Table 4). Each rule is accompanied by four examples of Level 2 ratings to illustrate the effect on relative survival associated with each Level 3 attribute.

Table 4. Levels of proof assigned to the use of Level 2 Environmental Attributes 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

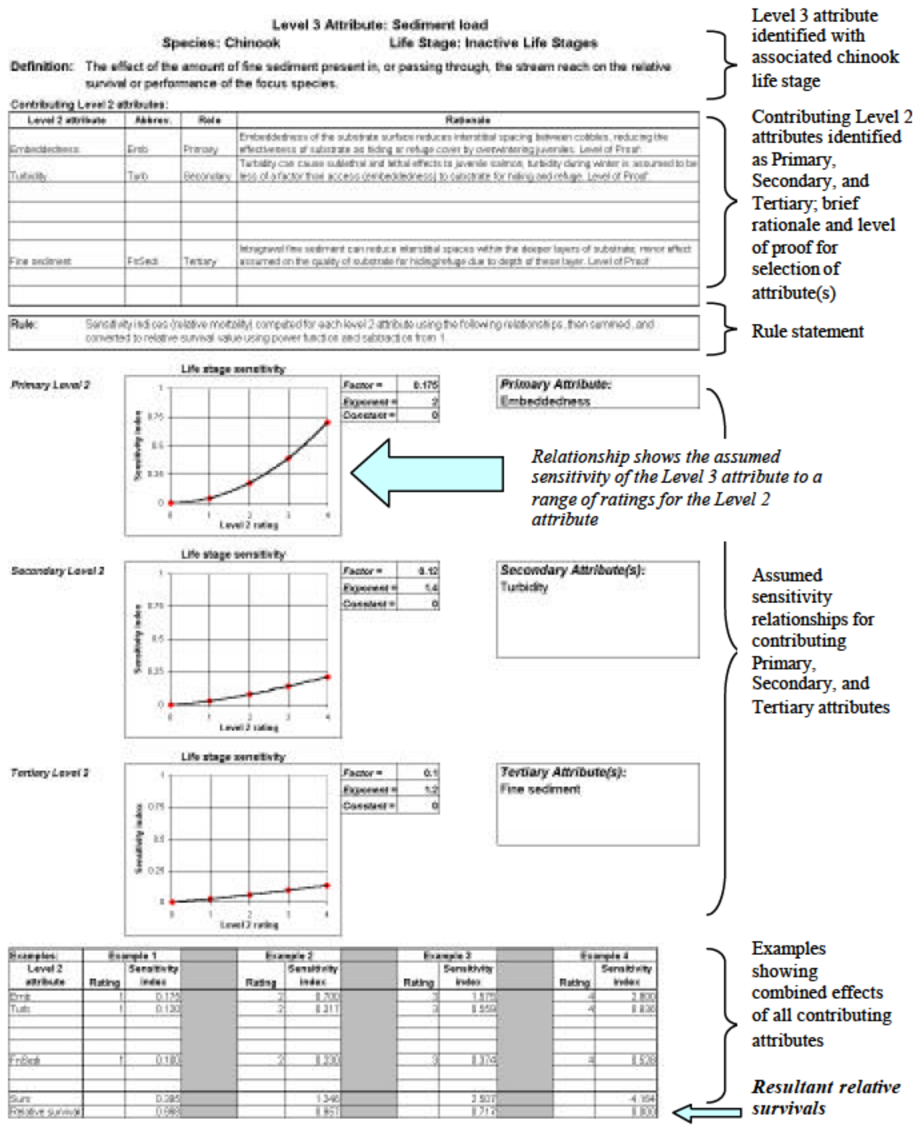


Figure 4. Format for rule presentation for Level 3 Biological Performance Attributes describing environmental quality. An example rule is shown (size reduced for display).

Rules for Habitat Quantity Attributes

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

The use of habitat types by individual life stages of chinook salmon is not necessarily "all" or none", 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.

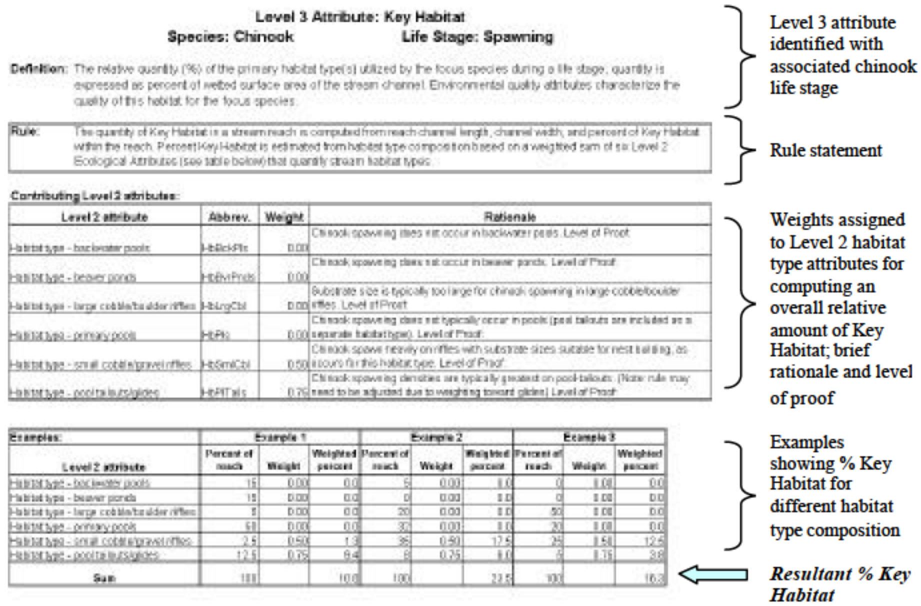
The rules were formulated by assigning weights to each habitat type by Chris Frissell and Larry Lestelle to represent relative levels of preference. The weights were assigned based on information contained within relevant literature and personal observation. As with the rules for assessing environmental quality, the weights are assumptions that will require futher refinement.

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 explained in Figure 5. For each rule, the preference weight is shown for each habitat type accompanied by a brief rationale. The rationale is assigned a Level of Proof to indicate the relative amount of evidence supporting the assigned weight. Levels of proof are those listed in Table 4. Each rule is accompanied by three examples showing different combinations of habitat types and resultant estimates of Key Habitat.



Level 3 Attribute: Key Habitat

Species: Chinook **Life Stage: Spawning**

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 six Level 2 Ecological Attributes (see table below) that quantify stream habitat types.

Contributing Level 2 attributes:

Level 2 attribute	Abbrev.	Weight	Rationale
Habitat type - backwater pools	HbBckPls	0.00	Chinook spawning does not occur in backwater pools. Level of Proof:
Habitat type - beaver ponds	HbBvrPnds	0.00	Chinook spawning does not occur in beaver ponds. Level of Proof:
Habitat type - large cobble/boulder riffles	HbLrgCbl	0.00	Substrate size is typically too large for chinook spawning in large cobble/boulder riffles. Level of Proof:
Habitat type - primary pools	HbPls	0.00	Chinook spawning does not typically occur in pools (pool tailouts are included as a separate habitat type). Level of Proof:
Habitat type - small cobble/gravel riffles	HbSmlCbl	0.50	Chinook spawn heavily on riffles with substrate sizes suitable for nest building, as occurs for this habitat type. Level of Proof:
Habitat type - pool tailouts/glides	HbPlTails	0.75	Chinook spawning densities are typically greatest on pool-tailouts. (Note: rule may need to be adjusted due to weighting toward glides) Level of Proof:

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	15	0.00	0.0	5	0.00	0.0	0	0.00	0.0
Habitat type - beaver ponds	15	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	50	0.00	0.0	30	0.00	0.0	20	0.00	0.0
Habitat type - small cobble/gravel riffles	2.5	0.50	1.3	35	0.50	17.5	25	0.50	12.5
Habitat type - pool tailouts/glides	12.5	0.75	9.4	8	0.75	6.0	5	0.75	3.8
Sum	100		10.6	100		23.5	100		16.3

Figure 5. Format for rule presentation for the Level 3 Biological Performance Attribute Key Habitat. An example rule is shown (size reduced for display).

Part II - Rules

Rule for Translation to Level 3 Biometric

Channel Stability

Definition: The effect of stream channel stability (within reach) on the relative survival or performance of the focus species; the extent of channel stability is with respect to its streambed, banks, and its channel shape and location.

Rule for Translation to Level 3 Biometric

Chemicals (Toxic Substances)

Definition: The effect of toxic substances or toxic conditions on the relative survival or performance of the focus species. Substances include chemicals and heavy metals. Toxic conditions include low pH.

Rule for Translation to Level 3 Biometric

Competition with Hatchery Fish

Definition: The effect of competition with hatchery produced animals on the relative survival or performance of the focus species; competition might be for food or space within the stream reach.

Rule for Translation to Level 3 Biometric

Competition with Other Species

Definition: The effect of competition with other species on the relative survival or performance of the focus species; competition might be for food or space.

Rule for Translation to Level 3 Biometric

Flow

Definition: The effect of the amount of stream flow, or the the pattern and extent of flow fluctuations, within the stream reach on the relative survival or performance of the focus species. Effects of flow reductions or dewatering due to water withdrawals are to be included as part of this attribute.

Rule for Translation to Level 3 Biometric

Food

Definition: The effect of the amount, diversity, and availability of food that can support the focus species on the its relative survival or performance.

Rule for Translation to Level 3 Biometric

Habitat Diversity

Definition: The effect of the extent of habitat complexity within a stream reach on the relative survival or performance of the focus species.

Rule for Translation to Level 3 Biometric

Harassment

Definition: The effect of harassment, poaching, or non-directed harvest (i.e., as can occur through hook and release) on the relative survival or performance of the focus species.

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Rule for Translation to Level 3 Biometric

Key Habitat

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.

Rule for Translation to Level 3 Biometric

Obstructions

Definition: The effect of physical structures impeding movement of the focus species on its relative survival or performance within a stream reach; structures include dams and waterfalls.

Rule for Translation to Level 3 Biometric

Oxygen

Definition: The effect of the concentration of dissolved oxygen within the stream reach on the relative survival or performance of the focus species.

Rule for Translation to Level 3 Biometric

Pathogens

Definition: The effect of pathogens within the stream reach on the relative survival or performance of the focus species. The life stage when infection occurs is when this effect is accounted for.

Rule for Translation to Level 3 Biometric

Predation

Definition: The effect of the relative abundance of predator species on the relative survival or performance of the focus species.

Rule for Translation to Level 3 Biometric

Salinity

Definition: The effect of the concentration of salts within the reach on the relative survival or performance of the focus species.

Rule for Translation to Level 3 Biometric

Sediment Load

Definition: The effect of the amount of the amount of fine sediment present in, or passing through, the stream reach on the relative survival or performance of the focus species.

Rule for Translation to Level 3 Biometric

Temperature

Definition: The effect of water temperature within the the stream reach on the relative survival or performance of the focus species.

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Rule for Translation to Level 3 Biometric

Withdrawals (or Entrainment)

Definition: The effect of entrainment (or injury by screens) at water withdrawal structures within the stream reach on the relative survival or performance of the focus species. This effect does not include dewatering due to water withdrawals, which is covered by the flow attribute.

Appendix B-3. Associations used in translating Level 2 Ecological Attribute values to Level 3 Biological Performance Attribute values through rule sets.

Life stage	Level 3 Biological Performance Attribute	Level 2 Ecological Attribute							
		Primary	Secondary	Secondary	Secondary	Secondary	Tertiary	Tertiary	Tertiary
Spawning	Channel stability	Bed scour							
	Chemicals	Miscellaneous toxic pollutants - water	Metals - in water column				Metals/Pollutants - in sediments/soils	Nutrient enrichment	
	Competition (with hatchery fish)	Hatchery fish outplants							
	Competition (with o her species)	Fish community richness							
	Flow	Flow - Intra daily (diel) varia ion							
	Food	Alkalinity							
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood			
	Harvest	Harassment	Habitat type - primary pools	Riparian func ion	Turbidity	Wood			
	KeyHabitat	Habitat type - pool tailouts/glides	Habitat type - small cobble/gravel riffles						
	Obstruc ions	Obstructions to fish migration							
	Oxygen	Dissolved oxygen							
	Pathogens	Fish pathogens	Fish species introduc ions	Temperature - daily maximum (by month)			Nutrient enrichment		
	Predation	Predation risk					Flow - changes in interannual variability		
	Sediment load	Turbidity	Flow - changes in interannual variability	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation						
	Withdrawals	Water withdrawals							
Incubation	Channel stability	Bed scour	Icing	Riparian func ion	Wood		Confinement - Hydromodifications	Flow - change in interannual variability	Flow - intra-annual flow pattern
	Chemicals	Miscellaneous toxic pollutants - water	Metals/Pollutants - in sediments/soils	Metals - in water column			Nutrient enrichment		
	Competition (with hatchery fish)	Hatchery fish outplants							
	Competition (with o her species)	Fish community richness							
	Flow	Flow - Intra daily (diel) varia ion							
	Food	Alkalinity							
	Harvest	Harassment							
	KeyHabitat	Habitat type - pool tailouts/glides	Habitat type - small cobble/gravel riffles						

Appendix B-3. Associations used in translating Level 2 Ecological Attribute values to Level 3 Biological Performance Attribute values through rule sets.

Life stage	Level 3 Biological Performance Attribute	Level 2 Ecological Attribute							
		Primary	Secondary	Secondary	Secondary	Secondary	Tertiary	Tertiary	Tertiary
	Obstruc ions	Obstructions to fish migration							
	Oxygen	Dissolved oxygen							
	Pathogens	Fish pathogens	Fish species introduc ions	Temperature - daily maximum (by month)			Nutrient enrichment		
	Sediment load	Fine sediment	Embeddedness	Turbidity					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation						
	Withdrawals	Water withdrawals							
Fry colonization	Channel stability	Bed scour	Icing	Riparian func ion	Wood		Confinement - Hydromodifications	Flow - change in interannual variability	Flow - intra-annual flow pattern
	Chemicals	Miscellaneous toxic pollutants - water	Metals - in water column				Metals/Pollutants - in sediments/soils	Nutrient enrichment	
	Competition (with hatchery fish)	Hatchery fish outplants							
	Competition (with o her species)	Fish community richness	Alkalinity	Ben hos diversity and production	Riparian function	Salmon Carcasses			
	Flow	Flow - change in interannual variability	Confinement - natural	Confinement - Hydromodifications	Gradient			Riparian function	Wood
	Food	Benthos diversity and production	Alkalinity	Riparian func ion	Salmon Carcasses				
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood	Embeddedness	Icing	
	Harvest	Harassment	Habitat type - primary pools	Riparian func ion	Turbidity	Wood			
	KeyHabitat	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - large cobble/boulder riffles	Habitat type - primary pools	Habitat type - small cobble/gravel riffles	Habitat type - pool tailouts/glides		
	Obstruc ions	Obstructions to fish migration							
	Oxygen	Dissolved oxygen							
	Pathogens	Fish pathogens	Fish species introduc ions	Temperature - daily maximum (by month)			Nutrient enrichment		
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)		Flow - changes in interannual variability	Hatchery fish outplants	
	Sediment load	Turbidity	Embeddedness						
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation						
	Withdrawals	Water withdrawals							
0-age resident rearing	Channel stability	Bed scour	Icing	Riparian func ion	Wood				
	Chemicals	Miscellaneous toxic pollutants - water	Metals - in water column				Metals/Pollutants - in sediments/soils	Nutrient enrichment	

Appendix B-3. Associations used in translating Level 2 Ecological Attribute values to Level 3 Biological Performance Attribute values through rule sets.

Life stage	Level 3 Biological Performance Attribute	Level 2 Ecological Attribute							
		Primary	Secondary	Secondary	Secondary	Secondary	Tertiary	Tertiary	Tertiary
	Competition (with hatchery fish)	Hatchery fish outplants	Alkalinity	Ben hos diversity and production	Riparian function	Salmon Carcasses			
	Competition (with o her species)	Fish community richness	Alkalinity	Ben hos diversity and production	Riparian function	Salmon Carcasses			
	Flow	Flow - changes in interannual variability		Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - primary pools	Confinement - natural	Confinement - Hydromodifications	
	Food	Benthos diversity and production	Alkalinity	Riparian func ion	Salmon Carcasses				
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood	Embeddedness	Icing	
	Harvest	Harassment	Habitat type - primary pools	Riparian func ion	Turbidity	Wood			
	KeyHabitat	Habitat type - primary pools	Habitat type - backwater pools	Habitat type - pool tailouts/glides			Habitat type - beaver ponds	Habitat type - large cobble/boulder riffles	
	Obstruc ions	Obstructions to fish migration							
	Oxygen	Dissolved oxygen							
	Pathogens	Fish pathogens	Fish species introduc ions	Temperature - daily maximum (by month)			Nutrient enrichment		
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)		Flow - changes in interannual variability	Hatchery fish outplants	
	Sediment load	Turbidity	Flow - changes in interannual variability	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation						
	Withdrawals	Water withdrawals							
0-age transient rearing	Channel stability	Bed scour	Icing	Riparian func ion	Wood				
	Chemicals	Miscellaneous toxic pollutants - water	Metals - in water column				Metals/Pollutants - in sediments/soils	Nutrient enrichment	
	Competition (with hatchery fish)	Hatchery fish outplants	Alkalinity	Ben hos diversity and production	Riparian function	Salmon Carcasses			
	Competition (with o her species)	Fish community richness	Alkalinity	Ben hos diversity and production	Riparian function	Salmon Carcasses			
	Flow	Flow - changes in interannual variability		Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - primary pools	Confinement - natural	Confinement - Hydromodifications	
	Food	Benthos diversity and production	Alkalinity	Riparian func ion	Salmon Carcasses				
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood	Embeddedness	Icing	
	Harvest	Harassment	Habitat type - primary pools	Riparian func ion	Turbidity	Wood			
	KeyHabitat	Habitat type - primary pools	Habitat type - backwater pools	Habitat type - pool tailouts/glides			Habitat type - beaver ponds	Habitat type - large cobble/boulder riffles	
	Obstruc ions	Obstructions to fish migration							

Appendix B-3. Associations used in translating Level 2 Ecological Attribute values to Level 3 Biological Performance Attribute values through rule sets.

Life stage	Level 3 Biological Performance Attribute	Level 2 Ecological Attribute							
		Primary	Secondary	Secondary	Secondary	Secondary	Tertiary	Tertiary	Tertiary
	Oxygen	Dissolved oxygen							
	Pathogens	Fish pathogens	Fish species introduc ions	Temperature - daily maximum (by month)			Nutrient enrichment		
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)		Flow - changes in interannual variability	Hatchery fish outplants	
	Sediment load	Turbidity	Flow - changes in interannual variability	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation						
	Withdrawals	Water withdrawals							
0-age migrant	Channel stability	Bed scour							
	Chemicals	Miscellaneous toxic pollutants - water	Metals - in water column				Metals/Pollutants - in sediments/soils	Nutrient enrichment	
	Competition (with hatchery fish)	Hatchery fish outplants							
	Competition (with o her species)	Fish community richness							
	Flow	Flow - changes in interannual variability							
	Food	Benthos diversity and production	Alkalinity	Riparian func ion	Salmon Carcasses				
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood			
	Harvest	Harassment							
	KeyHabitat	<all habitat types applied equally>							
	Obstruc ions	Obstructions to fish migration							
	Oxygen	Dissolved oxygen							
	Pathogens	Fish pathogens	Fish species introduc ions	Temperature - daily maximum (by month)			Nutrient enrichment		
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)		Flow - changes in interannual variability	Hatchery fish outplants	
	Sediment load	Turbidity					Flow - changes in interannual variability	Temperature - daily maximum (by month)	
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation						
	Withdrawals	Water withdrawals							
Inactive	Channel stability	Bed scour	Icing	Riparian func ion	Wood		Confinement - Hydromodifications	Flow - change in interannual variability	Flow - intra-annual flow pattern
	Chemicals	Miscellaneous toxic pollutants - water	Metals - in water column				Metals/Pollutants - in sediments/soils	Nutrient enrichment	

Appendix B-3. Associations used in translating Level 2 Ecological Attribute values to Level 3 Biological Performance Attribute values through rule sets.

Life stage	Level 3 Biological Performance Attribute	Level 2 Ecological Attribute							
		Primary	Secondary	Secondary	Secondary	Secondary	Tertiary	Tertiary	Tertiary
	Competition (with hatchery fish)	Hatchery fish outplants							
	Competition (with o her species)	Fish community richness							
	Flow	Flow - change in interannual variability	Confinement - natural	Confinement - Hydromodifications	Gradient			Riparian function	Wood
	Food	Benthos diversity and production	Alkalinity	Riparian func ion	Salmon Carcasses				
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood	Embeddedness	Icing	
	Harvest	Harassment							
	KeyHabitat	Habitat type - primary pools	Habitat type - backwater pools	Habitat type - beaver ponds			Habitat type - large cobble/boulder riffles		
	Obstruc ions	Obstructions to fish migration							
	Oxygen	Dissolved oxygen							
	Pathogens	Fish pathogens	Fish species introduc ions	Temperature - daily maximum (by month)			Nutrient enrichment		
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily minimum (by month)		Flow - changes in interannual variability	Hatchery fish outplants	
	Sediment load	Embeddedness	Turbidity				Fine sediment		
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation						
	Withdrawals	Water withdrawals							
1-age resident rearing	Channel stability	Bed scour	Icing	Riparian func ion	Wood				
	Chemicals	Miscellaneous toxic pollutants - water	Metals - in water column				Metals/Pollutants - in sediments/soils	Nutrient enrichment	
	Competition (with hatchery fish)	Hatchery fish outplants	Alkalinity	Ben hos diversity and production	Riparian function	Salmon Carcasses			
	Competition (with o her species)	Fish community richness	Alkalinity	Ben hos diversity and production	Riparian function	Salmon Carcasses			
	Flow	Flow - change in interannual variability	Confinement - natural	Confinement - Hydromodifications	Gradient			Riparian function	Wood
	Food	Benthos diversity and production	Alkalinity	Riparian func ion	Salmon Carcasses				
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood	Embeddedness	Icing	
	Harvest	Harassment	Habitat type - primary pools	Riparian func ion	Turbidity	Wood			
	KeyHabitat	Habitat type - primary pools	Habitat type - backwater pools	Habitat type - pool tailouts/glides			Habitat type - beaver ponds	Habitat type - large cobble/boulder riffles	
	Obstruc ions	Obstructions to fish migration							

Appendix B-3. Associations used in translating Level 2 Ecological Attribute values to Level 3 Biological Performance Attribute values through rule sets.

Life stage	Level 3 Biological Performance Attribute	Level 2 Ecological Attribute							
		Primary	**Secondary**	**Secondary**	**Secondary**	**Secondary**	**Tertiary**	**Tertiary**	**Tertiary**
	Oxygen	Dissolved oxygen							
	Pathogens	Fish pathogens	Fish species introduc ions	Temperature - daily maximum (by month)			Nutrient enrichment		
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)		Flow - changes in interannual variability	Hatchery fish outplants	
	Sediment load	Turbidity	Flow - changes in interannual variability	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation						
	Withdrawals	Water withdrawals							
1-age migrant	Channel stability	Bed scour							
	Chemicals	Miscellaneous toxic pollutants - water	Metals - in water column				Metals/Pollutants - in sediments/soils	Nutrient enrichment	
	Competition (with hatchery fish)	Hatchery fish outplants							
	Competition (with o her species)	Fish community richness							
	Flow	Flow - changes in interannual variability							
	Food	Benthos diversity and production	Alkalinity	Riparian func ion	Salmon Carcasses				
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood	Embeddedness	Icing	
	Harvest	Harassment							
	KeyHabitat	<all habitat types applied equally>							
	Obstruc ions	Obstructions to fish migration							
	Oxygen	Dissolved oxygen							
	Pathogens	Fish pathogens	Fish species introduc ions	Temperature - daily maximum (by month)			Nutrient enrichment		
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)		Flow - changes in interannual variability	Hatchery fish outplants	
	Sediment load	Turbidity					Flow - changes in interannual variability	Temperature - daily maximum (by month)	
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation						
	Withdrawals	Water withdrawals							
Prespawning migrant	Channel stability	Bed scour							
	Chemicals	Miscellaneous toxic pollutants - water	Metals - in water column				Metals/Pollutants - in sediments/soils	Nutrient enrichment	

Appendix B-3. Associations used in translating Level 2 Ecological Attribute values to Level 3 Biological Performance Attribute values through rule sets.

Life stage	Level 3 Biological Performance Attribute	Level 2 Ecological Attribute							
		Primary	Secondary	Secondary	Secondary	Secondary	Tertiary	Tertiary	Tertiary
	Competition (with hatchery fish)	Hatchery fish outplants							
	Competition (with o her species)	Fish community richness							
	Flow	Flow - changes in interannual variability							
	Food	Alkalinity							
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood			
	Harvest	Harassment	Habitat type - primary pools	Riparian func ion	Turbidity	Wood			
	KeyHabitat	<all habitat types applied equally>							
	Obstruc ions	Obstructions to fish migration							
	Oxygen	Dissolved oxygen							
	Pathogens	Fish pathogens	Fish species introduc ions	Temperature - daily maximum (by month)					Nutrient enrichment
	Predation	Predation risk					Flow - changes in interannual variability		
	Sediment load	Turbidity	Flow - changes in interannual variability	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation						
	Withdrawals	Water withdrawals							
Prespawning holding	Channel stability	Bed scour							
	Chemicals	Miscellaneous toxic pollutants - water	Metals - in water column				Metals/Pollutants - in sediments/soils	Nutrient enrichment	
	Competition (with hatchery fish)	Hatchery fish outplants							
	Competition (with o her species)	Fish community richness							
	Flow	Flow - changes in interannual variability		Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - primary pools	Confinement - natural	Confinement - Hydromodifications	
	Food	Alkalinity							
	Habitat diversity	Gradient	Confinement - Hydromodifications	Riparian func ion	Wood				
	Harvest	Harassment	Habitat type - primary pools	Riparian func ion	Turbidity	Wood			
	KeyHabitat								
	Obstruc ions	Obstructions to fish migration							

Appendix B-3. Associations used in translating Level 2 Ecological Attribute values to Level 3 Biological Performance Attribute values through rule sets.

Life stage	Level 3 Biological Performance Attribute	Level 2 Ecological Attribute							
		Primary	**Secondary**	**Secondary**	**Secondary**	**Secondary**	**Tertiary**	**Tertiary**	**Tertiary**
	Oxygen	Dissolved oxygen							
	Pathogens	Fish pathogens	Fish species introduc ions	Temperature - daily maximum (by month)			Nutrient enrichment		
	Predation	Predation risk					Flow - changes in interannual variability		
	Sediment load	Turbidity	Flow - changes in interannual variability	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation						
	Withdrawals	Water withdrawals							

Appendix B-4

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 "though the eyes of salmon" by species and life stage. The procedure for deriving these productivity and capacity values involves what we refer to as a shaping of survival conditions over time and space, as salmon might experience them in completing their life cycle. The shaping of survival conditions is done with reference to a defined set of "benchmark" conditions.

From 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. We refer to the survival and density values associated with optimal conditions as reference benchmarks. Thus benchmarks provide us with a set of descriptions for optimal conditions expressed as productivity survival, maximum densities, and habitat characteristics for each life stage. These conditions constitute what can be thought of "as good as it gets" for survival of the species in nature. We have employed a set of benchmark values derived from reviewing relevant sources of information, including discussions with scientists having expertise in survival of salmonids by life stage under various conditions.

The systematic shaping of survival conditions using the habitat rating procedures 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.

It is important to keep in mind that benchmark or optimal conditions are different from template (pre-development) conditions. Template conditions were not always optimal for salmon survival. The benchmark descriptions serve as a point of reference for both the patient and template and for all watersheds.

Table 1 provides a list of productivity survival values for chinook salmon used in the Columbia River analysis for freshwater environments. Tables 2 and 3 provide this information for steelhead and bull trout.

Table 1. Benchmark productivity survival values by freshwater life stage for chinook salmon. Values have been rounded. Sterotypical life stage durations are shown.

Life stage	Stereotypical duration (weeks)	Life stage productivity survival
Spawning	1	1
Egg incubation	25	0.57
Fry colonization	2	0.75
0-age resident rearing	30	0.70
0-age migrant	2	0.96
Inactive (full winter)	19	0.70
1-age resident rearing	8	0.97
1-age migrant	2	0.98
Migrant prespawner	8	0.92
Holding prespawner	8	0.98

Table .2. Benchmark productivity survival values and capacity densities at the end of each life stage used in previous EDT analyses for steelhead trout. Values have been rounded.

Life stage	Environmental type	Stereotypical duration (weeks)	Life stage productivity survival	End of life stage density (per sq m)
Spawning	All types	1	1	0.33
Egg incubation	All types	7	0.6	400
Fry colonization	Headwater streams	2	0.65	13.58
Fry colonization	Low order streams	2	0.65	6.79
Fry colonization	Mid order streams	2	0.65	3.40
Fry colonization	High order streams	2	0.65	1.70
Fry colonization	Mainstem reservoirs	2	0.65	1.70
0-age resident rearing	Headwater streams	16	0.5	1.33
0-age resident rearing	Low order streams	16	0.5	0.67
0-age resident rearing	Mid order streams	16	0.5	0.33
0-age resident rearing	High order streams	16	0.5	0.17
0-age resident rearing	Mainstem reservoirs	16	0.5	0.17
0-age migrant	All types	2	0.975	30
0-age inactive	Headwater streams	20	0.85	0.60
0-age inactive	Low order streams	20	0.85	0.30
0-age inactive	Mid order streams	20	0.85	0.15
0-age inactive	High order streams	20	0.85	0.08
0-age inactive	Mainstem reservoirs	20	0.85	0.08
1-age resident rearing	Headwater streams	28	0.95	0.13
1-age resident rearing	Low order streams	28	0.95	0.07
1-age resident rearing	Mid order streams	28	0.95	0.03
1-age resident rearing	High order streams	28	0.95	0.02
1-age resident rearing	Mainstem reservoirs	28	0.95	0.02
1-age migrant	All types	2	0.975	30
1-age inactive	Headwater streams	20	0.95	0.11
1-age inactive	Low order streams	20	0.95	0.06
1-age inactive	Mid order streams	20	0.95	0.03
1-age inactive	High order streams	20	0.95	0.01
1-age inactive	Mainstem reservoirs	20	0.95	0.01
2-age resident rearing	Headwater streams	28	0.95	0.06
2-age resident rearing	Low order streams	28	0.95	0.03
2-age resident rearing	Mid order streams	28	0.95	0.02
2-age resident rearing	High order streams	28	0.95	0.01
2-age resident rearing	Mainstem reservoirs	28	0.95	0.01
2-age migrant	All types	2	0.99	30
2-age inactive	Headwater streams	20	0.95	0.06
2-age inactive	Low order streams	20	0.95	0.03
2-age inactive	Mid order streams	20	0.95	0.02
2-age inactive	High order streams	20	0.95	0.01
2-age inactive	Mainstem reservoirs	20	0.95	0.01
Migrant prespawner	Free flowing rivers and streams	3	1	1
Holding prespawner	All types	8	1	1

Table.3. Benchmark productivity survival values and capacity densities at the end of each life stage used in previous EDT analyses for bull trout.

Life stage	Environmental type	Sterotypical duration (weeks)	Life stage productivity survival	End of life stage density (per sq m)
Spawning	Headwater	1	1	0.22
Spawning	Low Stream Order	1	1	0.22
Spawning	Mid Stream Order	1	1	0.22
Egg incubation	Headwater	27	0.6	400
Egg incubation	Low Stream Order	27	0.6	400
Egg incubation	Mid Stream Order	27	0.6	400
Fry colonization	Headwater	2	0.75	16.7
Fry colonization	Low Stream Order	2	0.75	16.7
Fry colonization	Mid Stream Order	2	0.75	16.7
0-age resident rearing	Headwater	27	0.6	3
0-age resident rearing	Low Stream Order	27	0.6	3
0-age resident rearing	Mid Stream Order	27	0.6	3
0-age transient rearing	Headwater	27	0.5	3
0-age transient rearing	Low Stream Order	27	0.5	3
0-age transient rearing	Mid Stream Order	27	0.5	3
0-age migrant	Headwater	2	0.9	3
0-age migrant	Low Stream Order	2	0.9	3
0-age migrant	Mid Stream Order	2	0.9	3
0-age inactive	Headwater	18	0.6	2.3
0-age inactive	Low Stream Order	18	0.6	2.3
0-age inactive	Mid Stream Order	18	0.6	2.3
1-age resident rearing	Headwater	34	0.75	1
1-age resident rearing	Low Stream Order	34	0.75	1
1-age resident rearing	Mid Stream Order	34	0.75	1
1-age transient rearing	Headwater	34	0.6	1
1-age transient rearing	Low Stream Order	34	0.6	1
1-age transient rearing	Mid Stream Order	34	0.6	1
1-age migrant	Headwater	2	0.95	1
1-age migrant	Low Stream Order	2	0.95	1
1-age migrant	Mid Stream Order	2	0.95	1
1-age inactive	Headwater	18	0.75	0.5
1-age inactive	Low Stream Order	18	0.75	0.5
1-age inactive	Mid Stream Order	18	0.75	0.5
2+-age resident rearing	Headwater	34	0.9	0.09
2+-age resident rearing	Low Stream Order	34	0.9	0.09
2+-age resident rearing	Mid Stream Order	34	0.9	0.09
2+-age transient rearing	Headwater	6	0.95	0.09
2+-age transient rearing	Low Stream Order	6	0.95	0.09
2+-age transient rearing	Mid Stream Order	6	0.95	0.09
2+-age migrant	Headwater	2	0.975	0.5
2+-age migrant	Low Stream Order	2	0.975	0.5
2+-age migrant	Mid Stream Order	2	0.975	0.5
2+-age inactive	Headwater	18	0.9	0.09
2+-age inactive	Low Stream Order	18	0.9	0.09
2+-age inactive	Mid Stream Order	18	0.9	0.09
5+-age resident rearing	Headwater	34	0.95	0.005
5+-age resident rearing	Low Stream Order	34	0.95	0.005
5+-age resident rearing	Mid Stream Order	34	0.95	0.005
5+-age transient rearing	Headwater	6	0.95	0.005
5+-age transient rearing	Low Stream Order	6	0.95	0.005
5+-age transient rearing	Mid Stream Order	6	0.95	0.005
5+-age migrant	Headwater	2	1	0.09

5+-age migrant	Low Stream Order	2	1	0.09
5+-age migrant	Mid Stream Order	2	1	0.09
5+-age inactive	Headwater	18	0.95	0.005
5+-age inactive	Low Stream Order	18	0.95	0.005
5+-age inactive	Mid Stream Order	18	0.95	0.005
Transient prespawner	Headwater	6	0.95	0.005
Transient prespawner	Low Stream Order	6	0.95	0.005
Transient prespawner	Mid Stream Order	6	0.95	0.005
Holding prespawner	Headwater	10	0.95	0.005
Holding prespawner	Low Stream Order	10	0.95	0.005
Holding prespawner	Mid Stream Order	10	0.95	0.005
Post spawner holding/migrant	Headwater	2	0.7	0.005
Post spawner holding/migrant	Low Stream Order	2	0.7	0.005
Post spawner holding/migrant	Mid Stream Order	2	0.7	0.005

Appendix B-5

References
(organized by Level 3 Biological Performance Attribute)

Channel Stability

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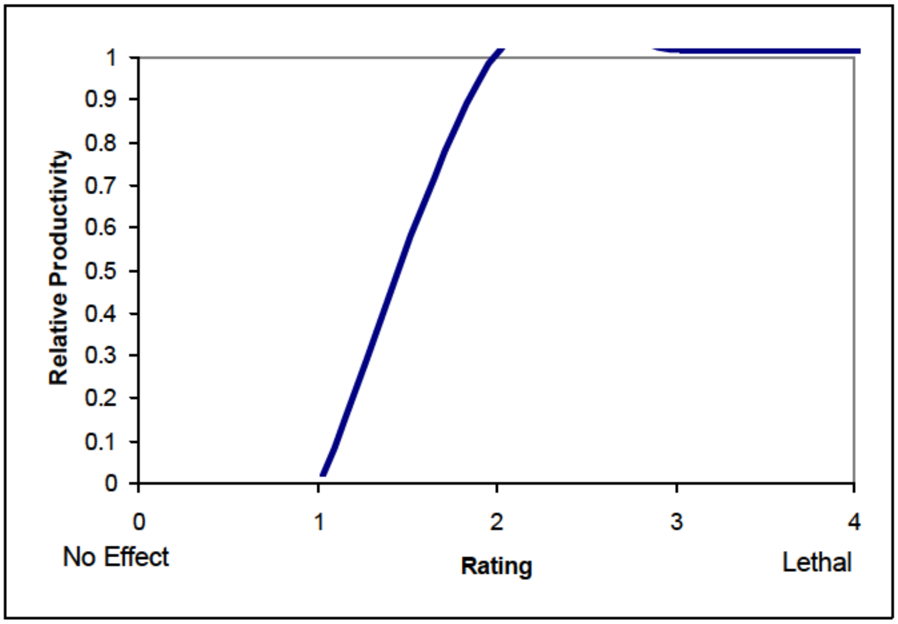
In the tables that follow Attribute Ratings are expressed on scale from 0 to 4. The graph below shows how these ratings are converted into relative Productivity values.



Rating	Relative Productivity
0	1
0.01	0.9999999
0.02	0.9999994
0.03	0.9999982
0.04	0.999996
0.05	0.9999927
0.06	0.9999881
0.07	0.999982
0.08	0.9999741
0.09	0.9999644
0.1	0.9999527
0.11	0.9999389
0.12	0.9999227
0.13	0.999904
0.14	0.9998828
0.15	0.9998588
0.16	0.9998319
0.17	0.999802
0.18	0.999769
0.19	0.9997327
0.2	0.9996929
0.21	0.9996497
0.22	0.9996028
0.23	0.9995522
0.24	0.9994976
0.25	0.9994391
0.26	0.9993765
0.27	0.9993096
0.28	0.9992383
0.29	0.9991626
0.3	0.9990824
0.31	0.9989974
0.32	0.9989077
0.33	0.9988131
0.34	0.9987134
0.35	0.9986087
0.36	0.9984987
0.37	0.9983835
0.38	0.9982628
0.39	0.9981366
0.4	0.9980047
0.41	0.9978672
0.42	0.9977238
0.43	0.9975745
0.44	0.9974192
0.45	0.9972577

0.46	0.9970901
0.47	0.9969161
0.48	0.9967357
0.49	0.9965488
0.5	0.9963553
0.51	0.9961552
0.52	0.9959482
0.53	0.9957344
0.54	0.9955136
0.55	0.9952857
0.56	0.9950507
0.57	0.9948084
0.58	0.9945588
0.59	0.9943018
0.6	0.9940373
0.61	0.9937651
0.62	0.9934853
0.63	0.9931977
0.64	0.9929022
0.65	0.9925988
0.66	0.9922873
0.67	0.9919677
0.68	0.9916399
0.69	0.9913038
0.7	0.9909593
0.71	0.9906063
0.72	0.9902448
0.73	0.9898747
0.74	0.9894958
0.75	0.9891081
0.76	0.9887115
0.77	0.988306
0.78	0.9878914
0.79	0.9874677
0.8	0.9870347
0.81	0.9865925
0.82	0.9861409
0.83	0.9856798
0.84	0.9852092
0.85	0.9847289
0.86	0.984239
0.87	0.9837393
0.88	0.9832297
0.89	0.9827102
0.9	0.9821806
0.91	0.981641
0.92	0.9810911
0.93	0.9805311
0.94	0.9799607
0.95	0.9793799

0.96	0.9787886
0.97	0.9781867
0.98	0.9775742
0.99	0.9769509
1	0.9763169
1.01	0.975672
1.02	0.9750162
1.03	0.9743493
1.04	0.9736714
1.05	0.9729823
1.06	0.9722819
1.07	0.9715702
1.08	0.9708471
1.09	0.9701125
1.1	0.9693664
1.11	0.9686086
1.12	0.9678392
1.13	0.967058
1.14	0.966265
1.15	0.96546
1.16	0.9646431
1.17	0.9638141
1.18	0.9629729
1.19	0.9621196
1.2	0.961254
1.21	0.960376
1.22	0.9594856
1.23	0.9585827
1.24	0.9576672
1.25	0.9567391
1.26	0.9557983
1.27	0.9548448
1.28	0.9538783
1.29	0.952899
1.3	0.9519066
1.31	0.9509012
1.32	0.9498827
1.33	0.948851
1.34	0.947806
1.35	0.9467476
1.36	0.9456758
1.37	0.9445906
1.38	0.9434918
1.39	0.9423794
1.4	0.9412533
1.41	0.9401134
1.42	0.9389597
1.43	0.9377921
1.44	0.9366106
1.45	0.935415

1.46	0.9342053
1.47	0.9329815
1.48	0.9317434
1.49	0.930491
1.5	0.9292243
1.51	0.9279431
1.52	0.9266474
1.53	0.9253371
1.54	0.9240122
1.55	0.9226726
1.56	0.9213182
1.57	0.9199489
1.58	0.9185648
1.59	0.9171657
1.6	0.9157515
1.61	0.9143223
1.62	0.9128779
1.63	0.9114182
1.64	0.9099432
1.65	0.9084529
1.66	0.9069471
1.67	0.9054258
1.68	0.903889
1.69	0.9023365
1.7	0.9007684
1.71	0.8991845
1.72	0.8975847
1.73	0.8959691
1.74	0.8943375
1.75	0.8926899
1.76	0.8910262
1.77	0.8893463
1.78	0.8876503
1.79	0.8859379
1.8	0.8842093
1.81	0.8824642
1.82	0.8807027
1.83	0.8789246
1.84	0.8771299
1.85	0.8753186
1.86	0.8734905
1.87	0.8716457
1.88	0.869784
1.89	0.8679055
1.9	0.8660099
1.91	0.8640973
1.92	0.8621676
1.93	0.8602207
1.94	0.8582566
1.95	0.8562753

1.96	0.8542766
1.97	0.8522604
1.98	0.8502268
1.99	0.8481757
2	0.8461069
2.01	0.8440206
2.02	0.8419164
2.03	0.8397945
2.04	0.8376548
2.05	0.8354971
2.06	0.8333215
2.07	0.8311279
2.08	0.8289161
2.09	0.8266863
2.1	0.8244382
2.11	0.8221718
2.12	0.8198871
2.13	0.817584
2.14	0.8152624
2.15	0.8129224
2.16	0.8105637
2.17	0.8081864
2.18	0.8057905
2.19	0.8033757
2.2	0.8009422
2.21	0.7984897
2.22	0.7960184
2.23	0.793528
2.24	0.7910186
2.25	0.78849
2.26	0.7859423
2.27	0.7833754
2.28	0.7807891
2.29	0.7781835
2.3	0.7755585
2.31	0.772914
2.32	0.77025
2.33	0.7675663
2.34	0.7648631
2.35	0.7621401
2.36	0.7593973
2.37	0.7566348
2.38	0.7538523
2.39	0.7510499
2.4	0.7482275
2.41	0.745385
2.42	0.7425224
2.43	0.7396396
2.44	0.7367366
2.45	0.7338132

2.46	0.7308696
2.47	0.7279055
2.48	0.7249209
2.49	0.7219158
2.5	0.7188902
2.51	0.7158438
2.52	0.7127768
2.53	0.709689
2.54	0.7065804
2.55	0.703451
2.56	0.7003006
2.57	0.6971292
2.58	0.6939367
2.59	0.6907232
2.6	0.6874885
2.61	0.6842325
2.62	0.6809553
2.63	0.6776568
2.64	0.6743368
2.65	0.6709955
2.66	0.6676326
2.67	0.6642481
2.68	0.6608421
2.69	0.6574143
2.7	0.6539649
2.71	0.6504936
2.72	0.6470005
2.73	0.6434855
2.74	0.6399486
2.75	0.6363896
2.76	0.6328086
2.77	0.6292054
2.78	0.6255801
2.79	0.6219325
2.8	0.6182626
2.81	0.6145704
2.82	0.6108558
2.83	0.6071187
2.84	0.6033591
2.85	0.5995769
2.86	0.5957721
2.87	0.5919446
2.88	0.5880944
2.89	0.5842213
2.9	0.5803255
2.91	0.5764067
2.92	0.572465
2.93	0.5685002
2.94	0.5645124
2.95	0.5605014

2.96	0.5564673
2.97	0.5524099
2.98	0.5483293
2.99	0.5442253
3	0.5400979
3.01	0.535947
3.02	0.5317727
3.03	0.5275747
3.04	0.5233532
3.05	0.519108
3.06	0.514839
3.07	0.5105463
3.08	0.5062297
3.09	0.5018892
3.1	0.4975248
3.11	0.4931364
3.12	0.488724
3.13	0.4842874
3.14	0.4798267
3.15	0.4753417
3.16	0.4708325
3.17	0.466299
3.18	0.4617411
3.19	0.4571587
3.2	0.4525519
3.21	0.4479205
3.22	0.4432645
3.23	0.4385839
3.24	0.4338786
3.25	0.4291486
3.26	0.4243937
3.27	0.419614
3.28	0.4148093
3.29	0.4099797
3.3	0.4051251
3.31	0.4002454
3.32	0.3953405
3.33	0.3904105
3.34	0.3854553
3.35	0.3804748
3.36	0.3754689
3.37	0.3704376
3.38	0.3653809
3.39	0.3602987
3.4	0.355191
3.41	0.3500576
3.42	0.3448986
3.43	0.3397139
3.44	0.3345034
3.45	0.3292671

3.46	0.324005
3.47	0.3187169
3.48	0.3134029
3.49	0.3080628
3.5	0.3026967
3.51	0.2973044
3.52	0.2918859
3.53	0.2864413
3.54	0.2809703
3.55	0.275473
3.56	0.2699493
3.57	0.2643992
3.58	0.2588226
3.59	0.2532194
3.6	0.2475896
3.61	0.2419332
3.62	0.2362501
3.63	0.2305402
3.64	0.2248036
3.65	0.2190401
3.66	0.2132496
3.67	0.2074322
3.68	0.2015879
3.69	0.1957164
3.7	0.1898178
3.71	0.1838921
3.72	0.1779392
3.73	0.1719589
3.74	0.1659514
3.75	0.1599165
3.76	0.1538542
3.77	0.1477644
3.78	0.1416471
3.79	0.1355022
3.8	0.1293297
3.81	0.1231295
3.82	0.1169016
3.83	0.1106459
3.84	0.1043624
3.85	0.098051
3.86	0.0917116
3.87	0.0853443
3.88	0.078949
3.89	0.0725256
3.9	0.066074
3.91	0.0595943
3.92	0.0530863
3.93	0.04655
3.94	0.0399854
3.95	0.0333925

3.96	0.026771
3.97	0.0201211
3.98	0.0134427
3.99	0.0067357
4	0

Table C-1a. **Subyearling** biological performance attribute ratings for Columbia River and Snake River mainstem habitat under the **Current** condition and worldview **Moderate**.

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Col R Below Bonneville Dam	Hab	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	
to Estuary-A	Temp	0.00	0.00	0.00	0.00	0.00	0.00	3.11	3.62	3.23	0.00	0.00	0.00	
	Pred	1.55	1.55	2.00	2.00	2.30	2.30	2.00	2.00	2.00	2.00	1.55	1.55	
	CompH	1.00	1.00	1.00	1.00	1.50	2.00	1.80	1.50	1.50	1.00	1.00	1.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.84	0.84	0.77	0.77	0.67	0.61	0.34	0.17	0.32	0.77	0.84	0.84	0.43
Col R Bonneville Pool-A	Hab	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
	Temp	0.00	0.00	0.00	0.00	0.00	0.00	3.09	3.56	3.39				
	Pred	1.78	1.78	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	1.78	1.78	
	CompH	1.50	1.50	1.50	1.50	1.50	1.00	1.50	1.00	1.00	1.50	1.50	1.50	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.70	0.70	0.61	0.61	0.61	0.64	0.31	0.17	0.23	0.61	0.70	0.70	0.43
Col R The Dalles Pool-A	Hab	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
	Temp							3.09	3.56	3.39				
	Pred	1.78	1.78	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	1.78	1.78	
	CompH	0.00	0.00	0.00		1.00	1.50	1.00	1.00	1.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.75	0.75	0.66	0.66	0.64	0.61	0.32	0.17	0.23	0.66	0.75	0.75	0.42
Col R John Day Pool-A	Hab	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
	Temp							3.13	3.65	3.49				
	Pred	1.78	1.78	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	1.78	1.78	
	CompH	0.00	0.00	0.00			1.50	1.00	1.00	1.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.75	0.75	0.66	0.66	0.66	0.61	0.31	0.14	0.20	0.66	0.75	0.75	0.41
Col R McNary Pool-A	Hab	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
	Temp							3.02	3.51	3.23				
	Pred	1.78	1.78	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	1.78	1.78	
	CompH	0.00	0.00	0.00		1.50	1.50	1.00		0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.75	0.75	0.66	0.66	0.61	0.61	0.34	0.20	0.29	0.66	0.75	0.75	0.43
Snake R Ice Harbor Pool-A	Hab	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
	Temp							3.28	3.54	3.21				
	Pred	1.78	1.78	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	1.78	1.78	
	CompH	0.00	0.00	0.00						0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.75	0.75	0.66	0.66	0.66	0.66	0.27	0.18	0.29	0.66	0.75	0.75	0.25
Snake R Low Monumental Pool-A	Hab	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
	Temp							3.08	3.77	2.90				
	Pred	1.78	1.78	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	1.78	1.78	
	CompH	0.00	0.00	0.00						0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.75	0.75	0.66	0.66	0.66	0.66	0.33	0.10	0.38	0.66	0.75	0.75	0.26
Snake R Little Goose Pool-A	Hab	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
	Temp							3.28	3.33	2.80				
	Pred	1.78	1.78	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	1.78	1.78	
	CompH	0.00	0.00	0.00						0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.75	0.75	0.66	0.66	0.66	0.66	0.27	0.26	0.40	0.66	0.75	0.75	0.27
Snake R Low Granite Pool-A	Hab	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
	Temp							3.11	3.01	3.26				
	Pred	1.78	1.78	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	1.78	1.78	
	CompH	0.00	0.00	0.00						0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.75	0.75	0.66	0.66	0.66	0.66	0.32	0.35	0.28	0.66	0.75	0.75	0.34
Columbia River Hanford Reach-A	Hab	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

	Temp							2.06	3.10	2.66				
	Pred	1.39	1.39	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.39	1.39	
	CompH	0.00	0.00	0.00			1.50	1.00		0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.90	0.90	0.84	0.84	0.84	0.78	0.69	0.42	0.56	0.84	0.90	0.90	0.69
Col R Priest Rapids Pool-A	Hab	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
	Temp							2.33	3.22	2.99				
	Pred	1.78	1.78	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	1.78	1.78	
	CompH	0.00	0.00	0.00			1.00			0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.75	0.75	0.66	0.66	0.66	0.64	0.50	0.29	0.36	0.66	0.75	0.75	0.52

Table C-1b. **Subyearling** biological performance attribute ratings for Columbia River and Snake River mainstem habitat under the **Current** condition and worldview **Technology Pessimistic**

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Col R Below Bonneville Dam to Estuary-A	Hab	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	
	Temp	0.00	0.00	0.00	0.00	0.00	0.00	3.50	3.85	3.85	0.00	0.00	0.00	
	Pred	1.74	1.74	2.25	2.25	2.59	2.59	2.25	2.25	2.25	2.25	1.74	1.74	
	CompH	1.12	1.12	1.12	1.12	1.69	2.25	2.02	1.69	1.69	1.12	1.12	1.12	
	CompO	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	
	Unadj Prod	0.78	0.78	0.69	0.69	0.56	0.49	0.18	0.06	0.06	0.69	0.78	0.78	0.29
Col R Bonneville Pool-A	Hab	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	
	Temp	0.00	0.00	0.00	0.00	0.00	0.00	3.49	3.85	3.85				
	Pred	2.01	2.01	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.01	2.01	
	CompH	1.69	1.69	1.69	1.69	1.69	1.13	1.69	1.13	1.13	1.69	1.69	1.69	
	CompO	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	
	Unadj Prod	0.60	0.60	0.49	0.49	0.49	0.52	0.15	0.05	0.05	0.49	0.60	0.60	0.29
Col R The Dalles Pool-A	Hab	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	
	Temp				0.00	0.00	0.00	3.47	3.85	3.85				
	Pred	2.00	2.00	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.00	2.00	
	CompH	0.00	0.00	0.00	0.00	1.12	1.68	1.12	1.12	1.12	0.00	0.00	0.00	
	CompO	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	
	Unadj Prod	0.67	0.67	0.55	0.55	0.53	0.49	0.17	0.05	0.05	0.55	0.67	0.67	0.29
Col R John Day Pool-A	Hab	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	
	Temp				0.00	0.00	0.00	3.52	3.85	3.85				
	Pred	2.00	2.00	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.00	2.00	
	CompH	0.00	0.00	0.00	0.00	0.00	1.68	1.12	1.12	1.12	0.00	0.00	0.00	
	CompO	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	
	Unadj Prod	0.67	0.67	0.55	0.55	0.55	0.50	0.16	0.05	0.05	0.55	0.67	0.67	0.28
Col R McNary Pool-A	Hab	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	
	Temp				0.00	0.00	0.00	3.40	3.85	3.85				
	Pred	2.00	2.00	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.00	2.00	
	CompH	0.00	0.00	0.00	0.00	1.69	1.69	1.13	0.00	0.00	0.00	0.00	0.00	
	CompO	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	
	Unadj Prod	0.67	0.67	0.54	0.54	0.49	0.49	0.19	0.05	0.05	0.54	0.67	0.67	0.30
Snake R Ice Harbor Pool-A	Hab	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	
	Temp				0.00	0.00	0.00	3.47	3.75	3.75				
	Pred	1.88	1.88	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	1.88	1.88	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	
	Unadj Prod	0.71	0.71	0.61	0.61	0.61	0.61	0.19	0.10	0.10	0.61	0.71	0.71	0.17
Snake R Low Monumental Pool-A	Hab	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	
	Temp				0.00	0.00	0.00	3.34	3.85	3.85				
	Pred	1.93	1.93	2.49	2.49	2.49	2.49	2.49	2.49	2.49	2.49	1.93	1.93	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	
	Unadj Prod	0.70	0.70	0.58	0.58	0.58	0.58	0.23	0.06	0.06	0.58	0.70	0.70	0.18
Snake R Little Goose Pool-A	Hab	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	
	Temp				0.00	0.00	0.00	3.49	3.55	3.55				
	Pred	1.89	1.89	2.45	2.45	2.45	2.45	2.45	2.45	2.45	2.45	1.89	1.89	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	
	Unadj Prod	0.71	0.71	0.60	0.60	0.60	0.60	0.19	0.17	0.17	0.60	0.71	0.71	0.19
Snake R Low Granite Pool-A	Hab	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	
	Temp				0.00	0.00	0.00	3.37	3.27	3.27				
	Pred	1.93	1.93	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	1.93	1.93	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	
	Unadj Prod	0.69	0.69	0.58	0.58	0.58	0.58	0.21	0.24	0.24	0.58	0.69	0.69	0.23
Columbia River Hanford Reach-A	Hab	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	

	Temp				0.00	0.00	0.00	2.55	3.83	3.83				
	Pred	1.72	1.72	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	1.72	1.72	
	CompH	0.00	0.00	0.00	0.00	0.00	1.85	1.24	0.00	0.00	0.00	0.00	0.00	
	CompO	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	
	Unadj Prod	0.82	0.82	0.73	0.73	0.73	0.64	0.49	0.08	0.08	0.73	0.82	0.82	0.47
Col R Priest Rapids Pool-A	Hab	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	
	Temp				0.00	0.00	0.00	2.68	3.70	3.70				
	Pred	2.04	2.04	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.04	2.04	
	CompH	0.00	0.00	0.00	0.00	0.00	1.15	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	
	Unadj Prod	0.65	0.65	0.52	0.52	0.52	0.51	0.35	0.10	0.10	0.52	0.65	0.65	0.35

Table C-1c. **Subyearling** biological performance attribute ratings for Columbia River and Snake River mainstem habitat under the **Current** condition and worldview **Technology Optimistic**.

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Col R Below Bonneville Dam to Estuary-A	Hab	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	
	Temp	0.00	0.00	0.00	0.00	0.00	0.00	2.57	3.00	3.00	0.00	0.00	0.00	
	Pred	1.28	1.28	1.66	1.66	1.90	1.90	1.66	1.66	1.66	1.66	1.28	1.28	
	CompH	0.83	0.83	0.83	0.83	1.24	1.66	1.49	1.24	1.24	0.83	0.83	0.83	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.90	0.90	0.86	0.86	0.79	0.75	0.56	0.45	0.45	0.86	0.90	0.90	0.63
Col R Bonneville Pool-A	Hab	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	
	Temp	0.00	0.00	0.00	0.00	0.00	0.00	2.56	2.95	2.95				
	Pred	1.47	1.47	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.47	1.47	
	CompH	1.24	1.24	1.24	1.24	1.24	0.83	1.24	0.83	0.83	1.24	1.24	1.24	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.81	0.81	0.75	0.75	0.75	0.77	0.53	0.43	0.43	0.75	0.81	0.81	0.62
Col R The Dalles Pool-A	Hab	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	
	Temp				0.00	0.00	0.00	2.56	2.95	2.95				
	Pred	1.47	1.47	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.47	1.47	
	CompH	0.00	0.00	0.00	0.00	0.83	1.24	0.83	0.83	0.83	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.85	0.85	0.78	0.78	0.77	0.75	0.54	0.43	0.43	0.78	0.85	0.85	0.61
Col R John Day Pool-A	Hab	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	
	Temp				0.00	0.00	0.00	2.59	3.02	3.02				
	Pred	1.47	1.47	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.47	1.47	
	CompH	0.00	0.00	0.00	0.00	0.00	1.24	0.83	0.83	0.83	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.85	0.85	0.78	0.78	0.78	0.75	0.53	0.41	0.41	0.78	0.85	0.85	0.61
Col R McNary Pool-A	Hab	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	
	Temp				0.00	0.00	0.00	2.50	2.90	2.90				
	Pred	1.47	1.47	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.47	1.47	
	CompH	0.00	0.00	0.00	0.00	1.24	1.24	0.83	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.85	0.85	0.78	0.78	0.75	0.75	0.56	0.45	0.45	0.78	0.85	0.85	0.62
Snake R Ice Harbor Pool-A	Hab	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	
	Temp				0.00	0.00	0.00	2.71	2.93	2.93				
	Pred	1.47	1.47	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.47	1.47	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.85	0.85	0.78	0.78	0.78	0.78	0.51	0.44	0.44	0.78	0.85	0.85	0.49
Snake R Low Monumental Pool-A	Hab	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	
	Temp				0.00	0.00	0.00	2.55	3.12	3.12				
	Pred	1.47	1.47	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.47	1.47	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.85	0.85	0.78	0.78	0.78	0.78	0.55	0.38	0.38	0.78	0.85	0.85	0.50
Snake R Little Goose Pool-A	Hab	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	
	Temp				0.00	0.00	0.00	2.71	2.76	2.76				
	Pred	1.47	1.47	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.47	1.47	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.85	0.85	0.78	0.78	0.78	0.78	0.51	0.50	0.50	0.78	0.85	0.85	0.51
Snake R Low Granite Pool-A	Hab	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	
	Temp				0.00	0.00	0.00	2.57	2.49	2.49				
	Pred	1.47	1.47	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.47	1.47	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.85	0.85	0.78	0.78	0.78	0.78	0.55	0.57	0.57	0.78	0.85	0.85	0.56
Columbia River Hanford Reach-A	Hab	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	

	Temp				0.00	0.00	0.00	1.71	2.56	2.56				
	Pred	1.15	1.15	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.15	1.15	
	CompH	0.00	0.00	0.00	0.00	0.00	1.24	0.83	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.94	0.94	0.90	0.90	0.90	0.87	0.80	0.63	0.63	0.90	0.94	0.94	0.82
Col R Priest Rapids Pool-A	Hab	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	
	Temp				0.00	0.00	0.00	1.93	2.67	2.67				
	Pred	1.47	1.47	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.47	1.47	
	CompH	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.85	0.85	0.78	0.78	0.78	0.77	0.67	0.52	0.52	0.78	0.85	0.85	0.70

Table C-2a. **Subyearling** biological performance attribute ratings for Columbia River and Snake River mainstem habitat under the **Historic** condition and worldview **Moderate**.

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Col R Below Bonneville Dam	Hab	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
to Estuary-A	Temp	0.00	0.00	0.00				2.60	3.30	2.94	0.00	0.00	0.00	
	Pred	1.16	1.16	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.16	1.16	
	CompH	0.00	0.00	0.00						0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.92	0.92	0.89	0.89	0.89	0.89	0.61	0.36	0.50	0.89	0.92	0.92	0.69
Col R Bonneville Pool-A	Hab	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Temp	0.00	0.00	0.00				2.60	3.30	3.14	0.00	0.00	0.00	
	Pred	1.16	1.16	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.16	1.16	
	CompH	0.00	0.00	0.00						0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.92	0.92	0.89	0.89	0.89	0.89	0.61	0.36	0.42	0.89	0.92	0.92	0.69
Col R The Dalles Pool-A	Hab	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	
	Temp							2.60	3.30	3.14	0.00	0.00	0.00	
	Pred	1.16	1.16	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.16	1.16	
	CompH	0.00	0.00	0.00						0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.90	0.90	0.86	0.86	0.86	0.86	0.59	0.35	0.41	0.86	0.90	0.90	0.68
Col R John Day Pool-A	Hab	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Temp							2.60	3.30	3.16	0.00	0.00	0.00	
	Pred	1.16	1.16	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.16	1.16	
	CompH	0.00	0.00	0.00						0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.92	0.92	0.89	0.89	0.89	0.89	0.61	0.36	0.42	0.89	0.92	0.92	0.69
Col R McNary Pool-A	Hab	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Temp							2.60	3.30	3.04	0.00	0.00	0.00	
	Pred	1.16	1.16	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.16	1.16	
	CompH	0.00	0.00	0.00						0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.92	0.92	0.89	0.89	0.89	0.89	0.61	0.36	0.46	0.89	0.92	0.92	0.69
Snake R Ice Harbor Pool-A	Hab	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Temp							2.80	3.40	3.08	0.00	0.00	0.00	
	Pred	1.16	1.16	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.16	1.16	
	CompH	0.00	0.00	0.00						0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.92	0.92	0.89	0.89	0.89	0.89	0.55	0.31	0.45	0.89	0.92	0.92	0.48
Snake R Low Monumental Pool-A	Hab	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	
	Temp							2.70	3.30	2.53	0.00	0.00	0.00	
	Pred	1.16	1.16	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.16	1.16	
	CompH	0.00	0.00	0.00						0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.90	0.90	0.86	0.86	0.86	0.86	0.56	0.35	0.61	0.86	0.90	0.90	0.50
Snake R Little Goose Pool-A	Hab	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	
	Temp							2.60	3.20	2.69	0.00	0.00	0.00	
	Pred	1.16	1.16	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.16	1.16	
	CompH	0.00	0.00	0.00						0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.90	0.90	0.86	0.86	0.86	0.86	0.59	0.39	0.57	0.86	0.90	0.90	0.53
Snake R Low Granite Pool-A	Hab	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	
	Temp							2.50	3.00	3.24	0.00	0.00	0.00	
	Pred	1.16	1.16	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.16	1.16	
	CompH	0.00	0.00	0.00						0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.90	0.90	0.86	0.86	0.86	0.86	0.62	0.47	0.37	0.86	0.90	0.90	0.57
Columbia River Hanford Reach-A	Hab	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

	Temp							1.80	2.80	2.41	0.00	0.00	0.00	
	Pred	1.16	1.16	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.16	1.16	
	CompH	0.00	0.00	0.00						0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.92	0.92	0.89	0.89	0.89	0.89	0.78	0.55	0.66	0.89	0.92	0.92	0.80
Col R Priest Rapids Pool-A	Hab	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Temp							1.80	2.80	2.60	0.00	0.00	0.00	
	Pred	1.16	1.16	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.16	1.16	
	CompH	0.00	0.00	0.00						0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.92	0.92	0.89	0.89	0.89	0.89	0.78	0.55	0.61	0.89	0.92	0.92	0.80

Table C-2b. **Subyearling** biological performance attribute ratings for Columbia River and Snake River mainstem habitat under the **Historic** condition and worldview **Technology Pessimistic**

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Col R Below Bonneville Dam	Hab	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	
to Estuary-A	Temp	0.00	0.00	0.00	0.00	0.00	0.00	2.92	3.71	3.71	0.00	0.00	0.00	
	Pred	1.30	1.30	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.30	1.30	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	
	Unadj Prod	0.89	0.89	0.85	0.85	0.85	0.85	0.48	0.16	0.16	0.85	0.89	0.89	0.59
Col R Bonneville Pool-A	Hab	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	
	Temp	0.00	0.00	0.00	0.00	0.00	0.00	2.93	3.72	3.72	0.00	0.00	0.00	
	Pred	1.31	1.31	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.31	1.31	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	
	Unadj Prod	0.89	0.89	0.84	0.84	0.84	0.84	0.48	0.15	0.15	0.84	0.89	0.89	0.59
Col R The Dalles Pool-A	Hab	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	
	Temp				0.00	0.00	0.00	2.92	3.71	3.71	0.00	0.00	0.00	
	Pred	1.30	1.30	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.30	1.30	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	
	Unadj Prod	0.86	0.86	0.82	0.82	0.82	0.82	0.47	0.15	0.15	0.82	0.86	0.86	0.58
Col R John Day Pool-A	Hab	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	
	Temp				0.00	0.00	0.00	2.92	3.70	3.70	0.00	0.00	0.00	
	Pred	1.30	1.30	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.30	1.30	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	
	Unadj Prod	0.89	0.89	0.85	0.85	0.85	0.85	0.48	0.16	0.16	0.85	0.89	0.89	0.60
Col R McNary Pool-A	Hab	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	
	Temp				0.00	0.00	0.00	2.93	3.72	3.72	0.00	0.00	0.00	
	Pred	1.31	1.31	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.31	1.31	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	
	Unadj Prod	0.89	0.89	0.84	0.84	0.84	0.84	0.48	0.15	0.15	0.84	0.89	0.89	0.59
Snake R Ice Harbor Pool-A	Hab	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	
	Temp				0.00	0.00	0.00	2.96	3.60	3.60	0.00	0.00	0.00	
	Pred	1.23	1.23	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.23	1.23	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	
	Unadj Prod	0.91	0.91	0.87	0.87	0.87	0.87	0.48	0.22	0.22	0.87	0.91	0.91	0.40
Snake R Low Monumental Pool-A	Hab	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	
	Temp				0.00	0.00	0.00	2.93	3.58	3.58	0.00	0.00	0.00	
	Pred	1.26	1.26	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.26	1.26	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	
	Unadj Prod	0.87	0.87	0.83	0.83	0.83	0.83	0.47	0.22	0.22	0.83	0.87	0.87	0.40
Snake R Little Goose Pool-A	Hab	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	
	Temp				0.00	0.00	0.00	2.77	3.41	3.41	0.00	0.00	0.00	
	Pred	1.24	1.24	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.24	1.24	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	
	Unadj Prod	0.88	0.88	0.84	0.84	0.84	0.84	0.53	0.30	0.30	0.84	0.88	0.88	0.46
Snake R Low Granite Pool-A	Hab	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	
	Temp				0.00	0.00	0.00	2.71	3.26	3.26	0.00	0.00	0.00	
	Pred	1.26	1.26	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.26	1.26	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	
	Unadj Prod	0.87	0.87	0.83	0.83	0.83	0.83	0.54	0.35	0.35	0.83	0.87	0.87	0.48
Columbia River Hanford Reach-A	Hab	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	

	Temp				0.00	0.00	0.00	2.22	3.46	3.46	0.00	0.00	0.00	
	Pred	1.43	1.43	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.43	1.43	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	
	Unadj Prod	0.86	0.86	0.80	0.80	0.80	0.80	0.64	0.26	0.26	0.80	0.86	0.86	0.64
Col R Priest Rapids Pool-A	Hab	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	
	Temp				0.00	0.00	0.00	2.07	3.22	3.22	0.00	0.00	0.00	
	Pred	1.33	1.33	1.72	1.72	1.72	1.72	1.72	1.72	1.72	1.72	1.33	1.33	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	
	Unadj Prod	0.88	0.88	0.84	0.84	0.84	0.84	0.70	0.37	0.37	0.84	0.88	0.88	0.70

Table C-2c. **Subyearling** biological performance attribute ratings for Columbia River and Snake River mainstem habitat under the **Historic** condition and worldview **Technology Optimistic**.

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Col R Below Bonneville Dam	Hab	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
to Estuary-A	Temp	0.00	0.00	0.00	0.00	0.00	0.00	2.15	2.73	2.73	0.00	0.00	0.00	
	Pred	0.96	0.96	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	0.96	0.96	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.95	0.95	0.93	0.93	0.93	0.93	0.76	0.60	0.60	0.93	0.95	0.95	0.81
Col R Bonneville Pool-A	Hab	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Temp	0.00	0.00	0.00	0.00	0.00	0.00	2.15	2.73	2.73	0.00	0.00	0.00	
	Pred	0.96	0.96	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	0.96	0.96	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.95	0.95	0.93	0.93	0.93	0.93	0.76	0.60	0.60	0.93	0.95	0.95	0.81
Col R The Dalles Pool-A	Hab	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	
	Temp				0.00	0.00	0.00	2.15	2.73	2.73	0.00	0.00	0.00	
	Pred	0.96	0.96	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	0.96	0.96	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.94	0.94	0.92	0.92	0.92	0.92	0.74	0.59	0.59	0.92	0.94	0.94	0.80
Col R John Day Pool-A	Hab	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Temp				0.00	0.00	0.00	2.15	2.73	2.73	0.00	0.00	0.00	
	Pred	0.96	0.96	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	0.96	0.96	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.95	0.95	0.93	0.93	0.93	0.93	0.76	0.60	0.60	0.93	0.95	0.95	0.81
Col R McNary Pool-A	Hab	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Temp				0.00	0.00	0.00	2.15	2.73	2.73	0.00	0.00	0.00	
	Pred	0.96	0.96	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	0.96	0.96	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.95	0.95	0.93	0.93	0.93	0.93	0.76	0.60	0.60	0.93	0.95	0.95	0.81
Snake R Ice Harbor Pool-A	Hab	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Temp				0.00	0.00	0.00	2.32	2.81	2.81	0.00	0.00	0.00	
	Pred	0.96	0.96	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	0.96	0.96	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.95	0.95	0.93	0.93	0.93	0.93	0.72	0.57	0.57	0.93	0.95	0.95	0.67
Snake R Low Monumental Pool-A	Hab	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	
	Temp				0.00	0.00	0.00	2.23	2.73	2.73	0.00	0.00	0.00	
	Pred	0.96	0.96	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	0.96	0.96	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.94	0.94	0.92	0.92	0.92	0.92	0.73	0.59	0.59	0.92	0.94	0.94	0.69
Snake R Little Goose Pool-A	Hab	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	
	Temp				0.00	0.00	0.00	2.15	2.65	2.65	0.00	0.00	0.00	
	Pred	0.96	0.96	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	0.96	0.96	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.94	0.94	0.92	0.92	0.92	0.92	0.74	0.62	0.62	0.92	0.94	0.94	0.71
Snake R Low Granite Pool-A	Hab	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	
	Temp				0.00	0.00	0.00	2.07	2.48	2.48	0.00	0.00	0.00	
	Pred	0.96	0.96	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	0.96	0.96	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.94	0.94	0.92	0.92	0.92	0.92	0.76	0.66	0.66	0.92	0.94	0.94	0.73
Columbia River Hanford Reach-A	Hab	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	

	Temp				0.00	0.00	0.00	1.49	2.32	2.32	0.00	0.00	0.00	
	Pred	0.96	0.96	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	0.96	0.96	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.95	0.95	0.93	0.93	0.93	0.93	0.87	0.72	0.72	0.93	0.95	0.95	0.90
Col R Priest Rapids Pool-A	Hab	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Temp				0.00	0.00	0.00	1.49	2.32	2.32	0.00	0.00	0.00	
	Pred	0.96	0.96	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	0.96	0.96	
	CompH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.95	0.95	0.93	0.93	0.93	0.93	0.87	0.72	0.72	0.93	0.95	0.95	0.90

Table C-3a. **Subyearling** biological performance attribute ratings for Columbia River and Snake River mainstem habitat under the **Alternative 2** condition and worldview **Moderate**.

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Col R Below Bonneville Dam to Estuary-A	Hab	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
	Temp	0.00	0.00	0.00	0.00	0.00	0.00	3.18	3.68	3.29	0.00	0.00	0.00	
	Pred	1.70	1.70	2.20	2.20	2.20	2.20	2.30	2.30	2.30	2.30	1.78	1.78	
	CompH	1.00	1.00	1.00	1.00	1.50	2.00	1.80	1.50	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.82	0.82	0.73	0.73	0.70	0.63	0.30	0.14	0.30	0.73	0.83	0.83	0.42
Col R Bonneville Pool-A	Hab	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	
	Temp	0.00	0.00	0.00	0.00	0.00	0.00	3.09	3.56	3.39	0.00	0.00	0.00	
	Pred	1.57	1.57	2.02	2.02	2.02	2.02	2.12	2.12	2.12	2.12	1.64	1.64	
	CompH	1.50	1.50	1.50	1.50	1.50	1.00	1.50	1.00	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.74	0.74	0.68	0.68	0.68	0.71	0.33	0.19	0.26	0.71	0.79	0.79	0.47
Col R The Dalles Pool-A	Hab	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
	Temp				0.00	0.00	0.00	3.09	3.56	3.39	0.00	0.00	0.00	
	Pred	1.78	1.78	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	1.78	1.78	
	CompH	0.00	0.00	0.00	0.00	1.00	1.50	1.00	1.00	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.75	0.75	0.66	0.66	0.64	0.61	0.32	0.17	0.24	0.66	0.75	0.75	0.42
Col R John Day Pool-A	Hab	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	
	Temp				0.00	0.00	0.00	2.96	3.57	3.41	0.00	0.00	0.00	
	Pred	1.42	1.42	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.42	1.42	
	CompH	0.00	0.00	0.00	0.00	0.00	1.60	1.00	1.00	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.85	0.85	0.79	0.79	0.79	0.73	0.43	0.21	0.28	0.79	0.85	0.85	0.53
Col R McNary Pool-A	Hab	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	
	Temp				0.00	0.00	0.00	2.85	3.43	3.15	0.00	0.00	0.00	
	Pred	1.78	1.78	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	1.78	1.78	
	CompH	0.00	0.00	0.00	0.00	1.60	1.60	1.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.77	0.77	0.67	0.67	0.61	0.61	0.39	0.23	0.32	0.67	0.77	0.77	0.46
Snake R Ice Harbor Pool-A	Hab	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	
	Temp				0.00	0.00	0.00	2.81	3.81	3.45	0.00	0.00	0.00	
	Pred	1.42	1.42	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.42	1.42	
	CompH	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.83	0.83	0.78	0.78	0.76	0.76	0.48	0.10	0.26	0.78	0.83	0.83	0.36
Snake R Low Monumental Pool-A	Hab	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	
	Temp				0.00	0.00	0.00	2.81	3.90	2.99	0.00	0.00	0.00	
	Pred	1.42	1.42	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.42	1.42	
	CompH	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.83	0.83	0.78	0.78	0.76	0.76	0.48	0.05	0.42	0.78	0.83	0.83	0.34
Snake R Little Goose Pool-A	Hab	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	
	Temp				0.00	0.00	0.00	2.81	3.62	3.05	0.00	0.00	0.00	
	Pred	1.42	1.42	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.42	1.42	
	CompH	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.83	0.83	0.78	0.78	0.76	0.76	0.48	0.18	0.40	0.78	0.83	0.83	0.39
Snake R Low Granite Pool-A	Hab	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	
	Temp				0.00	0.00	0.00	2.81	3.35	3.62	0.00	0.00	0.00	
	Pred	1.42	1.42	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.42	1.42	
	CompH	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.83	0.83	0.78	0.78	0.76	0.76	0.48	0.30	0.18	0.78	0.83	0.83	0.42
Columbia River Hanford Reach-A	Hab	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

	Temp				0.00	0.00	0.00	1.90	2.90	2.50	0.00	0.00	0.00	
	Pred	1.39	1.39	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.39	1.39	
	CompH	0.00	0.00	0.00	0.00	1.00	1.60	1.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.90	0.90	0.84	0.84	0.82	0.77	0.71	0.49	0.61	0.84	0.90	0.90	0.72
Col R Priest Rapids Pool-A	Hab	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
	Temp				0.00	0.00	0.00	2.10	3.00	2.78	0.00	0.00	0.00	
	Pred	1.78	1.78	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	1.78	1.78	
	CompH	0.00	0.00	0.00	0.00	1.00	1.50	1.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.75	0.75	0.66	0.66	0.64	0.61	0.53	0.35	0.41	0.66	0.75	0.75	0.54

Table C-3b. **Subyearling** biological performance attribute ratings for Columbia River and Snake River mainstem habitat under the **Alternative 2** condition and worldview **Technology Pessimistic**

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Col R Below Bonneville Dam	Hab	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	
to Estuary-A	Temp	0.00	0.00	0.00	0.00	0.00	0.00	3.57	3.85	3.85	0.00	0.00	0.00	
	Pred	1.52	1.52	1.97	1.97	2.27	2.27	1.97	1.97	1.97	1.97	1.52	1.52	
	CompH	1.12	1.12	1.12	1.12	1.69	2.25	2.02	1.69	0.00	0.00	0.00	0.00	
	CompO	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	
	Unadj Prod	0.82	0.82	0.75	0.75	0.65	0.57	0.17	0.07	0.08	0.78	0.85	0.85	0.32
Col R Bonneville Pool-A	Hab	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	
	Temp	0.00	0.00	0.00	0.00	0.00	0.00	3.49	3.85	3.85	0.00	0.00	0.00	
	Pred	1.77	1.77	2.28	2.28	2.28	2.28	2.39	2.39	2.39	2.39	1.85	1.85	
	CompH	1.69	1.69	1.69	1.69	1.69	1.13	1.69	1.13	0.00	0.00	0.00	0.00	
	CompO	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	
	Unadj Prod	0.65	0.65	0.57	0.57	0.57	0.61	0.17	0.06	0.06	0.61	0.71	0.71	0.34
Col R The Dalles Pool-A	Hab	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	
	Temp				0.00	0.00	0.00	3.47	3.85	3.85	0.00	0.00	0.00	
	Pred	2.00	2.00	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.00	2.00	
	CompH	0.00	0.00	0.00	0.00	1.12	1.68	1.12	1.12	0.00	0.00	0.00	0.00	
	CompO	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	
	Unadj Prod	0.67	0.67	0.55	0.55	0.53	0.49	0.17	0.05	0.05	0.55	0.67	0.67	0.29
Col R John Day Pool-A	Hab	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	
	Temp				0.00	0.00	0.00	3.32	3.85	3.85	0.00	0.00	0.00	
	Pred	1.60	1.60	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	1.60	1.60	
	CompH	0.00	0.00	0.00	0.00	0.00	1.80	1.12	1.12	0.00	0.00	0.00	0.00	
	CompO	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	
	Unadj Prod	0.80	0.80	0.72	0.72	0.72	0.64	0.28	0.07	0.07	0.72	0.80	0.80	0.40
Col R McNary Pool-A	Hab	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	
	Temp				0.00	0.00	0.00	3.21	3.85	3.85	0.00	0.00	0.00	
	Pred	2.00	2.00	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.00	2.00	
	CompH	0.00	0.00	0.00	0.00	1.80	1.80	1.13	0.00	0.00	0.00	0.00	0.00	
	CompO	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	
	Unadj Prod	0.69	0.69	0.56	0.56	0.50	0.50	0.24	0.06	0.06	0.56	0.69	0.69	0.33
Snake R Ice Harbor Pool-A	Hab	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74	
	Temp				0.00	0.00	0.00	2.97	3.85	3.85	0.00	0.00	0.00	
	Pred	1.51	1.51	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.51	1.51	
	CompH	0.00	0.00	0.00	0.00	1.06	1.06	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	
	Unadj Prod	0.81	0.81	0.75	0.75	0.72	0.72	0.41	0.07	0.07	0.75	0.81	0.81	0.31
Snake R Low Monumental Pool-A	Hab	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	
	Temp				0.00	0.00	0.00	3.04	3.85	3.85	0.00	0.00	0.00	
	Pred	1.54	1.54	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.54	1.54	
	CompH	0.00	0.00	0.00	0.00	1.08	1.08	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	
	Unadj Prod	0.80	0.80	0.73	0.73	0.71	0.71	0.38	0.07	0.07	0.73	0.80	0.80	0.29
Snake R Little Goose Pool-A	Hab	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	
	Temp				0.00	0.00	0.00	2.99	3.85	3.85	0.00	0.00	0.00	
	Pred	1.52	1.52	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.52	1.52	
	CompH	0.00	0.00	0.00	0.00	1.06	1.06	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	
	Unadj Prod	0.80	0.80	0.74	0.74	0.72	0.72	0.40	0.07	0.07	0.74	0.80	0.80	0.30
Snake R Low Granite Pool-A	Hab	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	
	Temp				0.00	0.00	0.00	3.05	3.63	3.63	0.00	0.00	0.00	
	Pred	1.55	1.55	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.55	1.55	
	CompH	0.00	0.00	0.00	0.00	1.09	1.09	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	
	Unadj Prod	0.79	0.79	0.73	0.73	0.71	0.71	0.38	0.17	0.17	0.73	0.79	0.79	0.32
Columbia River Hanford Reach-A	Hab	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	

	Temp				0.00	0.00	0.00	2.35	3.58	3.58	0.00	0.00	0.00	
	Pred	1.72	1.72	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	1.72	1.72	
	CompH	0.00	0.00	0.00	0.00	1.24	1.98	1.24	0.00	0.00	0.00	0.00	0.00	
	CompO	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	
	Unadj Prod	0.82	0.82	0.73	0.73	0.70	0.62	0.53	0.19	0.19	0.73	0.82	0.82	0.51
Col R Priest Rapids Pool-A	Hab	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	
	Temp				0.00	0.00	0.00	2.41	3.44	3.44	0.00	0.00	0.00	
	Pred	2.04	2.04	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.04	2.04	
	CompH	0.00	0.00	0.00	0.00	1.15	1.72	1.15	0.00	0.00	0.00	0.00	0.00	
	CompO	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	
	Unadj Prod	0.65	0.65	0.52	0.52	0.51	0.47	0.38	0.17	0.17	0.52	0.65	0.65	0.38

Table C-3c. **Subyearling** biological performance attribute ratings for Columbia River and Snake River mainstem habitat under the **Alternative 2** condition and worldview **Technology Optimistic**.

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Col R Below Bonneville Dam to Estuary-A	Hab	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	
	Temp	0.00	0.00	0.00	0.00	0.00	0.00	2.63	3.05	3.05	0.00	0.00	0.00	
	Pred	1.12	1.12	1.45	1.45	1.67	1.67	1.45	1.45	1.45	1.45	1.12	1.12	
	CompH	0.83	0.83	0.83	0.83	1.24	1.66	1.49	1.24	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.92	0.92	0.89	0.89	0.83	0.79	0.57	0.45	0.47	0.90	0.93	0.93	0.64
Col R Bonneville Pool-A	Hab	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	
	Temp	0.00	0.00	0.00	0.00	0.00	0.00	2.56	2.95	2.95	0.00	0.00	0.00	
	Pred	1.30	1.30	1.68	1.68	1.68	1.68	1.75	1.75	1.75	1.75	1.35	1.35	
	CompH	1.24	1.24	1.24	1.24	1.24	0.83	1.24	0.83	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.84	0.84	0.80	0.80	0.80	0.82	0.55	0.45	0.46	0.82	0.87	0.87	0.65
Col R The Dalles Pool-A	Hab	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	
	Temp				0.00	0.00	0.00	2.56	2.95	2.95	0.00	0.00	0.00	
	Pred	1.47	1.47	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.47	1.47	
	CompH	0.00	0.00	0.00	0.00	0.83	1.24	0.83	0.83	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.85	0.85	0.78	0.78	0.77	0.75	0.54	0.43	0.44	0.78	0.85	0.85	0.61
Col R John Day Pool-A	Hab	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	
	Temp				0.00	0.00	0.00	2.45	2.95	2.95	0.00	0.00	0.00	
	Pred	1.18	1.18	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.18	1.18	
	CompH	0.00	0.00	0.00	0.00	0.00	1.32	0.83	0.83	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.91	0.91	0.87	0.87	0.87	0.83	0.63	0.48	0.49	0.87	0.91	0.91	0.70
Col R McNary Pool-A	Hab	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	
	Temp				0.00	0.00	0.00	2.36	2.84	2.84	0.00	0.00	0.00	
	Pred	1.47	1.47	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.47	1.47	
	CompH	0.00	0.00	0.00	0.00	1.32	1.32	0.83	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.86	0.86	0.79	0.79	0.75	0.75	0.59	0.48	0.48	0.79	0.86	0.86	0.65
Snake R Ice Harbor Pool-A	Hab	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	
	Temp				0.00	0.00	0.00	2.32	3.15	3.15	0.00	0.00	0.00	
	Pred	1.18	1.18	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.18	1.18	
	CompH	0.00	0.00	0.00	0.00	0.83	0.83	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.90	0.90	0.86	0.86	0.85	0.85	0.66	0.41	0.41	0.86	0.90	0.90	0.58
Snake R Low Monumental Pool-A	Hab	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	
	Temp				0.00	0.00	0.00	2.32	3.23	3.23	0.00	0.00	0.00	
	Pred	1.18	1.18	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.18	1.18	
	CompH	0.00	0.00	0.00	0.00	0.83	0.83	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.90	0.90	0.86	0.86	0.85	0.85	0.66	0.38	0.38	0.86	0.90	0.90	0.57
Snake R Little Goose Pool-A	Hab	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	
	Temp				0.00	0.00	0.00	2.32	3.00	3.00	0.00	0.00	0.00	
	Pred	1.18	1.18	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.18	1.18	
	CompH	0.00	0.00	0.00	0.00	0.83	0.83	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.90	0.90	0.86	0.86	0.85	0.85	0.66	0.47	0.47	0.86	0.90	0.90	0.60
Snake R Low Granite Pool-A	Hab	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	
	Temp				0.00	0.00	0.00	2.32	2.77	2.77	0.00	0.00	0.00	
	Pred	1.18	1.18	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.18	1.18	
	CompH	0.00	0.00	0.00	0.00	0.83	0.83	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.90	0.90	0.86	0.86	0.85	0.85	0.66	0.54	0.54	0.86	0.90	0.90	0.63
Columbia River Hanford Reach-A	Hab	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	

	Temp				0.00	0.00	0.00	1.57	2.40	2.40	0.00	0.00	0.00	
	Pred	1.15	1.15	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.15	1.15	
	CompH	0.00	0.00	0.00	0.00	0.83	1.32	0.83	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.94	0.94	0.90	0.90	0.89	0.86	0.82	0.68	0.68	0.90	0.94	0.94	0.84
Col R Priest Rapids Pool-A	Hab	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	
	Temp				0.00	0.00	0.00	1.74	2.48	2.48	0.00	0.00	0.00	
	Pred	1.47	1.47	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.47	1.47	
	CompH	0.00	0.00	0.00	0.00	0.83	1.24	0.83	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.85	0.85	0.78	0.78	0.77	0.75	0.69	0.57	0.57	0.78	0.85	0.85	0.72

Table C-4a. **Subyearling** biological performance attribute ratings for Columbia River and Snake River mainstem habitat under the **Alternative 5** condition and worldview **Moderate**.

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Col R Below Bonneville Dam	Hab	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
to Estuary-A	Temp	0.00	0.00	0.00	0.00	0.00	0.00	3.18	3.68	3.29	0.00	0.00	0.00	
	Pred	1.62	1.62	2.10	2.10	2.10	2.10	2.20	2.20	2.20	2.20	1.70	1.70	
	CompH	1.00	1.00	1.00	1.00	1.70	2.30	1.80	1.50	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.83	0.83	0.75	0.75	0.70	0.60	0.31	0.14	0.31	0.75	0.84	0.84	0.41
Col R Bonneville Pool-A	Hab	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	
	Temp	0.00	0.00	0.00	0.00	0.00	0.00	3.09	3.56	3.39	0.00	0.00	0.00	
	Pred	1.49	1.49	1.93	1.93	1.93	1.93	2.02	2.02	2.02	2.02	1.57	1.57	
	CompH	1.50	1.50	1.50	1.50	1.70	1.50	1.50	1.00	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.75	0.75	0.69	0.69	0.67	0.69	0.34	0.19	0.26	0.73	0.80	0.80	0.47
Col R The Dalles Pool-A	Hab	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
	Temp				0.00	0.00	0.00	3.09	3.56	3.39	0.00	0.00	0.00	
	Pred	1.64	1.64	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	1.64	1.64	
	CompH	0.00	0.00	0.00	0.00	1.40	1.80	1.00	1.00	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.77	0.77	0.69	0.69	0.65	0.61	0.34	0.18	0.25	0.69	0.77	0.77	0.43
Col R John Day Pool-A	Hab	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	
	Temp				0.00	0.00	0.00	3.13	3.65	3.49	0.00	0.00	0.00	
	Pred	1.64	1.64	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	1.64	1.64	
	CompH	0.00	0.00	0.00	0.00	1.20	1.70	1.50	1.00	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.79	0.79	0.71	0.71	0.68	0.64	0.32	0.15	0.22	0.71	0.79	0.79	0.43
Col R McNary Pool-A	Hab	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	
	Temp				0.00	0.00	0.00	3.02	3.51	3.23	0.00	0.00	0.00	
	Pred	1.64	1.64	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	1.64	1.64	
	CompH	0.00	0.00	0.00	0.00	2.00	1.90	1.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.79	0.79	0.71	0.71	0.60	0.61	0.37	0.21	0.31	0.71	0.79	0.79	0.45
Snake R Ice Harbor Pool-A	Hab	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	
	Temp				0.00	0.00	0.00	3.28	3.54	3.21	0.00	0.00	0.00	
	Pred	1.64	1.64	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	1.64	1.64	
	CompH	0.00	0.00	0.00	0.00	1.20	1.20	1.20	1.20	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.80	0.80	0.72	0.72	0.69	0.69	0.29	0.19	0.32	0.72	0.80	0.80	0.27
Snake R Low Monumental Pool-A	Hab	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	
	Temp				0.00	0.00	0.00	3.08	3.77	2.90	0.00	0.00	0.00	
	Pred	1.64	1.64	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	1.64	1.64	
	CompH	0.00	0.00	0.00	0.00	1.20	1.20	1.20	1.20	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.80	0.80	0.72	0.72	0.69	0.69	0.35	0.10	0.42	0.72	0.80	0.80	0.27
Snake R Little Goose Pool-A	Hab	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	
	Temp				0.00	0.00	0.00	3.28	3.33	2.80	0.00	0.00	0.00	
	Pred	1.64	1.64	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	1.64	1.64	
	CompH	0.00	0.00	0.00	0.00	1.20	1.20	1.20	1.20	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.80	0.80	0.72	0.72	0.69	0.69	0.29	0.27	0.44	0.72	0.80	0.80	0.29
Snake R Low Granite Pool-A	Hab	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	
	Temp				0.00	0.00	0.00	3.11	3.01	3.26	0.00	0.00	0.00	
	Pred	1.64	1.64	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	1.64	1.64	
	CompH	0.00	0.00	0.00	0.00	1.20	1.20	1.20	1.20	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.80	0.80	0.72	0.72	0.69	0.69	0.34	0.37	0.31	0.72	0.80	0.80	0.36
Columbia River Hanford Reach-A	Hab	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

	Temp				0.00	0.00	0.00	2.06	3.10	2.66	0.00	0.00	0.00	
	Pred	1.39	1.39	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.39	1.39	
	CompH	0.00	0.00	0.00	0.00	0.00	1.80	1.20	0.00	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.90	0.90	0.84	0.84	0.84	0.75	0.67	0.42	0.56	0.84	0.90	0.90	0.68
Col R Priest Rapids Pool-A	Hab	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
	Temp				0.00	0.00	0.00	2.33	3.22	2.99	0.00	0.00	0.00	
	Pred	1.64	1.64	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	1.64	1.64	
	CompH	0.00	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.77	0.77	0.69	0.69	0.69	0.67	0.53	0.31	0.38	0.69	0.77	0.77	0.55

Table C-4b. **Subyearling** biological performance attribute ratings for Columbia River and Snake River mainstem habitat under the **Alternative 5** condition and worldview **Technology Pessimistic**

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Col R Below Bonneville Dam	Hab	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	
to Estuary-A	Temp	0.00	0.00	0.00	0.00	0.00	0.00	3.57	3.85	3.85	0.00	0.00	0.00	
	Pred	1.52	1.52	1.97	1.97	2.27	2.27	1.97	1.97	1.97	1.97	1.52	1.52	
	CompH	1.12	1.12	1.12	1.12	1.91	2.59	2.02	1.69	0.00	0.00	0.00	0.00	
	CompO	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	
	Unadj Prod	0.82	0.82	0.75	0.75	0.62	0.50	0.17	0.07	0.08	0.78	0.85	0.85	0.29
Col R Bonneville Pool-A	Hab	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	
	Temp	0.00	0.00	0.00	0.00	0.00	0.00	3.49	3.85	3.85	0.00	0.00	0.00	
	Pred	1.69	1.69	2.18	2.18	2.18	2.18	2.28	2.28	2.28	2.28	1.77	1.77	
	CompH	1.69	1.69	1.69	1.69	1.92	1.69	1.69	1.13	0.00	0.00	0.00	0.00	
	CompO	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	
	Unadj Prod	0.66	0.66	0.59	0.59	0.57	0.59	0.18	0.06	0.06	0.63	0.72	0.72	0.33
Col R The Dalles Pool-A	Hab	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	
	Temp				0.00	0.00	0.00	3.47	3.85	3.85	0.00	0.00	0.00	
	Pred	1.84	1.84	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38	1.84	1.84	
	CompH	0.00	0.00	0.00	0.00	1.57	2.02	1.12	1.12	0.00	0.00	0.00	0.00	
	CompO	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	
	Unadj Prod	0.69	0.69	0.60	0.60	0.55	0.50	0.18	0.06	0.06	0.60	0.69	0.69	0.30
Col R John Day Pool-A	Hab	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	
	Temp				0.00	0.00	0.00	3.52	3.85	3.85	0.00	0.00	0.00	
	Pred	1.84	1.84	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38	1.84	1.84	
	CompH	0.00	0.00	0.00	0.00	1.35	1.91	1.68	1.12	0.00	0.00	0.00	0.00	
	CompO	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	
	Unadj Prod	0.72	0.72	0.62	0.62	0.58	0.53	0.16	0.06	0.06	0.62	0.72	0.72	0.30
Col R McNary Pool-A	Hab	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	
	Temp				0.00	0.00	0.00	3.40	3.85	3.85	0.00	0.00	0.00	
	Pred	1.84	1.84	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38	1.84	1.84	
	CompH	0.00	0.00	0.00	0.00	2.25	2.14	1.13	0.00	0.00	0.00	0.00	0.00	
	CompO	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	
	Unadj Prod	0.71	0.71	0.61	0.61	0.48	0.50	0.21	0.06	0.06	0.61	0.71	0.71	0.31
Snake R Ice Harbor Pool-A	Hab	1.81	1.81	1.81	1.81	1.81	1.81	1.81	1.81	1.81	1.81	1.81	1.81	
	Temp				0.00	0.00	0.00	3.47	3.75	3.75	0.00	0.00	0.00	
	Pred	1.73	1.73	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	1.73	1.73	
	CompH	0.00	0.00	0.00	0.00	1.27	1.27	1.27	1.27	0.00	0.00	0.00	0.00	
	CompO	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	
	Unadj Prod	0.77	0.77	0.68	0.68	0.65	0.65	0.21	0.10	0.11	0.68	0.77	0.77	0.18
Snake R Low Monumental Pool-A	Hab	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	
	Temp				0.00	0.00	0.00	3.34	3.85	3.85	0.00	0.00	0.00	
	Pred	1.77	1.77	2.29	2.29	2.29	2.29	2.29	2.29	2.29	2.29	1.77	1.77	
	CompH	0.00	0.00	0.00	0.00	1.30	1.30	1.30	1.30	0.00	0.00	0.00	0.00	
	CompO	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	
	Unadj Prod	0.75	0.75	0.66	0.66	0.63	0.63	0.24	0.06	0.07	0.66	0.75	0.75	0.19
Snake R Little Goose Pool-A	Hab	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	
	Temp				0.00	0.00	0.00	3.49	3.55	3.55	0.00	0.00	0.00	
	Pred	1.74	1.74	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	1.74	1.74	
	CompH	0.00	0.00	0.00	0.00	1.28	1.28	1.28	1.28	0.00	0.00	0.00	0.00	
	CompO	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	
	Unadj Prod	0.77	0.77	0.67	0.67	0.64	0.64	0.20	0.18	0.19	0.67	0.77	0.77	0.20
Snake R Low Granite Pool-A	Hab	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	
	Temp				0.00	0.00	0.00	3.37	3.27	3.27	0.00	0.00	0.00	
	Pred	1.78	1.78	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	1.78	1.78	
	CompH	0.00	0.00	0.00	0.00	1.30	1.30	1.30	1.30	0.00	0.00	0.00	0.00	
	CompO	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	
	Unadj Prod	0.75	0.75	0.66	0.66	0.63	0.63	0.23	0.26	0.28	0.66	0.75	0.75	0.25
Columbia River Hanford Reach-A	Hab	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	

	Temp				0.00	0.00	0.00	2.55	3.83	3.83	0.00	0.00	0.00	
	Pred	1.72	1.72	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	1.72	1.72	
	CompH	0.00	0.00	0.00	0.00	0.00	2.22	1.48	0.00	0.00	0.00	0.00	0.00	
	CompO	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	
	Unadj Prod	0.82	0.82	0.73	0.73	0.73	0.58	0.48	0.08	0.08	0.73	0.82	0.82	0.45
Col R Priest Rapids Pool-A	Hab	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	
	Temp				0.00	0.00	0.00	2.68	3.70	3.70	0.00	0.00	0.00	
	Pred	1.88	1.88	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	1.88	1.88	
	CompH	0.00	0.00	0.00	0.00	0.00	1.38	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	
	Unadj Prod	0.68	0.68	0.58	0.58	0.58	0.54	0.38	0.11	0.11	0.58	0.68	0.68	0.39

Table C-4c. **Subyearling** biological performance attribute ratings for Columbia River and Snake River mainstem habitat under the **Alternative 5** condition and worldview **Technology Optimistic**.

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Col R Below Bonneville Dam	Hab	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	
to Estuary-A	Temp	0.00	0.00	0.00	0.00	0.00	0.00	2.63	3.05	3.05	0.00	0.00	0.00	
	Pred	1.12	1.12	1.45	1.45	1.67	1.67	1.45	1.45	1.45	1.45	1.12	1.12	
	CompH	0.83	0.83	0.83	0.83	1.41	1.90	1.49	1.24	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.92	0.92	0.89	0.89	0.82	0.75	0.57	0.45	0.47	0.90	0.93	0.93	0.63
Col R Bonneville Pool-A	Hab	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	
	Temp	0.00	0.00	0.00	0.00	0.00	0.00	2.56	2.95	2.95	0.00	0.00	0.00	
	Pred	1.24	1.24	1.60	1.60	1.60	1.60	1.68	1.68	1.68	1.68	1.30	1.30	
	CompH	1.24	1.24	1.24	1.24	1.41	1.24	1.24	0.83	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.84	0.84	0.81	0.81	0.79	0.81	0.56	0.46	0.47	0.83	0.87	0.87	0.65
Col R The Dalles Pool-A	Hab	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	
	Temp				0.00	0.00	0.00	2.56	2.95	2.95	0.00	0.00	0.00	
	Pred	1.35	1.35	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.35	1.35	
	CompH	0.00	0.00	0.00	0.00	1.16	1.49	0.83	0.83	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.86	0.86	0.81	0.81	0.78	0.75	0.56	0.45	0.45	0.81	0.86	0.86	0.63
Col R John Day Pool-A	Hab	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	
	Temp				0.00	0.00	0.00	2.59	3.02	3.02	0.00	0.00	0.00	
	Pred	1.35	1.35	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.35	1.35	
	CompH	0.00	0.00	0.00	0.00	0.99	1.41	1.24	0.83	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.87	0.87	0.82	0.82	0.80	0.77	0.54	0.43	0.44	0.82	0.87	0.87	0.62
Col R McNary Pool-A	Hab	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	
	Temp				0.00	0.00	0.00	2.50	2.90	2.90	0.00	0.00	0.00	
	Pred	1.35	1.35	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.35	1.35	
	CompH	0.00	0.00	0.00	0.00	1.66	1.57	0.83	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.87	0.87	0.82	0.82	0.74	0.75	0.58	0.48	0.48	0.82	0.87	0.87	0.64
Snake R Ice Harbor Pool-A	Hab	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	
	Temp				0.00	0.00	0.00	2.71	2.93	2.93	0.00	0.00	0.00	
	Pred	1.35	1.35	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.35	1.35	
	CompH	0.00	0.00	0.00	0.00	0.99	0.99	0.99	0.99	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.88	0.88	0.83	0.83	0.81	0.81	0.52	0.46	0.47	0.83	0.88	0.88	0.51
Snake R Low Monumental Pool-A	Hab	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	
	Temp				0.00	0.00	0.00	2.55	3.12	3.12	0.00	0.00	0.00	
	Pred	1.35	1.35	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.35	1.35	
	CompH	0.00	0.00	0.00	0.00	0.99	0.99	0.99	0.99	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.88	0.88	0.83	0.83	0.81	0.81	0.57	0.39	0.40	0.83	0.88	0.88	0.52
Snake R Little Goose Pool-A	Hab	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	
	Temp				0.00	0.00	0.00	2.71	2.76	2.76	0.00	0.00	0.00	
	Pred	1.35	1.35	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.35	1.35	
	CompH	0.00	0.00	0.00	0.00	0.99	0.99	0.99	0.99	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.88	0.88	0.83	0.83	0.81	0.81	0.52	0.51	0.52	0.83	0.88	0.88	0.53
Snake R Low Granite Pool-A	Hab	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	
	Temp				0.00	0.00	0.00	2.57	2.49	2.49	0.00	0.00	0.00	
	Pred	1.35	1.35	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.35	1.35	
	CompH	0.00	0.00	0.00	0.00	0.99	0.99	0.99	0.99	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.88	0.88	0.83	0.83	0.81	0.81	0.56	0.58	0.60	0.83	0.88	0.88	0.57
Columbia River Hanford Reach-A	Hab	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	

	Temp				0.00	0.00	0.00	1.71	2.56	2.56	0.00	0.00	0.00	
	Pred	1.15	1.15	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.15	1.15	
	CompH	0.00	0.00	0.00	0.00	0.00	1.49	0.99	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.94	0.94	0.90	0.90	0.90	0.84	0.79	0.63	0.63	0.90	0.94	0.94	0.81
Col R Priest Rapids Pool-A	Hab	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	
	Temp				0.00	0.00	0.00	1.93	2.67	2.67	0.00	0.00	0.00	
	Pred	1.35	1.35	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.35	1.35	
	CompH	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.86	0.86	0.81	0.81	0.81	0.79	0.70	0.54	0.54	0.81	0.86	0.86	0.72

Table C-5a. **Subyearling** biological performance attribute ratings for Columbia River and Snake River mainstem habitat under the **Alternative 6** condition and worldview **Moderate**.

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Col R Below Bonneville Dam to Estuary-A	Hab	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	
	Temp	0.00	0.00	0.00	0.00	0.00	0.00	3.18	3.68	3.29	0.00	0.00	0.00	
	Pred	1.62	1.62	2.10	2.10	2.10	2.10	2.20	2.20	2.20	2.20	1.70	1.70	
	CompH	1.00	1.00	1.00	1.00	1.70	2.30	1.80	1.50	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.83	0.83	0.75	0.75	0.69	0.59	0.30	0.14	0.31	0.74	0.84	0.84	0.40
Col R Bonneville Pool-A	Hab	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
	Temp	0.00	0.00	0.00	0.00	0.00	0.00	3.09	3.56	3.39	0.00	0.00	0.00	
	Pred	1.49	1.49	1.93	1.93	1.93	1.93	2.02	2.02	2.02	2.02	1.57	1.57	
	CompH	1.50	1.50	1.50	1.50	1.70	1.50	1.50	1.00	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.73	0.73	0.68	0.68	0.65	0.68	0.33	0.19	0.26	0.71	0.78	0.78	0.45
Col R The Dalles Pool-A	Hab	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
	Temp				0.00	0.00	0.00	3.09	3.56	3.39	0.00	0.00	0.00	
	Pred	1.49	1.49	1.93	1.93	1.93	1.93	2.02	2.02	2.02	2.02	1.57	1.57	
	CompH	0.00	0.00	0.00	0.00	1.40	1.80	1.00	1.00	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.79	0.79	0.73	0.73	0.68	0.64	0.35	0.19	0.26	0.71	0.78	0.78	0.45
Col R John Day Pool-A	Hab	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
	Temp				0.00	0.00	0.00	3.13	3.65	3.49	0.00	0.00	0.00	
	Pred	1.49	1.49	1.93	1.93	1.93	1.93	2.02	2.02	2.02	2.02	1.57	1.57	
	CompH	0.00	0.00	0.00	0.00	1.20	1.70	1.50	1.00	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.79	0.79	0.73	0.73	0.70	0.65	0.32	0.15	0.22	0.71	0.78	0.78	0.44
Col R McNary Pool-A	Hab	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
	Temp				0.00	0.00	0.00	3.02	3.51	3.23	0.00	0.00	0.00	
	Pred	1.49	1.49	1.93	1.93	1.93	1.93	2.02	2.02	2.02	2.02	1.57	1.57	
	CompH	0.00	0.00	0.00	0.00	2.00	1.90	1.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.79	0.79	0.73	0.73	0.62	0.63	0.37	0.21	0.31	0.71	0.78	0.78	0.46
Snake R Ice Harbor Pool-A	Hab	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
	Temp				0.00	0.00	0.00	3.28	3.54	3.21	0.00	0.00	0.00	
	Pred	1.64	1.64	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	1.64	1.64	
	CompH	0.00	0.00	0.00	0.00	1.20	1.20	1.20	1.20	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.77	0.77	0.69	0.69	0.67	0.67	0.28	0.19	0.31	0.69	0.77	0.77	0.26
Snake R Low Monumental Pool-A	Hab	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
	Temp				0.00	0.00	0.00	3.08	3.77	2.90	0.00	0.00	0.00	
	Pred	1.64	1.64	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	1.64	1.64	
	CompH	0.00	0.00	0.00	0.00	1.20	1.20	1.20	1.20	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.77	0.77	0.69	0.69	0.67	0.67	0.34	0.10	0.40	0.69	0.77	0.77	0.26
Snake R Little Goose Pool-A	Hab	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
	Temp				0.00	0.00	0.00	3.28	3.33	2.80	0.00	0.00	0.00	
	Pred	1.64	1.64	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	1.64	1.64	
	CompH	0.00	0.00	0.00	0.00	1.20	1.20	1.20	1.20	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.77	0.77	0.69	0.69	0.67	0.67	0.28	0.26	0.43	0.69	0.77	0.77	0.28
Snake R Low Granite Pool-A	Hab	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
	Temp				0.00	0.00	0.00	3.11	3.01	3.26	0.00	0.00	0.00	
	Pred	1.64	1.64	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	1.64	1.64	
	CompH	0.00	0.00	0.00	0.00	1.20	1.20	1.20	1.20	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.77	0.77	0.69	0.69	0.67	0.67	0.33	0.36	0.30	0.69	0.77	0.77	0.35
Columbia River Hanford Reach-A	Hab	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

	Temp				0.00	0.00	0.00	2.06	3.10	2.66	0.00	0.00	0.00	
	Pred	1.39	1.39	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.39	1.39	
	CompH	0.00	0.00	0.00	0.00	0.00	1.80	1.20	0.00	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.90	0.90	0.84	0.84	0.84	0.75	0.67	0.42	0.56	0.84	0.90	0.90	0.68
Col R Priest Rapids Pool-A	Hab	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
	Temp				0.00	0.00	0.00	2.33	3.22	2.99	0.00	0.00	0.00	
	Pred	1.78	1.78	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	1.78	1.78	
	CompH	0.00	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Unadj Prod	0.75	0.75	0.66	0.66	0.66	0.63	0.50	0.29	0.36	0.66	0.75	0.75	0.52

Table C-5b. **Subyearling** biological performance attribute ratings for Columbia River and Snake River mainstem habitat under the **Alternative 6** condition and worldview **Technology Pessimistic**

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Col R Below Bonneville Dam to Estuary-A	Hab	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	
	Temp	0.00	0.00	0.00	0.00	0.00	0.00	3.57	3.85	3.85	0.00	0.00	0.00	
	Pred	1.52	1.52	1.97	1.97	2.27	2.27	1.97	1.97	1.97	1.97	1.52	1.52	
	CompH	1.12	1.12	1.12	1.12	1.91	2.59	2.02	1.69	0.00	0.00	0.00	0.00	
	CompO	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	
	Unadj Prod	0.81	0.81	0.75	0.75	0.61	0.49	0.17	0.07	0.08	0.77	0.84	0.84	0.29
Col R Bonneville Pool-A	Hab	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	
	Temp	0.00	0.00	0.00	0.00	0.00	0.00	3.49	3.85	3.85	0.00	0.00	0.00	
	Pred	1.69	1.69	2.18	2.18	2.18	2.18	2.28	2.28	2.28	2.28	1.77	1.77	
	CompH	1.69	1.69	1.69	1.69	1.92	1.69	1.69	1.13	0.00	0.00	0.00	0.00	
	CompO	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	
	Unadj Prod	0.64	0.64	0.57	0.57	0.55	0.57	0.17	0.06	0.06	0.61	0.70	0.70	0.32
Col R The Dalles Pool-A	Hab	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	
	Temp				0.00	0.00	0.00	3.47	3.85	3.85	0.00	0.00	0.00	
	Pred	1.68	1.68	2.17	2.17	2.17	2.17	2.27	2.27	2.27	2.27	1.76	1.76	
	CompH	0.00	0.00	0.00	0.00	1.57	2.02	1.12	1.12	0.00	0.00	0.00	0.00	
	CompO	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	
	Unadj Prod	0.71	0.71	0.64	0.64	0.59	0.54	0.19	0.06	0.06	0.62	0.70	0.70	0.32
Col R John Day Pool-A	Hab	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	
	Temp				0.00	0.00	0.00	3.52	3.85	3.85	0.00	0.00	0.00	
	Pred	1.68	1.68	2.17	2.17	2.17	2.17	2.27	2.27	2.27	2.27	1.76	1.76	
	CompH	0.00	0.00	0.00	0.00	1.35	1.91	1.68	1.12	0.00	0.00	0.00	0.00	
	CompO	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	
	Unadj Prod	0.71	0.71	0.64	0.64	0.61	0.55	0.16	0.06	0.06	0.62	0.70	0.70	0.31
Col R McNary Pool-A	Hab	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	
	Temp				0.00	0.00	0.00	3.40	3.85	3.85	0.00	0.00	0.00	
	Pred	1.68	1.68	2.18	2.18	2.18	2.18	2.28	2.28	2.28	2.28	1.76	1.76	
	CompH	0.00	0.00	0.00	0.00	2.25	2.14	1.13	0.00	0.00	0.00	0.00	0.00	
	CompO	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	
	Unadj Prod	0.71	0.71	0.64	0.64	0.50	0.52	0.21	0.06	0.06	0.62	0.70	0.70	0.32
Snake R Ice Harbor Pool-A	Hab	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	
	Temp				0.00	0.00	0.00	3.47	3.75	3.75	0.00	0.00	0.00	
	Pred	1.73	1.73	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	1.73	1.73	
	CompH	0.00	0.00	0.00	0.00	1.27	1.27	1.27	1.27	0.00	0.00	0.00	0.00	
	CompO	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	
	Unadj Prod	0.74	0.74	0.65	0.65	0.62	0.62	0.20	0.10	0.10	0.65	0.74	0.74	0.18
Snake R Low Monumental Pool-A	Hab	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	
	Temp				0.00	0.00	0.00	3.34	3.85	3.85	0.00	0.00	0.00	
	Pred	1.77	1.77	2.29	2.29	2.29	2.29	2.29	2.29	2.29	2.29	1.77	1.77	
	CompH	0.00	0.00	0.00	0.00	1.30	1.30	1.30	1.30	0.00	0.00	0.00	0.00	
	CompO	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	
	Unadj Prod	0.72	0.72	0.63	0.63	0.60	0.60	0.23	0.06	0.06	0.63	0.72	0.72	0.18
Snake R Little Goose Pool-A	Hab	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	
	Temp				0.00	0.00	0.00	3.49	3.55	3.55	0.00	0.00	0.00	
	Pred	1.74	1.74	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	1.74	1.74	
	CompH	0.00	0.00	0.00	0.00	1.28	1.28	1.28	1.28	0.00	0.00	0.00	0.00	
	CompO	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	
	Unadj Prod	0.73	0.73	0.64	0.64	0.61	0.61	0.19	0.17	0.18	0.64	0.73	0.73	0.19
Snake R Low Granite Pool-A	Hab	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	
	Temp				0.00	0.00	0.00	3.37	3.27	3.27	0.00	0.00	0.00	
	Pred	1.78	1.78	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	1.78	1.78	
	CompH	0.00	0.00	0.00	0.00	1.30	1.30	1.30	1.30	0.00	0.00	0.00	0.00	
	CompO	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	
	Unadj Prod	0.72	0.72	0.63	0.63	0.60	0.60	0.22	0.25	0.26	0.63	0.72	0.72	0.24
Columbia River Hanford Reach-A	Hab	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	

	Temp				0.00	0.00	0.00	2.55	3.83	3.83	0.00	0.00	0.00	
	Pred	1.72	1.72	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	1.72	1.72	
	CompH	0.00	0.00	0.00	0.00	0.00	2.22	1.48	0.00	0.00	0.00	0.00	0.00	
	CompO	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	
	Unadj Prod	0.82	0.82	0.73	0.73	0.73	0.58	0.48	0.08	0.08	0.73	0.82	0.82	0.45
Col R Priest Rapids Pool-A	Hab	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	
	Temp				0.00	0.00	0.00	2.68	3.70	3.70	0.00	0.00	0.00	
	Pred	2.04	2.04	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.04	2.04	
	CompH	0.00	0.00	0.00	0.00	0.00	1.38	0.00	0.00	0.00	0.00	0.00	0.00	
	CompO	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	
	Unadj Prod	0.65	0.65	0.52	0.52	0.52	0.49	0.35	0.10	0.10	0.52	0.65	0.65	0.35

Table C-5c. **Subyearling** biological performance attribute ratings for Columbia River and Snake River mainstem habitat under the **Alternative 6** condition and worldview **Technology Optimistic**.

Reach	Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	W. mean
Col R Below Bonneville Dam	Hab	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	
to Estuary-A	Temp	0.00	0.00	0.00	0.00	0.00	0.00	2.63	3.05	3.05	0.00	0.00	0.00	
	Pred	1.12	1.12	1.45	1.45	1.67	1.67	1.45	1.45	1.45	1.45	1.12	1.12	
	CompH	0.83	0.83	0.83	0.83	1.41	1.90	1.49	1.24	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.91	0.91	0.88	0.88	0.82	0.75	0.56	0.45	0.47	0.90	0.93	0.93	0.63
Col R Bonneville Pool-A	Hab	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	
	Temp	0.00	0.00	0.00	0.00	0.00	0.00	2.56	2.95	2.95	0.00	0.00	0.00	
	Pred	1.24	1.24	1.60	1.60	1.60	1.60	1.68	1.68	1.68	1.68	1.30	1.30	
	CompH	1.24	1.24	1.24	1.24	1.41	1.24	1.24	0.83	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.83	0.83	0.80	0.80	0.78	0.80	0.55	0.45	0.46	0.82	0.86	0.86	0.64
Col R The Dalles Pool-A	Hab	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	
	Temp				0.00	0.00	0.00	2.56	2.95	2.95	0.00	0.00	0.00	
	Pred	1.24	1.24	1.60	1.60	1.60	1.60	1.68	1.68	1.68	1.68	1.30	1.30	
	CompH	0.00	0.00	0.00	0.00	1.16	1.49	0.83	0.83	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.87	0.87	0.83	0.83	0.80	0.77	0.57	0.45	0.46	0.82	0.86	0.86	0.64
Col R John Day Pool-A	Hab	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	
	Temp				0.00	0.00	0.00	2.59	3.02	3.02	0.00	0.00	0.00	
	Pred	1.24	1.24	1.60	1.60	1.60	1.60	1.68	1.68	1.68	1.68	1.30	1.30	
	CompH	0.00	0.00	0.00	0.00	0.99	1.41	1.24	0.83	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.87	0.87	0.83	0.83	0.81	0.78	0.54	0.43	0.44	0.82	0.86	0.86	0.63
Col R McNary Pool-A	Hab	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	
	Temp				0.00	0.00	0.00	2.50	2.90	2.90	0.00	0.00	0.00	
	Pred	1.24	1.24	1.60	1.60	1.60	1.60	1.68	1.68	1.68	1.68	1.30	1.30	
	CompH	0.00	0.00	0.00	0.00	1.66	1.57	0.83	0.00	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.87	0.87	0.83	0.83	0.75	0.76	0.58	0.48	0.48	0.82	0.86	0.86	0.64
Snake R Ice Harbor Pool-A	Hab	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	
	Temp				0.00	0.00	0.00	2.71	2.93	2.93	0.00	0.00	0.00	
	Pred	1.35	1.35	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.35	1.35	
	CompH	0.00	0.00	0.00	0.00	0.99	0.99	0.99	0.99	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.86	0.86	0.81	0.81	0.79	0.79	0.51	0.45	0.46	0.81	0.86	0.86	0.50
Snake R Low Monumental Pool-A	Hab	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	
	Temp				0.00	0.00	0.00	2.55	3.12	3.12	0.00	0.00	0.00	
	Pred	1.35	1.35	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.35	1.35	
	CompH	0.00	0.00	0.00	0.00	0.99	0.99	0.99	0.99	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.86	0.86	0.81	0.81	0.79	0.79	0.56	0.39	0.39	0.81	0.86	0.86	0.50
Snake R Little Goose Pool-A	Hab	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	
	Temp				0.00	0.00	0.00	2.71	2.76	2.76	0.00	0.00	0.00	
	Pred	1.35	1.35	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.35	1.35	
	CompH	0.00	0.00	0.00	0.00	0.99	0.99	0.99	0.99	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.86	0.86	0.81	0.81	0.79	0.79	0.51	0.50	0.51	0.81	0.86	0.86	0.51
Snake R Low Granite Pool-A	Hab	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	
	Temp				0.00	0.00	0.00	2.57	2.49	2.49	0.00	0.00	0.00	
	Pred	1.35	1.35	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.35	1.35	
	CompH	0.00	0.00	0.00	0.00	0.99	0.99	0.99	0.99	0.00	0.00	0.00	0.00	
	CompO	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
	Unadj Prod	0.86	0.86	0.81	0.81	0.79	0.79	0.55	0.57	0.58	0.81	0.86	0.86	0.56
Columbia River Hanford Reach-A	Hab	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	

Table 2. Average monthly flows assumed for Current Potential, Historic Potential and Alternatives 2,5, and 6.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Current Potential											
FLOWS	Snake	37,760	39,610	48,407	89,043	107,245	100,156	50,913	43,643	22,655	24,054	20,928	32,456
	Columbia	207,900	198,279	154,250	228,089	287,186	290,140	195,951	163,881	99,886	109,622	109,304	155,839
	Mid-Col	153,594	139,802	87,457	124,301	171,988	177,453	135,133	114,599	71,728	79,317	77,075	107,495
		Historic Potential											
FLOWS	Snake	32,484	38,312	50,797	81,981	120,971	111,823	40,081	20,875	21,153	24,979	28,076	31,657
	Columbia	82,258	93,725	117,171	213,915	415,627	465,011	251,442	133,313	92,277	82,123	83,077	85,051
	Mid-Col	42,154	46,036	57,982	126,855	294,254	350,371	207,074	108,600	67,959	54,090	50,520	47,048
		Alt 2											
FLOWS	Snake	33,519	35,085	47,863	85,842	117,531	103,585	49,164	43,995	34,370	17,889	20,790	31,298
	Columbia	162,926	166,863	168,129	235,131	310,658	322,553	212,786	174,392	127,103	95,752	103,180	149,409
	Mid-Col	112,860	112,911	101,881	139,594	185,386	206,710	153,777	122,426	84,932	69,453	71,160	102,223
		Alt 5											
FLOWS	Snake	37,760	39,610	48,407	88,944	107,245	100,156	50,913	43,637	22,655	24,054	20,928	32,455
	Columbia	183,362	185,654	150,772	237,938	290,611	291,174	205,706	176,549	100,559	110,284	108,882	158,564
	Mid-Col	129,056	127,177	83,980	135,698	175,414	178,379	144,988	127,432	71,757	79,979	76,653	110,220
		Alt 6											
FLOWS	Snake	39,561	40,184	48,651	89,340	106,309	100,399	48,493	40,231	20,383	24,054	21,343	33,944
	Columbia	209,157	193,261	156,489	229,393	283,715	290,864	197,443	160,663	97,744	109,903	109,227	154,962
	Mid-Col	153,050	134,211	89,452	123,627	169,397	177,841	139,030	112,812	71,859	79,598	76,583	105,129

		Current- Fall (Subyearling)											
		Jan-00	Feb-00	Mar-00	Apr-00	May-00	Jun-00	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00
FLOWS	Snake	37,760	39,610	48,407	89,043	107,245	100,156	50,913	43,643	22,655	24,054	20,928	32,456
	Columbia	207,900	198,279	154,250	228,089	287,186	290,140	195,951	163,881	99,886	109,622	109,304	155,839
	Mid-Col	153,594	139,802	87,457	124,301	171,988	177,453	135,133	114,599	71,728	79,317	77,075	107,495
LGR	at Dam	0.90	0.90	0.95	0.96	0.96	0.96	0.95	0.95	0.95	0.95	0.90	0.90
	%Transp	0.00	0.00	0.15	0.30	0.30	0.30	0.35	0.35	0.35	0.35	0.35	0.00
	1st Res	0.74	0.76	0.79	0.89	0.91	0.91	0.72	0.68	0.32	0.52	0.46	0.69
	2+ Res	0.86	0.87	0.89	0.95	0.96	0.95	0.85	0.83	0.56	0.72	0.68	0.83
LGS	at Dam	0.90	0.90	0.94	0.96	0.96	0.96	0.94	0.94	0.94	0.94	0.90	0.90
	%Transp	0.00	0.00	0.15	0.25	0.25	0.25	0.30	0.30	0.30	0.30	0.30	0.00
	1st Res	0.72	0.74	0.77	0.88	0.90	0.90	0.68	0.62	0.35	0.49	0.43	0.67
	2+ Res	0.85	0.86	0.88	0.94	0.95	0.95	0.83	0.79	0.59	0.70	0.66	0.82
LMO	at Dam	0.90	0.90	0.94	0.95	0.95	0.95	0.95	0.94	0.94	0.93	0.90	0.90
	%Transp	0.00	0.00	0.15	0.26	0.26	0.26	0.31	0.31	0.31	0.31	0.31	0.00
	1st Res	0.78	0.79	0.82	0.91	0.93	0.92	0.76	0.59	0.43	0.58	0.52	0.73
	2+ Res	0.88	0.89	0.91	0.95	0.96	0.96	0.87	0.77	0.66	0.76	0.72	0.86
IHR	at Dam	0.90	0.90	0.93	0.96	0.96	0.96	0.96	0.96	0.94	0.94	0.90	0.90
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.76	0.77	0.80	0.90	0.92	0.91	0.72	0.63	0.35	0.54	0.49	0.71
	2+ Res	0.87	0.88	0.90	0.95	0.96	0.95	0.85	0.79	0.59	0.74	0.70	0.84
WEL	at Dam	0.89	0.89	0.94	0.97	0.97	0.97	0.97	0.97	0.89	0.89	0.89	0.89
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.94	0.93	0.88	0.92	0.94	0.94	0.91	0.86	0.79	0.86	0.87	0.91
	2+ Res	0.97	0.97	0.94	0.96	0.97	0.97	0.95	0.93	0.89	0.93	0.93	0.95
RRC	at Dam	0.89	0.89	0.91	0.93	0.93	0.93	0.93	0.93	0.89	0.89	0.89	0.89
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.92	0.91	0.83	0.89	0.92	0.92	0.88	0.81	0.72	0.82	0.83	0.88
	2+ Res	0.96	0.95	0.91	0.94	0.96	0.96	0.94	0.90	0.85	0.90	0.91	0.94
RIS	at Dam	0.89	0.89	0.90	0.93	0.93	0.93	0.93	0.93	0.89	0.89	0.89	0.89
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.96	0.95	0.91	0.94	0.96	0.96	0.94	0.90	0.85	0.90	0.91	0.94
	2+ Res	0.98	0.98	0.96	0.97	0.98	0.98	0.97	0.95	0.92	0.95	0.95	0.97
WAN	at Dam	0.89	0.89	0.91	0.92	0.92	0.92	0.92	0.92	0.89	0.89	0.89	0.89
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.92	0.92	0.85	0.90	0.93	0.93	0.89	0.83	0.74	0.83	0.84	0.89
	2+ Res	0.96	0.96	0.92	0.95	0.96	0.96	0.94	0.91	0.86	0.91	0.92	0.94
PRD	at Dam	0.89	0.89	0.90	0.92	0.92	0.92	0.92	0.92	0.89	0.89	0.89	0.89
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.96	0.96	0.92	0.95	0.96	0.96	0.94	0.91	0.86	0.91	0.92	0.94
	2+ Res	0.98	0.98	0.96	0.97	0.98	0.98	0.97	0.95	0.93	0.96	0.96	0.97
MCN	at Dam	0.90	0.90	0.96	0.98	0.98	0.98	0.98	0.98	0.95	0.95	0.95	0.95
	%Transp	0.00	0.00	0.00	0.00	0.00	0.11	0.31	0.31	0.62	0.62	0.00	0.00
	1st ResSr	0.92	0.92	0.94	0.97	0.97	0.97	0.90	0.87	0.73	0.83	0.80	0.90
	2+ResSna	0.96	0.96	0.97	0.98	0.99	0.99	0.95	0.93	0.85	0.91	0.90	0.95
	1st Res C	0.75	0.76	0.79	0.90	0.91	0.90	0.73	0.62	0.33	0.53	0.47	0.70
	2+ Res Co	0.87	0.87	0.89	0.95	0.95	0.95	0.86	0.79	0.57	0.73	0.69	0.84
	1st ResMi	0.79	0.80	0.83	0.91	0.93	0.92	0.77	0.68	0.40	0.59	0.54	0.74
	2+ResMid	0.89	0.89	0.91	0.96	0.96	0.96	0.88	0.82	0.63	0.77	0.73	0.86
	1stHanfor	0.72	0.73	0.78	0.89	0.91	0.89	0.76	0.64	0.35	0.50	0.42	0.66
	2+Hanford	0.85	0.86	0.88	0.94	0.95	0.95	0.87	0.80	0.59	0.70	0.65	0.81
JDA	at Dam	0.90	0.90	0.95	0.97	0.97	0.97	0.97	0.97	0.95	0.95	0.90	0.90
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.65	0.63	0.49	0.65	0.72	0.71	0.46	0.26	0.08	0.31	0.34	0.53
	2+ Res	0.80	0.79	0.70	0.81	0.85	0.84	0.68	0.51	0.29	0.55	0.58	0.73
TDA	at Dam	0.90	0.90	0.93	0.98	0.98	0.98	0.98	0.98	0.90	0.90	0.90	0.90
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.87	0.86	0.80	0.87	0.90	0.90	0.78	0.67	0.47	0.69	0.71	0.82
	2+ Res	0.93	0.93	0.89	0.93	0.95	0.95	0.89	0.82	0.69	0.83	0.84	0.90
BON	at Dam	0.90	0.90	0.91	0.93	0.93	0.93	0.93	0.93	0.91	0.91	0.90	0.90
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.76	0.75	0.64	0.76	0.82	0.82	0.63	0.47	0.25	0.48	0.51	0.67
	2+ Res	0.87	0.86	0.80	0.87	0.90	0.91	0.79	0.69	0.50	0.69	0.71	0.82

		Template-Fall											
		Jan-00	Feb-00	Mar-00	Apr-00	May-00	Jun-00	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00
FLOWS	Snake	32,484	38,312	50,797	81,981	120,971	111,823	40,081	20,875	21,153	24,979	28,076	31,657
	Columbia	82,258	93,725	117,171	213,915	415,627	465,011	251,442	133,313	92,277	82,123	83,077	85,051
	Mid-Col	42,154	46,036	57,982	126,855	294,254	350,371	207,074	108,600	67,959	54,090	50,520	47,048
LGR	at Dam	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.88	0.90	0.92	0.95	0.97	0.97	0.88	0.71	0.68	0.83	0.86	0.88
	2+ Res	0.94	0.95	0.96	0.98	0.98	0.98	0.94	0.84	0.82	0.91	0.93	0.94
LGS	at Dam	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.87	0.89	0.92	0.95	0.97	0.96	0.86	0.66	0.72	0.82	0.85	0.87
	2+ Res	0.93	0.94	0.96	0.97	0.98	0.98	0.93	0.81	0.85	0.90	0.92	0.93
LMO	at Dam	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.90	0.91	0.94	0.96	0.97	0.97	0.89	0.71	0.78	0.86	0.88	0.89
	2+ Res	0.95	0.96	0.97	0.98	0.99	0.99	0.94	0.84	0.88	0.93	0.94	0.95
IHR	at Dam	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.89	0.91	0.93	0.96	0.97	0.97	0.87	0.67	0.72	0.85	0.87	0.89
	2+ Res	0.94	0.95	0.96	0.98	0.99	0.98	0.94	0.82	0.85	0.92	0.93	0.94
WEL	at Dam	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.90	0.91	0.93	0.97	0.99	0.99	0.98	0.95	0.92	0.92	0.92	0.91
	2+ Res	0.95	0.95	0.96	0.98	0.99	0.99	0.99	0.97	0.96	0.96	0.96	0.95
RRC	at Dam	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.86	0.88	0.90	0.96	0.98	0.98	0.97	0.93	0.89	0.89	0.89	0.88
	2+ Res	0.93	0.94	0.95	0.98	0.99	0.99	0.99	0.96	0.94	0.95	0.94	0.94
RIS	at Dam	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.93	0.94	0.95	0.98	0.99	0.99	0.99	0.96	0.95	0.95	0.94	0.94
	2+ Res	0.96	0.97	0.97	0.99	1.00	1.00	0.99	0.98	0.97	0.97	0.97	0.97
WAN	at Dam	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.88	0.89	0.91	0.96	0.98	0.99	0.97	0.93	0.90	0.90	0.90	0.89
	2+ Res	0.94	0.94	0.95	0.98	0.99	0.99	0.99	0.97	0.95	0.95	0.95	0.94
PRD	at Dam	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.94	0.94	0.95	0.98	0.99	0.99	0.99	0.97	0.95	0.95	0.95	0.94
	2+ Res	0.97	0.97	0.98	0.99	1.00	1.00	0.99	0.98	0.97	0.97	0.97	0.97
MCN	at Dam	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st ResSn	0.96	0.97	0.98	0.99	0.99	0.99	0.96	0.89	0.90	0.95	0.96	0.96
	2+ResSna	0.98	0.99	0.99	0.99	1.00	1.00	0.98	0.94	0.95	0.97	0.98	0.98
	1st Res C	0.88	0.90	0.93	0.96	0.97	0.97	0.88	0.68	0.71	0.84	0.86	0.88
	2+ Res Co	0.94	0.95	0.96	0.98	0.99	0.98	0.94	0.82	0.84	0.92	0.93	0.94
	1st ResMi	0.90	0.92	0.94	0.96	0.98	0.97	0.90	0.72	0.76	0.87	0.89	0.90
	2+ResMid	0.95	0.96	0.97	0.98	0.99	0.99	0.95	0.85	0.87	0.93	0.94	0.95
	1stHanfor	0.85	0.87	0.90	0.94	0.96	0.96	0.86	0.66	0.70	0.79	0.82	0.85
	2+Hanford	0.92	0.94	0.95	0.97	0.98	0.98	0.93	0.81	0.84	0.89	0.91	0.92
JDA	at Dam	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.60	0.65	0.72	0.85	0.92	0.93	0.83	0.61	0.48	0.59	0.61	0.62
	2+ Res	0.78	0.81	0.85	0.92	0.96	0.96	0.91	0.78	0.69	0.77	0.78	0.79
TDA	at Dam	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.85	0.87	0.90	0.95	0.97	0.98	0.94	0.85	0.79	0.85	0.85	0.86
	2+ Res	0.92	0.93	0.95	0.97	0.99	0.99	0.97	0.92	0.89	0.92	0.92	0.93
BON	at Dam	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.74	0.78	0.82	0.91	0.95	0.96	0.90	0.74	0.65	0.73	0.74	0.75
	2+ Res	0.86	0.88	0.91	0.95	0.98	0.98	0.95	0.86	0.81	0.86	0.86	0.87

		Alt 2 Fall -- Tribal											
		Jan-00	Feb-00	Mar-00	Apr-00	May-00	Jun-00	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00
FLOWS	Snake	33,519	35,085	47,863	85,842	117,531	103,585	49,164	43,995	34,370	17,889	20,790	31,298
	Columbia	162,926	166,863	168,129	235,131	310,658	322,553	212,786	174,392	127,103	95,752	103,180	149,409
	Mid-Col	112,860	112,911	101,881	139,594	185,386	206,710	153,777	122,426	84,932	69,453	71,160	102,223
LGR	at Dam	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.88	0.88	0.91	0.95	0.97	0.96	0.88	0.84	0.75	0.73	0.79	0.87
	2+ Res	0.94	0.94	0.96	0.98	0.98	0.98	0.94	0.92	0.87	0.86	0.89	0.93
LGS	at Dam	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.87	0.87	0.90	0.95	0.96	0.96	0.87	0.79	0.80	0.71	0.77	0.86
	2+ Res	0.93	0.93	0.95	0.97	0.98	0.98	0.94	0.89	0.90	0.84	0.88	0.93
LMO	at Dam	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.90	0.90	0.93	0.96	0.97	0.97	0.90	0.77	0.85	0.77	0.82	0.89
	2+ Res	0.95	0.95	0.96	0.98	0.99	0.98	0.95	0.88	0.92	0.88	0.90	0.94
IHR	at Dam	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.88	0.89	0.92	0.96	0.97	0.96	0.89	0.78	0.79	0.75	0.80	0.87
	2+ Res	0.94	0.94	0.96	0.98	0.98	0.98	0.94	0.88	0.89	0.86	0.89	0.94
WEL	at Dam	0.89	0.89	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.94
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.96	0.96	0.95	0.96	0.97	0.97	0.96	0.94	0.92	0.93	0.93	0.95
	2+ Res	0.98	0.98	0.97	0.98	0.99	0.99	0.98	0.97	0.96	0.96	0.97	0.98
RRC	at Dam	0.89	0.89	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.92
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.94	0.94	0.93	0.95	0.96	0.97	0.95	0.92	0.89	0.90	0.91	0.94
	2+ Res	0.97	0.97	0.97	0.97	0.98	0.98	0.97	0.96	0.94	0.95	0.95	0.97
RIS	at Dam	0.89	0.89	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.91
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.97	0.97	0.97	0.98	0.98	0.98	0.97	0.96	0.95	0.95	0.95	0.97
	2+ Res	0.99	0.99	0.98	0.99	0.99	0.99	0.99	0.98	0.97	0.97	0.98	0.98
WAN	at Dam	0.89	0.89	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.91
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.95	0.95	0.94	0.95	0.97	0.97	0.95	0.93	0.90	0.91	0.92	0.94
	2+ Res	0.97	0.97	0.97	0.98	0.98	0.98	0.98	0.96	0.95	0.95	0.96	0.97
PRD	at Dam	0.89	0.89	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.91
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.97	0.97	0.97	0.98	0.98	0.98	0.98	0.96	0.95	0.95	0.96	0.97
	2+ Res	0.99	0.99	0.98	0.99	0.99	0.99	0.99	0.98	0.97	0.98	0.98	0.99
MCN	at Dam	0.95	0.98	0.95	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.97
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st ResSn	0.96	0.97	0.97	0.99	0.99	0.99	0.97	0.93	0.93	0.92	0.93	0.96
	2+ResSna	0.98	0.98	0.99	0.99	0.99	0.99	0.98	0.96	0.97	0.96	0.97	0.98
	1st Res C	0.87	0.88	0.90	0.95	0.96	0.95	0.87	0.82	0.80	0.71	0.78	0.86
	2+ Res Co	0.93	0.94	0.95	0.97	0.98	0.98	0.94	0.91	0.89	0.84	0.88	0.93
	1st ResMi	0.89	0.90	0.92	0.96	0.97	0.96	0.90	0.85	0.83	0.76	0.81	0.88
	2+ResMid	0.95	0.95	0.96	0.98	0.98	0.98	0.95	0.92	0.91	0.87	0.90	0.94
	1stHanfor	0.85	0.86	0.89	0.94	0.96	0.95	0.88	0.84	0.81	0.69	0.75	0.84
	2+Hanford	0.92	0.93	0.95	0.97	0.98	0.97	0.94	0.91	0.90	0.83	0.86	0.92
JDA	at Dam	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.79	0.80	0.79	0.85	0.89	0.88	0.77	0.63	0.55	0.63	0.67	0.77
	2+ Res	0.89	0.89	0.89	0.92	0.94	0.94	0.87	0.79	0.74	0.79	0.82	0.88
TDA	at Dam	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.92	0.92	0.92	0.94	0.96	0.96	0.91	0.85	0.82	0.84	0.87	0.91
	2+ Res	0.96	0.96	0.96	0.97	0.98	0.98	0.95	0.92	0.90	0.92	0.93	0.96
BON	at Dam	0.95	0.95	0.95	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.95
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.86	0.86	0.85	0.90	0.92	0.93	0.83	0.75	0.69	0.74	0.78	0.85
	2+ Res	0.93	0.93	0.92	0.95	0.96	0.96	0.91	0.87	0.83	0.86	0.88	0.92

		Alt 5 Fall -- BiOp w/ IRCs											
		Jan-00	Feb-00	Mar-00	Apr-00	May-00	Jun-00	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00
FLOWS	Snake	37,760	39,610	48,407	88,944	107,245	100,156	50,913	43,637	22,655	24,054	20,928	32,455
	Columbia	183,362	185,654	150,772	237,938	290,611	291,174	205,706	176,549	100,559	110,284	108,882	158,564
	Mid-Col	129,056	127,177	83,980	135,698	175,414	178,379	144,988	127,432	71,757	79,979	76,653	110,220
LGR	at Dam	0.90	0.90	0.96	0.96	0.96	0.96	0.94	0.94	0.94	0.94	0.94	0.92
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.48	0.48	0.48	0.00
	1st Res	0.76	0.77	0.80	0.90	0.92	0.91	0.73	0.69	0.33	0.54	0.48	0.71
	2+ Res	0.87	0.88	0.90	0.95	0.96	0.95	0.85	0.83	0.58	0.74	0.69	0.84
LGS	at Dam	0.90	0.90	0.96	0.96	0.96	0.96	0.94	0.94	0.94	0.94	0.94	0.92
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.45	0.45	0.45	0.00
	1st Res	0.74	0.75	0.79	0.89	0.91	0.90	0.69	0.63	0.37	0.51	0.45	0.68
	2+ Res	0.86	0.87	0.89	0.94	0.95	0.95	0.83	0.79	0.60	0.72	0.67	0.83
LMO	at Dam	0.90	0.90	0.95	0.95	0.95	0.95	0.95	0.93	0.93	0.93	0.93	0.91
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.49	0.49	0.49	0.00
	1st Res	0.79	0.80	0.83	0.91	0.93	0.92	0.77	0.60	0.45	0.60	0.54	0.75
	2+ Res	0.89	0.89	0.91	0.96	0.96	0.96	0.88	0.77	0.67	0.77	0.73	0.86
IHR	at Dam	0.90	0.90	0.96	0.96	0.96	0.96	0.96	0.96	0.94	0.94	0.94	0.92
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.77	0.78	0.81	0.91	0.92	0.91	0.73	0.63	0.36	0.56	0.50	0.72
	2+ Res	0.88	0.88	0.90	0.95	0.96	0.96	0.85	0.79	0.60	0.75	0.71	0.85
WEL	at Dam	0.89	0.89	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.94
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.93	0.93	0.88	0.93	0.94	0.94	0.92	0.88	0.80	0.87	0.87	0.91
	2+ Res	0.96	0.96	0.94	0.96	0.97	0.97	0.96	0.94	0.89	0.93	0.93	0.96
RRC	at Dam	0.89	0.89	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.91
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.90	0.90	0.83	0.90	0.92	0.92	0.89	0.84	0.73	0.82	0.83	0.88
	2+ Res	0.95	0.95	0.91	0.95	0.96	0.96	0.94	0.91	0.85	0.91	0.91	0.94
RIS	at Dam	0.89	0.89	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.90
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.95	0.95	0.91	0.95	0.96	0.96	0.94	0.92	0.86	0.91	0.91	0.94
	2+ Res	0.97	0.97	0.96	0.97	0.98	0.98	0.97	0.96	0.93	0.95	0.95	0.97
WAN	at Dam	0.89	0.89	0.90	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.90
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.91	0.91	0.85	0.91	0.93	0.93	0.90	0.85	0.75	0.84	0.84	0.89
	2+ Res	0.95	0.95	0.92	0.95	0.96	0.96	0.95	0.92	0.87	0.92	0.92	0.95
PRD	at Dam	0.89	0.89	0.90	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.90
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.95	0.95	0.92	0.95	0.96	0.96	0.95	0.92	0.87	0.92	0.92	0.95
	2+ Res	0.98	0.98	0.96	0.98	0.98	0.98	0.97	0.96	0.93	0.96	0.96	0.97
MCN	at Dam	0.95	0.95	0.98	0.98	0.98	0.98	0.98	0.97	0.95	0.95	0.95	0.95
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.62	0.62	0.62	0.00
	1st ResSr	0.92	0.93	0.94	0.97	0.98	0.97	0.91	0.87	0.74	0.84	0.81	0.91
	2+ResSna	0.96	0.96	0.97	0.98	0.99	0.99	0.95	0.93	0.86	0.92	0.90	0.95
	1st Res C	0.76	0.77	0.80	0.90	0.91	0.90	0.74	0.63	0.34	0.55	0.48	0.71
	2+ Res Co	0.87	0.88	0.90	0.95	0.95	0.95	0.86	0.79	0.58	0.74	0.69	0.84
	1st ResMi	0.79	0.81	0.84	0.92	0.92	0.92	0.78	0.68	0.41	0.61	0.55	0.75
	2+ResMid	0.89	0.90	0.91	0.96	0.96	0.96	0.88	0.83	0.64	0.78	0.74	0.87
	1stHanfor	0.72	0.73	0.78	0.89	0.91	0.89	0.76	0.64	0.35	0.50	0.42	0.66
	2+Hanford	0.85	0.86	0.88	0.94	0.95	0.94	0.87	0.80	0.59	0.70	0.65	0.81
JDA	at Dam	0.95	0.95	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.96
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.61	0.61	0.50	0.68	0.73	0.72	0.48	0.31	0.09	0.33	0.35	0.55
	2+ Res	0.78	0.78	0.71	0.82	0.86	0.85	0.69	0.55	0.30	0.57	0.59	0.74
TDA	at Dam	0.95	0.95	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.96
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.85	0.85	0.80	0.88	0.90	0.90	0.80	0.70	0.49	0.70	0.71	0.82
	2+ Res	0.92	0.92	0.89	0.94	0.95	0.95	0.89	0.84	0.70	0.84	0.85	0.91
BON	at Dam	0.95	0.95	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.94	0.94	0.94
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.74	0.74	0.66	0.79	0.83	0.83	0.66	0.52	0.27	0.52	0.54	0.70
	2+ Res	0.86	0.86	0.81	0.89	0.91	0.91	0.81	0.72	0.52	0.72	0.73	0.84

		Alt 6 Fall --Summer flow shif											
		Jan-00	Feb-00	Mar-00	Apr-00	May-00	Jun-00	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00
FLOWS	Snake	39,561	40,184	48,651	89,340	106,309	100,399	48,493	40,231	20,383	24,054	21,343	33,944
	Columbia	209,157	193,261	156,489	229,393	283,715	290,864	197,443	160,663	97,744	109,903	109,227	154,962
	Mid-Col	153,050	134,211	89,452	123,627	169,397	177,841	139,030	112,812	71,859	79,598	76,583	105,129
LGR	at Dam	0.90	0.90	0.93	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.90	0.90
	%Transp	0.00	0.00	0.26	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.00
	1st Res	0.76	0.77	0.80	0.90	0.91	0.91	0.71	0.66	0.25	0.53	0.48	0.71
	2+ Res	0.87	0.88	0.89	0.95	0.96	0.95	0.84	0.81	0.50	0.73	0.70	0.85
LGS	at Dam	0.90	0.90	0.93	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.90	0.90
	%Transp	0.00	0.00	0.23	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.00
	1st Res	0.74	0.75	0.78	0.89	0.90	0.90	0.67	0.59	0.28	0.50	0.45	0.69
	2+ Res	0.86	0.86	0.89	0.94	0.95	0.95	0.82	0.77	0.53	0.71	0.67	0.83
LMO	at Dam	0.90	0.90	0.93	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.90	0.90
	%Transp	0.00	0.00	0.25	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.00
	1st Res	0.80	0.80	0.83	0.91	0.93	0.92	0.75	0.56	0.37	0.59	0.54	0.75
	2+ Res	0.89	0.89	0.91	0.96	0.96	0.96	0.87	0.75	0.61	0.77	0.74	0.87
IHR	at Dam	0.90	0.90	0.93	0.96	0.96	0.96	0.96	0.96	0.94	0.94	0.90	0.90
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.78	0.78	0.81	0.90	0.92	0.91	0.71	0.60	0.28	0.56	0.51	0.73
	2+ Res	0.88	0.88	0.90	0.95	0.96	0.96	0.84	0.77	0.53	0.75	0.71	0.85
WEL	at Dam	0.89	0.89	0.89	0.97	0.97	0.97	0.97	0.97	0.89	0.89	0.89	0.89
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.94	0.93	0.88	0.92	0.94	0.94	0.91	0.86	0.79	0.86	0.87	0.91
	2+ Res	0.97	0.96	0.94	0.96	0.97	0.97	0.96	0.93	0.89	0.93	0.93	0.95
RRC	at Dam	0.89	0.89	0.89	0.93	0.93	0.93	0.93	0.93	0.89	0.89	0.89	0.89
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.92	0.90	0.84	0.89	0.92	0.92	0.88	0.81	0.72	0.82	0.82	0.88
	2+ Res	0.96	0.95	0.92	0.94	0.96	0.96	0.94	0.90	0.85	0.90	0.91	0.94
RIS	at Dam	0.89	0.89	0.89	0.92	0.92	0.92	0.92	0.92	0.89	0.89	0.89	0.89
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.96	0.95	0.92	0.94	0.96	0.96	0.94	0.90	0.85	0.91	0.91	0.94
	2+ Res	0.98	0.98	0.96	0.97	0.98	0.98	0.97	0.95	0.92	0.95	0.95	0.97
WAN	at Dam	0.89	0.89	0.89	0.92	0.92	0.92	0.92	0.92	0.89	0.89	0.89	0.89
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.92	0.91	0.85	0.90	0.92	0.93	0.89	0.83	0.75	0.83	0.84	0.89
	2+ Res	0.96	0.96	0.92	0.95	0.96	0.96	0.94	0.91	0.86	0.91	0.92	0.94
PRD	at Dam	0.89	0.89	0.89	0.92	0.92	0.92	0.92	0.92	0.89	0.89	0.89	0.89
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.96	0.96	0.92	0.95	0.96	0.96	0.94	0.91	0.86	0.91	0.92	0.94
	2+ Res	0.98	0.98	0.96	0.97	0.98	0.98	0.97	0.95	0.93	0.96	0.96	0.97
MCN	at Dam	0.95	0.95	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.95
	%Transp	0.00	0.00	0.31	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.00
	1st ResSn	0.93	0.93	0.94	0.97	0.97	0.97	0.90	0.85	0.68	0.84	0.81	0.91
	2+ResSna	0.96	0.96	0.97	0.98	0.99	0.99	0.95	0.92	0.83	0.91	0.90	0.95
	1st Res C	0.77	0.77	0.81	0.90	0.91	0.91	0.73	0.60	0.27	0.55	0.49	0.72
	2+ Res Co	0.88	0.88	0.90	0.95	0.95	0.95	0.85	0.77	0.52	0.74	0.70	0.85
	1st ResMi	0.81	0.81	0.84	0.92	0.92	0.92	0.77	0.65	0.34	0.61	0.56	0.76
	2+ResMid	0.90	0.90	0.92	0.96	0.96	0.96	0.88	0.81	0.58	0.78	0.75	0.87
	1stHanfor	0.73	0.74	0.78	0.89	0.91	0.89	0.74	0.60	0.28	0.50	0.44	0.68
	2+Hanford	0.86	0.86	0.88	0.94	0.95	0.94	0.86	0.78	0.53	0.70	0.66	0.82
JDA	at Dam	0.90	0.90	0.92	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.92
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.66	0.63	0.52	0.67	0.73	0.72	0.46	0.26	0.08	0.33	0.35	0.53
	2+ Res	0.81	0.79	0.72	0.82	0.85	0.85	0.68	0.51	0.29	0.57	0.59	0.73
TDA	at Dam	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.88	0.86	0.81	0.88	0.90	0.90	0.79	0.67	0.48	0.70	0.72	0.82
	2+ Res	0.94	0.93	0.90	0.94	0.95	0.95	0.89	0.82	0.69	0.84	0.85	0.91
BON	at Dam	0.95	0.95	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.95
	%Transp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st Res	0.77	0.75	0.67	0.78	0.82	0.83	0.64	0.48	0.25	0.52	0.54	0.69
	2+ Res	0.88	0.86	0.82	0.88	0.91	0.91	0.80	0.69	0.50	0.72	0.73	0.83

Natural (unregulated with no irrigation) flows for Columbia River at The Dalles, OR, 1879-1978

Data from Michael Newsom, NMFS, Dec. 1995 Obtained from Jim Ruff, Sept 1999

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual Average
1879	89730	83300	90960	65810	86990	181400	360500	395900	612900	501700	184400	154500	234010
1880	109900	85190	85360	98310	76970	75600	151500	404900	698900	793900	275500	198700	254560
1881	130900	103700	80650	106900	210700	221500	386600	427200	547200	432100	386600	141800	264650
1882	109900	111700	86340	78260	66350	96200	229700	337400	771400	478300	244700	150900	230100
1883	109900	94020	120900	86940	87100	178700	197900	405700	535700	398500	263800	127100	217190
1884	90640	73870	73420	71710	71440	105800	204000	405900	649900	404700	202900	167200	210120
1885	132800	134500	80500	93190	163500	189900	260100	374100	447200	341900	256100	156400	219180
1886	121800	102500	102900	92170	177400	123000	210300	344400	579400	353100	204200	126500	211470
1887	85680	69110	75180	98840	74660	177100	260400	424600	811600	587300	202300	172600	253280
1888	113800	99350	99070	69420	143300	121200	190500	364800	517900	340500	290400	154800	208750
1889	101700	92500	85360	66100	62950	90010	153600	257100	271100	185600	214500	98290	139900
1890	87220	76640	64450	51070	116200	121400	193800	562300	440400	329000	150700	123200	193030
1891	88780	76740	69430	65530	61680	75310	139000	345800	423800	309400	195900	134400	165480
1892	87940	107000	99610	78580	71960	128800	155200	302200	548300	450700	207100	147700	198760
1893	110600	97130	85790	77240	80750	73000	172500	445700	601700	469100	212300	152900	214890
1894	121600	140800	165800	144500	112700	165200	325700	585100	1007000	557600	275600	178200	314980
1895	132500	134700	113700	101400	92630	121400	185000	381600	386700	352800	273800	132500	200730
1896	95980	77210	75030	89700	91120	136600	183200	274100	685100	644200	209000	160700	226830
1897	88740	120500	162700	114400	121400	111800	302500	630500	546600	377600	259300	141000	248090
1898	96500	112400	140700	112300	145300	150000	204700	427000	610100	404900	213500	147200	230380
1899	96760	81900	68170	97770	96180	109200	195900	316400	645500	620300	240700	197500	230520
1900	139300	128200	156600	167200	123100	190400	276200	457900	419000	329800	310900	140900	236630
1901	113300	123000	137600	128200	119900	190600	169500	437500	524600	347300	191300	137200	218330
1902	85010	81800	92090	87400	98750	113900	147900	367200	546300	414800	223600	130600	199110
1903	82760	82560	84360	116000	85300	101600	196200	318100	692100	436100	235900	155200	215520
1904	153900	130300	121100	99330	97490	171500	343700	518900	569200	405400	220600	128500	246660
1905	83860	70160	71120	65340	60320	110200	137500	216800	368000	255800	205600	102300	145580
1906	101700	76530	66720	62490	73700	97600	208400	312000	343200	288800	181100	122300	161210
1907	90500	133300	123500	102300	155600	172200	240300	392300	545800	442000	174300	169400	228460
1908	114300	84630	87670	74150	62980	120700	192300	356500	550800	426600	237000	129000	203050
1909	88820	84290	77190	77420	99860	113600	157600	246100	606800	438900	211000	137600	194930
1910	98330	123600	138400	107500	87520	276600	331300	506600	414200	253400	212200	102300	221000
1911	99360	117100	111300	77000	74810	110000	161800	320400	521700	394800	169700	129600	190630
1912	82170	73450	68500	79120	104500	89180	187000	389600	540700	322900	197700	138200	189420
1913	86240	88040	78400	72280	72560	104400	235700	395600	711000	411700	191500	151900	216610

1914	106600	95190	81400	93660	84940	155700	224900	393900	443500	334200	222100	121300	196450
1915	102100	112900	90140	69340	66590	90580	174900	272500	286500	243100	181400	135000	152090
1916	74710	78760	84150	70100	127000	205400	276000	405600	559100	609200	198000	165300	237780
1917	99710	78860	72710	63580	62190	77760	187200	413000	675100	500000	282900	135300	220690

1918	98410	71110	132700	203600	133100	135400	216000	359700	503600	361100	218600	134400	213980
1919	100500	78820	72800	80630	85490	113800	222800	358300	424300	309900	196200	123500	180590
1920	69550	59210	64040	76200	70710	85250	128700	270400	389100	397000	183700	133900	160650
1921	129700	104700	96610	119300	125200	200900	231300	470700	682500	373900	230700	123600	240760
1922	83740	92890	119200	77600	68140	95820	173500	352400	597600	322400	196100	133600	192750
1923	84390	70360	68550	101500	68960	91810	185200	343500	528700	378400	173300	135000	185810
1924	84330	67050	72670	65280	108900	104900	113800	318700	322400	215800	188900	117400	148340
1925	71830	78750	76700	92520	148000	139500	274500	495900	494600	337600	147300	119600	206400
1926	81850	65320	71850	64080	83180	106700	152800	263800	216800	189700	182800	106200	132090
1927	82760	94910	117800	97450	114900	128600	161600	345100	622100	429200	122200	170400	207250
1928	151000	195700	181200	148700	115500	174200	216200	516000	535800	334300	207400	117100	241090
1929	84700	72270	62530	54170	49340	95350	116200	238200	411000	249600	191800	107500	144390
1930	64920	53760	59520	44800	76540	85100	158100	274400	325600	257100	150600	115200	138800
1931	72950	56610	55470	51320	50420	84340	143800	271100	304300	220400	164300	113400	132370
1932	67940	60050	57230	58320	55190	164600	249300	458200	514500	339200	142100	127700	191190
1933	75310	84150	91950	87010	64230	101600	169700	330300	630900	469800	182300	147100	202860
1934	100300	130700	193300	209700	147900	169300	308900	446200	406600	247400	229100	118100	225630
1935	71990	87480	93230	82830	93810	107500	159900	312300	462700	348400	164400	127200	175980
1936	73790	56720	53040	57760	48870	96500	222300	448100	451900	244800	205900	113500	172770
1937	65670	48730	48930	38630	42290	78220	129500	269200	384900	278500	153300	115000	137740
1938	70970	80630	95430	90040	80340	143000	247100	428200	535600	353100	160300	118800	200290
1939	88010	66250	64190	60590	55390	115700	196400	365500	356600	264100	165700	117400	159650
1940	71420	74670	75480	67890	76010	144000	219000	334700	354700	239300	174700	124900	163060
1941	92660	85230	76460	72250	68600	109900	166900	276600	324400	224700	152600	137400	148980
1942	119100	111800	142200	105500	94670	104200	214600	326700	438900	327100	148800	126500	188340
1943	77200	74800	93100	95900	99810	133300	338400	406800	508500	436600	201100	125600	215930
1944	82100	70030	65480	53350	52370	77040	121900	235400	330400	217200	231000	115600	137660
1945	78880	68660	57390	66580	76580	96360	133600	326600	465300	295200	146900	114600	160550
1946	72010	75470	84980	98080	72620	140100	251400	481500	538800	343300	160300	135900	204540
1947	90730	83830	136300	94150	102500	138300	210300	469900	512800	315700	189700	127000	205930
1948	116500	125800	110400	106000	93980	109600	201400	517300	838800	400300	182300	156000	246530
1949	95780	77840	74780	59290	90790	163500	241300	517100	470600	234800	200000	120200	195500
1950	79450	75330	91480	74340	102200	167000	229400	363000	641600	537100	160000	147900	222400
1951	103800	120800	137400	138800	168000	171100	263900	498100	523300	376100	240800	135400	239790
1952	113400	102000	100000	83860	97160	130900	310100	512700	495500	319700	226400	119400	217590
1953	73210	52840	55540	96720	113200	119900	166200	339400	581600	401100	183700	138100	193460
1954	89340	79660	89890	83100	98490	124900	188100	410500	573900	487100	206000	180200	217600
1955	105300	92300	92580	73080	61930	84900	140400	291600	524900	474300	275100	136900	196110
1956	92690	108500	151300	139100	91270	161100	319800	598200	699600	383300	227400	137400	259140
1957	98200	82170	92900	68640	78570	160200	208300	582100	580700	266300	199800	121500	211620
1958	83000	66100	74840	72840	119500	136600	223500	491500	541300	261800	156400	125500	196070

1959	92590	97210	119800	129400	105200	127900	208300	400500	596000	450500	160100	170400	221490
1960	163900	146500	132300	85040	89570	139200	255000	359700	467800	365000	211800	128300	212010
1961	86880	84290	74800	66470	128100	158600	185200	407100	654900	328300	192200	124000	207570
1962	79580	68400	68750	70190	83290	112300	228700	371100	487100	318500	159400	133000	181690

1963	98420	95340	117000	85160	130200	133100	177300	341400	464600	316800	193700	136000	190750
1964	82470	69200	70750	62700	57530	92500	163900	334100	655600	455000	180400	139700	196990
1965	111200	87710	156600	146900	163900	164800	269100	447200	587600	380000	209500	148900	239450
1966	94230	85550	85320	79080	69100	116900	191800	336500	427800	328900	208000	120500	178640
1967	77230	68550	88470	96240	90810	116300	142200	347500	674400	465700	190500	135500	207780
1968	87370	85580	87530	82770	124800	154800	149300	293200	472000	366000	201300	157700	188530
1969	108900	108200	103300	122700	98560	143800	324700	553200	532900	326800	195200	121700	228330
1970	91000	70120	71690	108100	102700	122500	140000	341800	544100	323500	161800	118700	183000
1971	79670	71160	80940	122500	148300	165200	246500	570800	686700	405100	158400	143100	239860
1972	95080	78710	83860	98370	119300	294100	278300	513100	779700	481800	213400	151500	265600
1973	94470	75420	87380	91060	69180	113200	130700	275400	343100	251500	226800	105300	155290
1974	67300	91460	139600	194100	161200	193300	317400	479200	781700	534700	148700	145000	271140
1975	72930	59630	71520	81670	80060	136500	179400	392600	607000	448200	224300	136900	207560
1976	99820	103300	169100	143500	107600	143800	270800	522500	528900	384400	205700	196400	239650
1977	97180	66540	62900	53490	47700	75110	111900	220200	284800	195300	286400	119400	135080
1978	65500	57310	127900	96150	85610	155500	248400	384800	490600	371300	136900		201820
1894	121600	140800	165800	144500	112700	165200	325700	585100	1007000	557600	275600	178200	314980
Maximum	**163900**	**195700**	**193300**	**209700**	**210700**	**294100**	**386600**	**630500**	**1007000**	**793900**	**386600**	**198700**	**314980**
Average	**94610**	**89120**	**95200**	**91000**	**95760**	**131950**	**210560**	**389410**	**527710**	**371480**	**202950**	**136260**	**203050**
Minimum	**64920**	**48730**	**48930**	**38630**	**42290**	**73000**	**111900**	**216800**	**216800**	**185600**	**122200**	**98290**	**132090**
1926	81850	65320	71850	64080	83180	106700	152800	263800	216800	189700	182800	106200	132090

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1879	89730	83300	90960	65810	86990	181400	360500	395900	612900	501700	184400	154500	234010
1880	109900	85190	85360	98310	76970	75600	151500	404900	698900	793900	275500	198700	254560
1881	130900	103700	80650	106900	210700	221500	386600	427200	547200	432100	386600	141800	264650
1882	109900	111700	86340	78260	66350	96200	229700	337400	771400	478300	244700	150900	230100
1883	109900	94020	120900	86940	87100	178700	197900	405700	535700	398500	263800	127100	217190
1884	90640	73870	73420	71710	71440	105800	204000	405900	649900	404700	202900	167200	210120
1885	132800	134500	80500	93190	163500	189900	260100	374100	447200	341900	256100	156400	219180
1886	121800	102500	102900	92170	177400	123000	210300	344400	579400	353100	204200	126500	211470
1887	85680	69110	75180	98840	74660	177100	260400	424600	811600	587300	202300	172600	253280
1888	113800	99350	99070	69420	143300	121200	190500	364800	517900	340500	290400	154800	208750
1889	101700	92500	85360	66100	62950	90010	153600	257100	271100	185600	214500	98290	139900
1890	87220	76640	64450	51070	116200	121400	193800	562300	440400	329000	150700	123200	193030
1891	88780	76740	69430	65530	61680	75310	139000	345800	423800	309400	195900	134400	165480
1892	87940	107000	99610	78580	71960	128800	155200	302200	548300	450700	207100	147700	198760
1893	110600	97130	85790	77240	80750	73000	172500	445700	601700	469100	212300	152900	214890
1894	121600	140800	165800	144500	112700	165200	325700	585100	1007000	557600	275600	178200	314980
1895	132500	134700	113700	101400	92630	121400	185000	381600	386700	352800	273800	132500	200730
1896	95980	77210	75030	89700	91120	136600	183200	274100	685100	644200	209000	160700	226830
1897	88740	120500	162700	114400	121400	111800	302500	630500	546600	377600	259300	141000	248090
1898	96500	112400	140700	112300	145300	150000	204700	427000	610100	404900	213500	147200	230380
1899	96760	81900	68170	97770	96180	109200	195900	316400	645500	620300	240700	197500	230520
1900	139300	128200	156600	167200	123100	190400	276200	457900	419000	329800	310900	140900	236630
1901	113300	123000	137600	128200	119900	190600	169500	437500	524600	347300	191300	137200	218330
1902	85010	81800	92090	87400	98750	113900	147900	367200	546300	414800	223600	130600	199110
1903	82760	82560	84360	116000	85300	101600	196200	318100	692100	436100	235900	155200	215520
1904	153900	130300	121100	99330	97490	171500	343700	518900	569200	405400	220600	128500	246660
1905	83860	70160	71120	65340	60320	110200	137500	216800	368000	255800	205600	102300	145580
1906	101700	76530	66720	62490	73700	97600	208400	312000	343200	288800	181100	122300	161210
1907	90500	133300	123500	102300	155600	172200	240300	392300	545800	442000	174300	169400	228460
1908	114300	84630	87670	74150	62980	120700	192300	356500	550800	426600	237000	129000	203050
1909	88820	84290	77190	77420	99860	113600	157600	246100	606800	438900	211000	137600	194930
1910	98330	123600	138400	107500	87520	276600	331300	506600	414200	253400	212200	102300	221000
1911	99360	117100	111300	77000	74810	110000	161800	320400	521700	394800	169700	129600	190630
1912	82170	73450	68500	79120	104500	89180	187000	389600	540700	322900	197700	138200	189420
1913	86240	88040	78400	72280	72560	104400	235700	395600	711000	411700	191500	151900	216610
1914	106600	95190	81400	93660	84940	155700	224900	393900	443500	334200	222100	121300	196450
1915	102100	112900	90140	69340	66590	90580	174900	272500	286500	243100	181400	135000	152090
1916	74710	78760	84150	70100	127000	205400	276000	405600	559100	609200	198000	165300	237780
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1918	98410	71110	132700	203600	133100	135400	216000	359700	503600	361100	218600	134400	213980
1919	100500	78820	72800	80630	85490	113800	222800	358300	424300	309900	196200	123500	180590
1920	69550	59210	64040	76200	70710	85250	128700	270400	389100	397000	183700	133900	160650
1921	129700	104700	96610	119300	125200	200900	231300	470700	682500	373900	230700	123600	240760
1922	83740	92890	119200	77600	68140	95820	173500	352400	597600	322400	196100	133600	192750
1923	84390	70360	68550	101500	68960	91810	185200	343500	528700	378400	173300	135000	185810
1924	84330	67050	72670	65280	108900	104900	113800	318700	322400	215800	188900	117400	148340
1925	71830	78750	76700	92520	148000	139500	274500	495900	494600	337600	147300	119600	206400
1926	81850	65320	71850	64080	83180	106700	152800	263800	216800	189700	182800	106200	132090
1927	82760	94910	117800	97450	114900	128600	161600	345100	622100	429200	122200	170400	207250
1928	151000	195700	181200	148700	115500	174200	216200	516000	535800	334300	207400	117100	241090
1929	84700	72270	62530	54170	49340	95350	116200	238200	411000	249600	191800	107500	144390
1930	64920	53760	59520	44800	76540	85100	158100	274400	325600	257100	150600	115200	138800
1931	72950	56610	55470	51320	50420	84340	143800	271100	304300	220400	164300	113400	132370
1932	67940	60050	57230	58320	55190	164600	249300	458200	514500	339200	142100	127700	191190
1933	75310	84150	91950	87010	64230	101600	169700	330300	630900	469800	182300	147100	202860
1934	100300	130700	193300	209700	147900	169300	308900	446200	406600	247400	229100	118100	225630
1935	71990	87480	93230	82830	93810	107500	159900	312300	462700	348400	164400	127200	175980
1936	73790	56720	53040	57760	48870	96500	222300	448100	451900	244800	205900	113500	172770
1937	65670	48730	48930	38630	42290	78220	129500	269200	384900	278500	153300	115000	137740
1938	70970	80630	95430	90040	80340	143000	247100	428200	535600	353100	160300	118800	200290
1939	88010	66250	64190	60590	55390	115700	196400	365500	356600	264100	165700	117400	159650
1940	71420	74670	75480	67890	76010	144000	219000	334700	354700	239300	174700	124900	163060
1941	92660	85230	76460	72250	68600	109900	166900	276600	324400	224700	152600	137400	148980
1942	119100	111800	142200	105500	94670	104200	214600	326700	438900	327100	148800	126500	188340
1943	77200	74800	93100	95900	99810	133300	338400	406800	508500	436600	201100	125600	215930
1944	82100	70030	65480	53350	52370	77040	121900	235400	330400	217200	231000	115600	137660
1945	78880	68660	57390	66580	76580	96360	133600	326600	465300	295200	146900	114600	160550
1946	72010	75470	84980	98080	72620	140100	251400	481500	538800	343300	160300	135900	204540
1947	90730	83830	136300	94150	102500	138300	210300	469900	512800	315700	189700	127000	205930
1948	116500	125800	110400	106000	93980	109600	201400	517300	838800	400300	182300	156000	246530
1949	95780	77840	74780	59290	90790	163500	241300	517100	470600	234800	200000	120200	195500
1950	79450	75330	91480	74340	102200	167000	229400	363000	641600	537100	160000	147900	222400
1951	103800	120800	137400	138800	168000	171100	263900	498100	523300	376100	240800	135400	239790
1952	113400	102000	100000	83860	97160	130900	310100	512700	495500	319700	226400	119400	217590
1953	73210	52840	55540	96720	113200	119900	166200	339400	581600	401100	183700	138100	193460
1954	89340	79660	89890	83100	98490	124900	188100	410500	573900	487100	206000	180200	217600
1955	105300	92300	92580	73080	61930	84900	140400	291600	524900	474300	275100	136900	196110
1956	92690	108500	151300	139100	91270	161100	319800	598200	699600	383300	227400	137400	259140
1957	98200	82170	92900	68640	78570	160200	208300	582100	580700	266300	199800	121500	211620
1958	83000	66100	74840	72840	119500	136600	223500	491500	541300	261800	156400	125500	196070
1959	92590	97210	119800	129400	105200	127900	208300	400500	596000	450500	160100	170400	221490
1960	163900	146500	132300	85040	89570	139200	255000	359700	467800	365000	211800	128300	212010
1961	86880	84290	74800	66470	128100	158600	185200	407100	654900	328300	192200	124000	207570
1962	79580	68400	68750	70190	83290	112300	228700	371100	487100	318500	159400	133000	181690

Table 2. Natural (unregulated with no irrigation) flows for Columbia River at The Dalles, OR, 1879-1978.
Data from Michael Newsom, NMFS, Dec. 1995. Obtained from Jim Ruff, Sept 1999.

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual Average
1963	98420	95340	117000	85160	130200	133100	177300	341400	464600	316800	193700	136000	190750
1964	82470	69200	70750	62700	57530	92500	163900	334100	655600	455000	180400	139700	196990
1965	111200	87710	156600	146900	163900	164800	269100	447200	587600	380000	209500	148900	239450
1966	94230	85550	85320	79080	69100	116900	191800	336500	427800	328900	208000	120500	178640
1967	77230	68550	88470	96240	90810	116300	142200	347500	674400	465700	190500	135500	207780
1968	87370	85580	87530	82770	124800	154800	149300	293200	472000	366000	201300	157700	188530
1969	108900	108200	103300	122700	98560	143800	324700	553200	532900	326800	195200	121700	228330
1970	91000	70120	71690	108100	102700	122500	140000	341800	544100	323500	161800	118700	183000
1971	79670	71160	80940	122500	148300	165200	246500	570800	686700	405100	158400	143100	239860
1972	95080	78710	83860	98370	119300	294100	278300	513100	779700	481800	213400	151500	265600
1973	94470	75420	87380	91060	69180	113200	130700	275400	343100	251500	226800	105300	155290
1974	67300	91460	139600	194100	161200	193300	317400	479200	781700	534700	148700	145000	271140
1975	72930	59630	71520	81670	80060	136500	179400	392600	607000	448200	224300	136900	207560
1976	99820	103300	169100	143500	107600	143800	270800	522500	528900	384400	205700	196400	239650
1977	97180	66540	62900	53490	47700	75110	111900	220200	284800	195300	286400	119400	135080
1978	65500	57310	127900	96150	85610	155500	248400	384800	490600	371300	136900		201820
1894	121600	140800	165800	144500	112700	165200	325700	585100	1007000	557600	275600	178200	314980
Maximum	**163900**	**195700**	**193300**	**209700**	**210700**	**294100**	**386600**	**630500**	**1007000**	**793900**	**386600**	**198700**	**314980**
Average	**94610**	**89120**	**95200**	**91000**	**95760**	**131950**	**210560**	**389410**	**527710**	**371480**	**202950**	**136260**	**203050**
Minimum	**64920**	**48730**	**48930**	**38630**	**42290**	**73000**	**111900**	**216800**	**216800**	**185600**	**122200**	**98290**	**132090**
1926	81850	65320	71850	64080	83180	106700	152800	263800	216800	189700	182800	106200	132090

Table E-1a,b,c. **Subyearling** survival rates by month for Snake and Columbia River Hydroelectric Projects for the **Current** condition and moderate, nature, and technology worldviews.

a) Moderate

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.90	0 90	0.95	0 96	0.96	0.96	0 95	0.95	0 95	0.95	0 90	0.90
Little Goose	0.90	0 90	0.94	0 96	0.96	0.96	0 94	0.94	0 94	0.94	0 90	0.90
Lower Monumental	0.90	0 90	0.94	0 95	0.95	0.95	0 95	0.94	0 94	0.93	0 90	0.90
Ice Harbor	0.90	0 90	0.93	0 96	0.96	0.96	0 96	0.96	0 94	0.94	0 90	0.90
McNary	0.90	0 90	0.96	0 98	0.98	0.98	0 98	0.98	0 95	0.95	0 95	0.95
John Day	0.90	0 90	0.95	0 97	0.97	0.97	0 97	0.97	0 95	0.95	0 90	0.90
The Dalles	0.90	0 90	0.93	0 98	0.98	0.98	0 98	0.98	0 90	0.90	0 90	0.90
Bonneville	0.90	0 90	0.91	0 93	0.93	0.93	0 93	0.93	0 91	0.91	0 90	0.90
Rocky Reach	0.89	0 89	0.91	0 93	0.93	0.93	0 93	0.93	0 89	0.89	0 89	0.89
Rock Island	0.89	0 89	0.90	0 93	0.93	0.93	0 93	0.93	0 89	0.89	0 89	0.89
Wanapum	0.89	0 89	0.91	0 92	0.92	0.92	0 92	0.92	0 89	0.89	0 89	0.89
Priest Rapids	0.89	0 89	0.90	0 92	0.92	0.92	0 92	0.92	0 89	0.89	0 89	0.89
Wells	0.89	0 89	0.94	0 97	0.97	0.97	0 97	0.97	0 89	0.89	0 89	0.89
Reservoirs	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Lower Granite	0.86	0 87	0.89	0 95	0.96	0.95	0 85	0.83	0 56	0.72	0 68	0.83
Little Goose	0.85	0 86	0.88	0 94	0.95	0.95	0 83	0.79	0 59	0.70	0 66	0.82
Lower Monumental	0.88	0 89	0.91	0 95	0.96	0.96	0 87	0.77	0 66	0.76	0.72	0.86
Ice Harbor	0.87	0 88	0.90	0 95	0.96	0.95	0 85	0.79	0 59	0.74	0.70	0.84
McNary	0.83	0 87	0.89	0 95	0.95	0.95	0 86	0.79	0 57	0.73	0 69	0.84
John Day	0.80	0.79	0.70	0 81	0.85	0.84	0 68	0.51	0 29	0.55	0 58	0.73
The Dalles	0.93	0 93	0.89	0 93	0.95	0.95	0 89	0.82	0 69	0.83	0 84	0.90
Bonneville	0.87	0 86	0.80	0 87	0.90	0.91	0.79	0.69	0 50	0.69	0.71	0.82
Rocky Reach	0.96	0 95	0.91	0 94	0.96	0.96	0 94	0.90	0 85	0.90	0 91	0.94
Rock Island	0.98	0 98	0.96	0 97	0.98	0.98	0 97	0.95	0 92	0.95	0 95	0.97
Wanapum	0.96	0 96	0.92	0 95	0.96	0.96	0 94	0.91	0 86	0.91	0 92	0.94
Priest Rapids	0.98	0 98	0.96	0 97	0.98	0.98	0 97	0.95	0 93	0.96	0 96	0.97
Wells	0.97	0 97	0.94	0 96	0.97	0.97	0 95	0.93	0 89	0.93	0 93	0.95
Hanford Reach	0.85	0 86	0.88	0 94	0.95	0.95	0 87	0.80	0 59	0.70	0 65	0.81

b) Technology Pessimistic

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.90	0 90	0.95	0 96	0.96	0.96	0 95	0.95	0 95	0.95	0 90	0.90
Little Goose	0.90	0 90	0.94	0 96	0.96	0.96	0 94	0.94	0 94	0.94	0 90	0.90
Lower Monumental	0.90	0 90	0.94	0 95	0.95	0.95	0 95	0.94	0 94	0.93	0 90	0.90
Ice Harbor	0.90	0 90	0.93	0 96	0.96	0.96	0 96	0.96	0 94	0.94	0 90	0.90
McNary	0.90	0 90	0.96	0 98	0.98	0.98	0 98	0.98	0 95	0.95	0 95	0.95
John Day	0.90	0 90	0.95	0 97	0.97	0.97	0 97	0.97	0 95	0.95	0 90	0.90
The Dalles	0.90	0 90	0.93	0 98	0.98	0.98	0 98	0.98	0 90	0.90	0 90	0.90
Bonneville	0.90	0 90	0.91	0 93	0.93	0.93	0 93	0.93	0 91	0.91	0 90	0.90
Rocky Reach	0.89	0 89	0.91	0 93	0.93	0.93	0 93	0.93	0 89	0.89	0 89	0.89
Rock Island	0.89	0 89	0.90	0 93	0.93	0.93	0 93	0.93	0 89	0.89	0 89	0.89
Wanapum	0.89	0 89	0.91	0 92	0.92	0.92	0 92	0.92	0 89	0.89	0 89	0.89
Priest Rapids	0.89	0 89	0.90	0 92	0.92	0.92	0 92	0.92	0 89	0.89	0 89	0.89
Wells	0.89	0 89	0.94	0 97	0.97	0.97	0 97	0.97	0 89	0.89	0 89	0.89
Reservoirs	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Lower Granite	0.86	0 86	0.88	0 94	0.95	0.95	0 82	0.80	0 55	0.70	0 67	0.82
Little Goose	0.85	0 85	0.87	0 94	0.95	0.94	0 80	0.75	0.46	0.69	0 64	0.81
Lower Monumental	0.88	0 88	0.90	0 95	0.96	0.96	0 85	0.74	0.44	0.74	0.71	0.85
Ice Harbor	0.87	0 87	0.89	0 95	0.96	0.95	0 83	0.75	0.46	0.72	0 69	0.84
McNary	0.82	0 86	0.88	0 94	0.95	0.94	0 82	0.70	0 38	0.70	0 66	0.82
John Day	0.79	0.78	0.67	0.79	0.83	0.83	0 60	0.41	0.15	0.52	0 56	0.71
The Dalles	0.93	0 92	0.88	0 93	0.94	0.94	0 85	0.76	0 55	0.81	0 83	0.90
Bonneville	0.86	0 85	0.78	0 86	0.89	0.90	0.73	0.59	0 33	0.66	0 69	0.80
Rocky Reach	0.95	0 95	0.90	0 93	0.95	0.95	0 92	0.86	0.77	0.89	0 90	0.93
Rock Island	0.98	0 97	0.95	0 97	0.98	0.98	0 96	0.93	0 88	0.94	0 95	0.97
Wanapum	0.96	0 95	0.91	0 94	0.96	0.96	0 93	0.87	0.79	0.90	0 91	0.94
Priest Rapids	0.98	0 98	0.95	0 97	0.98	0.98	0 96	0.93	0 89	0.95	0 95	0.97
Wells	0.97	0 96	0.93	0 95	0.97	0.97	0 94	0.90	0 83	0.92	0 93	0.95
Hanford Reach	0.84	0 85	0.87	0 93	0.95	0.94	0 84	0.66	0 32	0.68	0 63	0.80

c) Technology Optimistic

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.90	0 90	0.95	0 96	0.96	0.96	0 95	0.95	0 95	0.95	0 90	0.90
Little Goose	0.90	0 90	0.94	0 96	0.96	0.96	0 94	0.94	0 94	0.94	0 90	0.90
Lower Monumental	0.90	0 90	0.94	0 95	0.95	0.95	0 95	0.94	0 94	0.93	0 90	0.90
Ice Harbor	0.90	0 90	0.93	0 96	0.96	0.96	0 96	0.96	0 94	0.94	0 90	0.90
McNary	0.90	0 90	0.96	0 98	0.98	0.98	0 98	0.98	0 95	0.95	0 95	0.95
John Day	0.90	0 90	0.95	0 97	0.97	0.97	0 97	0.97	0 95	0.95	0 90	0.90
The Dalles	0.90	0 90	0.93	0 98	0.98	0.98	0 98	0.98	0 90	0.90	0 90	0.90
Bonneville	0.90	0 90	0.91	0 93	0.93	0.93	0 93	0.93	0 91	0.91	0 90	0.90
Rocky Reach	0.89	0 89	0.91	0 93	0.93	0.93	0 93	0.93	0 89	0.89	0 89	0.89
Rock Island	0.89	0 89	0.90	0 93	0.93	0.93	0 93	0.93	0 89	0.89	0 89	0.89
Wanapum	0.89	0 89	0.91	0 92	0.92	0.92	0 92	0.92	0 89	0.89	0 89	0.89
Priest Rapids	0.89	0 89	0.90	0 92	0.92	0.92	0 92	0.92	0 89	0.89	0 89	0.89
Wells	0.89	0 89	0.94	0 97	0.97	0.97	0 97	0.97	0 89	0.89	0 89	0.89
Reservoirs	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Lower Granite	0.87	0 88	0.90	0 95	0.96	0.96	0 88	0.86	0 67	0.75	0.70	0.85
Little Goose	0.86	0 87	0.89	0 95	0.96	0.95	0 87	0.84	0 62	0.73	0 68	0.83
Lower Monumental	0.89	0 90	0.92	0 96	0.97	0.96	0 90	0.86	0 66	0.79	0.74	0.87
Ice Harbor	0.88	0 89	0.91	0 95	0.96	0.96	0 89	0.85	0 65	0.76	0.72	0.86
McNary	0.84	0 88	0.90	0 95	0.96	0.96	0 89	0.85	0 64	0.75	0.71	0.85
John Day	0.82	0 81	0.73	0 83	0.87	0.86	0.74	0.65	0.40	0.59	0 61	0.75
The Dalles	0.94	0 94	0.91	0 94	0.96	0.95	0 91	0.88	0.76	0.85	0 86	0.91
Bonneville	0.88	0 88	0.83	0 89	0.92	0.92	0 84	0.78	0 59	0.73	0.74	0.84
Rocky Reach	0.96	0 96	0.92	0 95	0.96	0.96	0 95	0.93	0 88	0.91	0 92	0.94
Rock Island	0.98	0 98	0.96	0 97	0.98	0.98	0 97	0.96	0 94	0.96	0 96	0.97
Wanapum	0.96	0 96	0.93	0 95	0.97	0.97	0 95	0.93	0 89	0.92	0 92	0.95
Priest Rapids	0.98	0 98	0.96	0 98	0.98	0.98	0 98	0.97	0 94	0.96	0 96	0.97
Wells	0.97	0 97	0.94	0 96	0.97	0.97	0 96	0.95	0 91	0.94	0 94	0.96
Hanford Reach	0.85	0 86	0.89	0 94	0.95	0.95	0 88	0.84	0 62	0.72	0 66	0.82

Table E-2a,b,c. **Subyearling** survival rates by month for Snake and Columbia River Hydroelectric Projects for the **Historic** condition and moderate, nature, and technology worldviews.

a) Moderate

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Little Goose	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Lower Monumental	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Ice Harbor	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
McNary	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
John Day	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
The Dalles	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Bonneville	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Rocky Reach	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Rock Island	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Wanapum	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Priest Rapids	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Wells	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Reservoirs	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Lower Granite	0 94	0.95	0 96	0.98	0 98	0.98	0 94	0.84	0.82	0 91	0.93	0 94
Little Goose	0 93	0.94	0 96	0.97	0 98	0.98	0 93	0.81	0.85	0 90	0.92	0 93
Lower Monumental	0 95	0.96	0 97	0.98	0 99	0.99	0 94	0.84	0.88	0 93	0.94	0 95
Ice Harbor	0 94	0.95	0 96	0.98	0 99	0.98	0 94	0.82	0.85	0 92	0.93	0 94
McNary	0 92	0.95	0 96	0.98	0 99	0.98	0 94	0.82	0.84	0 92	0.93	0 94
John Day	0.78	0.81	0 85	0.92	0 96	0.96	0 91	0.78	0.69	0.77	0.78	0.79
The Dalles	0 92	0.93	0 95	0.97	0 99	0.99	0 97	0.92	0.89	0 92	0.92	0 93
Bonneville	0 86	0.88	0 91	0.95	0 98	0.98	0 95	0.86	0.81	0 86	0.86	0 87
Rocky Reach	0 93	0.94	0 95	0.98	0 99	0.99	0 99	0.96	0.94	0 95	0.94	0 94
Rock Island	0 96	0.97	0 97	0.99	1 00	1.00	0 99	0.98	0.97	0 97	0.97	0 97
Wanapum	0 94	0.94	0 95	0.98	0 99	0.99	0 99	0.97	0.95	0 95	0.95	0 94
Priest Rapids	0 97	0.97	0 98	0.99	1 00	1.00	0 99	0.98	0.97	0 97	0.97	0 97
Wells	0 95	0.95	0 96	0.98	0 99	0.99	0 99	0.97	0.96	0 96	0.96	0 95
Hanford Reach	0 92	0.94	0 95	0.97	0 98	0.98	0 93	0.81	0.84	0 89	0.91	0 92

b) Technology Pessimistic

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Little Goose	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Lower Monumental	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Ice Harbor	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
McNary	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
John Day	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
The Dalles	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Bonneville	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Rocky Reach	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Rock Island	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Wanapum	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Priest Rapids	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Wells	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Reservoirs	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Lower Granite	0 94	0.95	0 96	0.98	0 98	0.98	0 93	0.82	0.82	0 91	0.92	0 93
Little Goose	0 93	0.94	0 96	0.97	0 98	0.98	0 92	0.79	0.79	0 90	0.92	0 93
Lower Monumental	0 95	0.96	0 97	0.98	0 99	0.99	0 94	0.81	0.81	0 92	0.94	0 94
Ice Harbor	0 94	0.95	0 96	0.98	0 99	0.98	0 93	0.79	0.80	0 92	0.93	0 94
McNary	0 92	0.95	0 96	0.98	0 98	0.98	0 93	0.76	0.76	0 91	0.93	0 94
John Day	0.77	0.80	0 84	0.92	0 96	0.96	0 90	0.70	0.58	0.76	0.77	0.78
The Dalles	0 92	0.93	0 95	0.97	0 99	0.99	0 97	0.89	0.84	0 92	0.92	0 92
Bonneville	0 86	0.88	0 90	0.95	0 98	0.98	0 94	0.81	0.71	0 85	0.86	0 86
Rocky Reach	0 93	0.93	0 95	0.98	0 99	0.99	0 98	0.96	0.93	0 94	0.94	0 94
Rock Island	0 96	0.97	0 97	0.99	1 00	1.00	0 99	0.98	0.96	0 97	0.97	0 97
Wanapum	0 93	0.94	0 95	0.98	0 99	0.99	0 99	0.96	0.93	0 95	0.95	0 94
Priest Rapids	0 97	0.97	0 98	0.99	1 00	1.00	0 99	0.98	0.97	0 97	0.97	0 97
Wells	0 95	0.95	0 96	0.98	0 99	0.99	0 99	0.97	0.95	0 96	0.96	0 95
Hanford Reach	0 92	0.93	0 95	0.97	0 98	0.98	0 92	0.74	0.74	0 88	0.90	0 92

c) Technology Optimistic

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Little Goose	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Lower Monumental	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Ice Harbor	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
McNary	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
John Day	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
The Dalles	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Bonneville	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Rocky Reach	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Rock Island	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Wanapum	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Priest Rapids	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Wells	1 00	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00
Reservoirs	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Lower Granite	0 94	0.95	0 96	0.98	0 99	0.98	0 94	0.87	0.87	0 92	0.93	0 94
Little Goose	0 93	0.95	0 96	0.98	0 98	0.98	0 94	0.85	0.85	0 91	0.92	0 93
Lower Monumental	0 95	0.96	0 97	0.98	0 99	0.99	0 95	0.88	0.88	0 93	0.94	0 95
Ice Harbor	0 94	0.95	0 97	0.98	0 99	0.99	0 95	0.86	0.87	0 92	0.93	0 94
McNary	0 93	0.95	0 96	0.98	0 99	0.98	0 95	0.86	0.86	0 92	0.93	0 94
John Day	0.78	0.81	0 85	0.92	0 96	0.97	0 92	0.83	0.74	0.78	0.79	0.79
The Dalles	0 92	0.94	0 95	0.98	0 99	0.99	0 98	0.94	0.91	0 92	0.93	0 93
Bonneville	0 87	0.89	0 91	0.95	0 98	0.98	0 95	0.89	0.84	0 86	0.87	0 87
Rocky Reach	0 93	0.94	0 95	0.98	0 99	0.99	0 99	0.97	0.95	0 95	0.94	0 94
Rock Island	0 97	0.97	0 98	0.99	1 00	1.00	0 99	0.98	0.98	0 97	0.97	0 97
Wanapum	0 94	0.94	0 96	0.98	0 99	0.99	0 99	0.97	0.95	0 95	0.95	0 95
Priest Rapids	0 97	0.97	0 98	0.99	1 00	1.00	0 99	0.99	0.98	0 98	0.97	0 97
Wells	0 95	0.95	0 96	0.98	0 99	0.99	0 99	0.98	0.96	0 96	0.96	0 96
Hanford Reach	0 92	0.94	0 95	0.97	0 98	0.98	0 94	0.84	0.84	0 89	0.91	0 92

Table E-3a,b,c. **Subyearling** survival rates by month for Snake and Columbia River Hydroelectric Projects for **Alternative 2** and moderate, nature, and technology worldviews.

a) Moderate

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Little Goose	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Lower Monumental	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Ice Harbor	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
McNary	0.95	0 98	0.95	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.97
John Day	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
The Dalles	0.98	0 98	0.98	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.98
Bonneville	0.95	0 95	0.95	0 96	0.96	0 96	0.96	0.96	0 96	0.96	0 96	0.95
Rocky Reach	0.89	0 89	0.93	0 93	0.93	0 93	0.93	0.93	0 93	0.93	0 93	0.92
Rock Island	0.89	0 89	0.92	0 92	0.92	0 92	0.92	0.92	0 92	0.92	0 92	0.91
Wanapum	0.89	0 89	0.92	0 92	0.92	0 92	0.92	0.92	0 92	0.92	0 92	0.91
Priest Rapids	0.89	0 89	0.92	0 92	0.92	0 92	0.92	0.92	0 92	0.92	0 92	0.91
Wells	0.89	0 89	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.94
Reservoirs	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.94	0 94	0.96	0 98	0.98	0 98	0.94	0.92	0 87	0.86	0 89	0.93
Little Goose	0.93	0 93	0.95	0 97	0.98	0 98	0.94	0.89	0 90	0.84	0 88	0.93
Lower Monumental	0.95	0 95	0.96	0 98	0.99	0 98	0.95	0.88	0 92	0.88	0 90	0.94
Ice Harbor	0.94	0 94	0.96	0 98	0.98	0 98	0.94	0.88	0 89	0.86	0 89	0.94
McNary	0.92	0 94	0.95	0 97	0.98	0 98	0.94	0.91	0 89	0.84	0 88	0.93
John Day	0.89	0 89	0.89	0 92	0.94	0 94	0.87	0.79	0.74	0.79	0 82	0.88
The Dalles	0.96	0 96	0.96	0 97	0.98	0 98	0.95	0.92	0 90	0.92	0 93	0.96
Bonneville	0.93	0 93	0.92	0 95	0.96	0 96	0.91	0.87	0 83	0.86	0 88	0.92
Rocky Reach	0.97	0 97	0.97	0 97	0.98	0 98	0.97	0.96	0 94	0.95	0 95	0.97
Rock Island	0.99	0 99	0.98	0 99	0.99	0 99	0.99	0.98	0 97	0.97	0 98	0.98
Wanapum	0.97	0 97	0.97	0 98	0.98	0 98	0.98	0.96	0 95	0.95	0 96	0.97
Priest Rapids	0.99	0 99	0.98	0 99	0.99	0 99	0.99	0.98	0 97	0.98	0 98	0.99
Wells	0.98	0 98	0.97	0 98	0.99	0 99	0.98	0.97	0 96	0.96	0 97	0.98
Hanford Reach	0.92	0 93	0.95	0 97	0.98	0 97	0.94	0.91	0 90	0.83	0 86	0.92

b) Technology Pessimistic

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Little Goose	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Lower Monumental	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Ice Harbor	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
McNary	0.95	0 98	0.95	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.97
John Day	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
The Dalles	0.98	0 98	0.98	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.98
Bonneville	0.95	0 95	0.95	0 96	0.96	0 96	0.96	0.96	0 96	0.96	0 96	0.95
Rocky Reach	0.89	0 89	0.93	0 93	0.93	0 93	0.93	0.93	0 93	0.93	0 93	0.92
Rock Island	0.89	0 89	0.92	0 92	0.92	0 92	0.92	0.92	0 92	0.92	0 92	0.91
Wanapum	0.89	0 89	0.92	0 92	0.92	0 92	0.92	0.92	0 92	0.92	0 92	0.91
Priest Rapids	0.89	0 89	0.92	0 92	0.92	0 92	0.92	0.92	0 92	0.92	0 92	0.91
Wells	0.89	0 89	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.94
Reservoirs	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.93	0 94	0.95	0 97	0.98	0 98	0.93	0.90	0 86	0.85	0 88	0.93
Little Goose	0.93	0 93	0.95	0 97	0.98	0 98	0.93	0.86	0 81	0.84	0 87	0.92
Lower Monumental	0.94	0 95	0.96	0 98	0.98	0 98	0.94	0.89	0 85	0.87	0 90	0.94
Ice Harbor	0.94	0 94	0.96	0 98	0.98	0 98	0.94	0.88	0 84	0.86	0 89	0.93
McNary	0.91	0 93	0.95	0 97	0.98	0 97	0.92	0.86	0 82	0.83	0 87	0.92
John Day	0.89	0 89	0.88	0 92	0.94	0 93	0.85	0.72	0 62	0.78	0 81	0.87
The Dalles	0.96	0 96	0.95	0 97	0.98	0 98	0.94	0.89	0 85	0.91	0 93	0.95
Bonneville	0.92	0 92	0.92	0 94	0.96	0 96	0.89	0.82	0.75	0.85	0 87	0.92
Rocky Reach	0.97	0 97	0.96	0 97	0.98	0 98	0.97	0.95	0 92	0.94	0 95	0.97
Rock Island	0.98	0 98	0.98	0 99	0.99	0 99	0.98	0.97	0 96	0.97	0 97	0.98
Wanapum	0.97	0 97	0.96	0 97	0.98	0 98	0.97	0.95	0 93	0.95	0 95	0.97
Priest Rapids	0.99	0 99	0.98	0 99	0.99	0 99	0.99	0.98	0 96	0.97	0 98	0.98
Wells	0.98	0 98	0.97	0 98	0.98	0 99	0.98	0.96	0 94	0.96	0 96	0.97
Hanford Reach	0.92	0 92	0.94	0 97	0.98	0 97	0.93	0.87	0 83	0.81	0 86	0.91

c) Technology Optimistic

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Little Goose	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Lower Monumental	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Ice Harbor	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
McNary	0.95	0 98	0.95	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.97
John Day	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
The Dalles	0.98	0 98	0.98	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.98
Bonneville	0.95	0 95	0.95	0 96	0.96	0 96	0.96	0.96	0 96	0.96	0 96	0.95
Rocky Reach	0.89	0 89	0.93	0 93	0.93	0 93	0.93	0.93	0 93	0.93	0 93	0.92
Rock Island	0.89	0 89	0.92	0 92	0.92	0 92	0.92	0.92	0 92	0.92	0 92	0.91
Wanapum	0.89	0 89	0.92	0 92	0.92	0 92	0.92	0.92	0 92	0.92	0 92	0.91
Priest Rapids	0.89	0 89	0.92	0 92	0.92	0 92	0.92	0.92	0 92	0.92	0 92	0.91
Wells	0.89	0 89	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.94
Reservoirs	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.94	0 94	0.96	0 98	0.98	0 98	0.95	0.94	0 92	0.87	0 89	0.94
Little Goose	0.93	0 94	0.95	0 98	0.98	0 98	0.95	0.93	0 90	0.86	0 88	0.93
Lower Monumental	0.95	0 95	0.96	0 98	0.99	0 98	0.96	0.94	0 92	0.89	0 91	0.95
Ice Harbor	0.94	0 95	0.96	0 98	0.98	0 98	0.95	0.93	0 91	0.87	0 90	0.94
McNary	0.92	0 94	0.96	0 98	0.98	0 98	0.95	0.93	0 91	0.86	0 89	0.93
John Day	0.90	0 90	0.90	0 93	0.95	0 95	0.90	0.85	0 80	0.81	0 83	0.89
The Dalles	0.96	0 96	0.96	0 97	0.98	0 98	0.96	0.95	0 93	0.93	0 94	0.96
Bonneville	0.93	0 93	0.93	0 95	0.96	0 97	0.93	0.91	0 87	0.87	0 89	0.93
Rocky Reach	0.97	0 97	0.97	0 98	0.98	0 98	0.98	0.97	0 95	0.95	0 96	0.97
Rock Island	0.99	0 99	0.98	0 99	0.99	0 99	0.99	0.98	0 98	0.98	0 98	0.99
Wanapum	0.98	0 98	0.97	0 98	0.98	0 99	0.98	0.97	0 96	0.96	0 96	0.97
Priest Rapids	0.99	0 99	0.99	0 99	0.99	0 99	0.99	0.99	0 98	0.98	0 98	0.99
Wells	0.98	0 98	0.98	0 98	0.99	0 99	0.98	0.98	0 97	0.97	0 97	0.98
Hanford Reach	0.93	0 93	0.95	0 97	0.98	0 98	0.95	0.93	0 91	0.84	0 87	0.92

Table E-4a,b,c. **Subyearling** survival rates by month for Snake and Columbia River Hydroelectric Projects for **Alternative 5** and moderate, nature, and technology worldviews.

a) Moderate

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.90	0 90	0.96	0 96	0.96	0 96	0.94	0.94	0 94	0.94	0 94	0.92
Little Goose	0.90	0 90	0.96	0 96	0.96	0 96	0.94	0.94	0 94	0.94	0 94	0.92
Lower Monumental	0.90	0 90	0.95	0 95	0.95	0 95	0.95	0.93	0 93	0.93	0 93	0.91
Ice Harbor	0.90	0 90	0.96	0 96	0.96	0 96	0.96	0.96	0 94	0.94	0 94	0.92
McNary	0.95	0 95	0.98	0 98	0.98	0 98	0.98	0.97	0 95	0.95	0 95	0.95
John Day	0.95	0 95	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.96
The Dalles	0.95	0 95	0.98	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.96
Bonneville	0.95	0 95	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.94	0 94	0.94
Rocky Reach	0.89	0 89	0.93	0 93	0.93	0 93	0.93	0.93	0 93	0.93	0 93	0.91
Rock Island	0.89	0 89	0.92	0 92	0.92	0 92	0.92	0.92	0 92	0.92	0 92	0.90
Wanapum	0.89	0 89	0.90	0 92	0.92	0 92	0.92	0.92	0 92	0.92	0 92	0.90
Priest Rapids	0.89	0 89	0.90	0 92	0.92	0 92	0.92	0.92	0 92	0.92	0 92	0.90
Wells	0.89	0 89	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.94
Reservoirs	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Lower Granite	0.87	0 88	0.90	0 95	0.96	0 95	0.85	0.83	0 58	0.74	0 69	0.84
Little Goose	0.86	0 87	0.89	0 94	0.95	0 95	0.83	0.79	0 60	0.72	0 67	0.83
Lower Monumental	0.89	0 89	0.91	0 96	0.96	0 96	0.88	0.77	0 67	0.77	0.73	0.86
Ice Harbor	0.88	0 88	0.90	0 95	0.96	0 96	0.85	0.79	0 60	0.75	0.71	0.85
McNary	0.84	0 88	0.90	0 95	0.95	0 95	0.86	0.79	0 58	0.74	0 69	0.84
John Day	0.78	0.78	0.71	0 82	0.86	0 85	0.69	0.55	0 30	0.57	0 59	0.74
The Dalles	0.92	0 92	0.89	0 94	0.95	0 95	0.89	0.84	0.70	0.84	0 85	0.91
Bonneville	0.86	0 86	0.81	0 89	0.91	0 91	0.81	0.72	0 52	0.72	0.73	0.84
Rocky Reach	0.95	0 95	0.91	0 95	0.96	0 96	0.94	0.91	0 85	0.91	0 91	0.94
Rock Island	0.97	0 97	0.96	0 97	0.98	0 98	0.97	0.96	0 93	0.95	0 95	0.97
Wanapum	0.95	0 95	0.92	0 95	0.96	0 96	0.95	0.92	0 87	0.92	0 92	0.95
Priest Rapids	0.98	0 98	0.96	0 98	0.98	0 98	0.97	0.96	0 93	0.96	0 96	0.97
Wells	0.96	0 96	0.94	0 96	0.97	0 97	0.96	0.94	0 89	0.93	0 93	0.96
Hanford Reach	0.85	0 86	0.88	0 94	0.95	0 94	0.87	0.80	0 59	0.70	0 65	0.81

b) Technology Pessimistic

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.90	0 90	0.96	0 96	0.96	0 96	0.94	0.94	0 94	0.94	0 94	0.92
Little Goose	0.90	0 90	0.96	0 96	0.96	0 96	0.94	0.94	0 94	0.94	0 94	0.92
Lower Monumental	0.90	0 90	0.95	0 95	0.95	0 95	0.95	0.93	0 93	0.93	0 93	0.91
Ice Harbor	0.90	0 90	0.96	0 96	0.96	0 96	0.96	0.96	0 94	0.94	0 94	0.92
McNary	0.95	0 95	0.98	0 98	0.98	0 98	0.98	0.97	0 95	0.95	0 95	0.95
John Day	0.95	0 95	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.96
The Dalles	0.95	0 95	0.98	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.96
Bonneville	0.95	0 95	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.94	0 94	0.94
Rocky Reach	0.89	0 89	0.93	0 93	0.93	0 93	0.93	0.93	0 93	0.93	0 93	0.91
Rock Island	0.89	0 89	0.92	0 92	0.92	0 92	0.92	0.92	0 92	0.92	0 92	0.90
Wanapum	0.89	0 89	0.90	0 92	0.92	0 92	0.92	0.92	0 92	0.92	0 92	0.90
Priest Rapids	0.89	0 89	0.90	0 92	0.92	0 92	0.92	0.92	0 92	0.92	0 92	0.90
Wells	0.89	0 89	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.94
Reservoirs	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Lower Granite	0.86	0 87	0.89	0 95	0.95	0 95	0.83	0.81	0 56	0.72	0 68	0.83
Little Goose	0.85	0 86	0.88	0 94	0.95	0 95	0.80	0.76	0.48	0.70	0 66	0.82
Lower Monumental	0.88	0 89	0.91	0 95	0.96	0 96	0.86	0.75	0.46	0.76	0.72	0.86
Ice Harbor	0.87	0 88	0.90	0 95	0.96	0 95	0.83	0.75	0.47	0.74	0.70	0.84
McNary	0.83	0 87	0.89	0 94	0.95	0 94	0.83	0.71	0 39	0.72	0 68	0.83
John Day	0.77	0.77	0.68	0 81	0.84	0 83	0.62	0.46	0.17	0.54	0 57	0.72
The Dalles	0.92	0 92	0.88	0 93	0.94	0 94	0.87	0.78	0 57	0.82	0 83	0.90
Bonneville	0.85	0 85	0.79	0 88	0.90	0 90	0.76	0.63	0 35	0.70	0.72	0.83
Rocky Reach	0.94	0 94	0.90	0 94	0.96	0 95	0.93	0.88	0.77	0.90	0 90	0.93
Rock Island	0.97	0 97	0.95	0 97	0.98	0 98	0.97	0.94	0 88	0.95	0 95	0.97
Wanapum	0.95	0 95	0.91	0 95	0.96	0 96	0.94	0.89	0.79	0.91	0 91	0.94
Priest Rapids	0.97	0 97	0.95	0 97	0.98	0 98	0.97	0.94	0 89	0.95	0 95	0.97
Wells	0.96	0 96	0.93	0 96	0.97	0 97	0.95	0.91	0 83	0.92	0 93	0.95
Hanford Reach	0.84	0 85	0.87	0 93	0.95	0 93	0.84	0.66	0 32	0.68	0 63	0.80

c) Technology Optimistic

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.90	0 90	0.96	0 96	0.96	0 96	0.94	0.94	0 94	0.94	0 94	0.92
Little Goose	0.90	0 90	0.96	0 96	0.96	0 96	0.94	0.94	0 94	0.94	0 94	0.92
Lower Monumental	0.90	0 90	0.95	0 95	0.95	0 95	0.95	0.93	0 93	0.93	0 93	0.91
Ice Harbor	0.90	0 90	0.96	0 96	0.96	0 96	0.96	0.96	0 94	0.94	0 94	0.92
McNary	0.95	0 95	0.98	0 98	0.98	0 98	0.98	0.97	0 95	0.95	0 95	0.95
John Day	0.95	0 95	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.96
The Dalles	0.95	0 95	0.98	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.96
Bonneville	0.95	0 95	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.94	0 94	0.94
Rocky Reach	0.89	0 89	0.93	0 93	0.93	0 93	0.93	0.93	0 93	0.93	0 93	0.91
Rock Island	0.89	0 89	0.92	0 92	0.92	0 92	0.92	0.92	0 92	0.92	0 92	0.90
Wanapum	0.89	0 89	0.90	0 92	0.92	0 92	0.92	0.92	0 92	0.92	0 92	0.90
Priest Rapids	0.89	0 89	0.90	0 92	0.92	0 92	0.92	0.92	0 92	0.92	0 92	0.90
Wells	0.89	0 89	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.94
Reservoirs	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Lower Granite	0.88	0 89	0.91	0 95	0.96	0 96	0.89	0.87	0 68	0.76	0.71	0.85
Little Goose	0.87	0 87	0.90	0 95	0.96	0 95	0.87	0.84	0 63	0.74	0 69	0.84
Lower Monumental	0.90	0 90	0.92	0 96	0.97	0 96	0.90	0.86	0 67	0.79	0.75	0.87
Ice Harbor	0.88	0 89	0.91	0 96	0.96	0 96	0.89	0.86	0 66	0.77	0.73	0.86
McNary	0.85	0 89	0.91	0 95	0.96	0 96	0.89	0.85	0 65	0.76	0.71	0.85
John Day	0.80	0 80	0.73	0 84	0.87	0 87	0.76	0.68	0.42	0.61	0 62	0.76
The Dalles	0.93	0 93	0.91	0 95	0.96	0 96	0.92	0.89	0.76	0.85	0 86	0.92
Bonneville	0.87	0 87	0.83	0 90	0.92	0 92	0.85	0.80	0 61	0.75	0.75	0.85
Rocky Reach	0.95	0 95	0.92	0 95	0.97	0 96	0.95	0.94	0 88	0.92	0 92	0.94
Rock Island	0.98	0 98	0.96	0 98	0.98	0 98	0.98	0.97	0 94	0.96	0 96	0.97
Wanapum	0.96	0 96	0.93	0 96	0.97	0 97	0.96	0.94	0 89	0.92	0 92	0.95
Priest Rapids	0.98	0 98	0.96	0 98	0.98	0 98	0.98	0.97	0 94	0.96	0 96	0.97
Wells	0.97	0 97	0.94	0 97	0.97	0 97	0.97	0.95	0 91	0.94	0 94	0.96
Hanford Reach	0.85	0 86	0.89	0 94	0.95	0 95	0.88	0.84	0 62	0.72	0 66	0.82

Table E-5a,b,c. **Subyearling** survival rates by month for Snake and Columbia River Hydroelectric Projects for **Alternative 6** and moderate, nature, and technology worldviews.

a) Moderate

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.90	0 90	0.93	0 96	0.96	0 96	0.96	0.96	0 96	0.96	0 90	0.90
Little Goose	0.90	0 90	0.93	0 96	0.96	0 96	0.96	0.96	0 96	0.96	0 90	0.90
Lower Monumental	0.90	0 90	0.93	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 90	0.90
Ice Harbor	0.90	0 90	0.93	0 96	0.96	0 96	0.96	0.96	0 94	0.94	0 90	0.90
McNary	0.95	0 95	0.97	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.95
John Day	0.90	0 90	0.92	0 93	0.93	0 93	0.93	0.93	0 93	0.93	0 93	0.92
The Dalles	0.97	0 97	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.97
Bonneville	0.95	0 95	0.96	0 96	0.96	0 96	0.96	0.96	0 96	0.96	0 96	0.95
Rocky Reach	0.89	0 89	0.89	0 93	0.93	0 93	0.93	0.93	0 89	0.89	0 89	0.89
Rock Island	0.89	0 89	0.89	0 92	0.92	0 92	0.92	0.92	0 89	0.89	0 89	0.89
Wanapum	0.89	0 89	0.89	0 92	0.92	0 92	0.92	0.92	0 89	0.89	0 89	0.89
Priest Rapids	0.89	0 89	0.89	0 92	0.92	0 92	0.92	0.92	0 89	0.89	0 89	0.89
Wells	0.89	0 89	0.89	0 97	0.97	0 97	0.97	0.97	0 89	0.89	0 89	0.89
Reservoirs	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Lower Granite	0.87	0 88	0.89	0 95	0.96	0 95	0.84	0.81	0 50	0.73	0.70	0.85
Little Goose	0.86	0 86	0.89	0 94	0.95	0 95	0.82	0.77	0 53	0.71	0 67	0.83
Lower Monumental	0.89	0 89	0.91	0 96	0.96	0 96	0.87	0.75	0 61	0.77	0.74	0.87
Ice Harbor	0.88	0 88	0.90	0 95	0.96	0 96	0.84	0.77	0 53	0.75	0.71	0.85
McNary	0.84	0 88	0.90	0 95	0.95	0 95	0.85	0.77	0 52	0.74	0.70	0.85
John Day	0.81	0.79	0.72	0 82	0.85	0 85	0.68	0.51	0 29	0.57	0 59	0.73
The Dalles	0.94	0 93	0.90	0 94	0.95	0 95	0.89	0.82	0 69	0.84	0 85	0.91
Bonneville	0.88	0 86	0.82	0 88	0.91	0 91	0.80	0.69	0 50	0.72	0.73	0.83
Rocky Reach	0.96	0 95	0.92	0 94	0.96	0 96	0.94	0.90	0 85	0.90	0 91	0.94
Rock Island	0.98	0 98	0.96	0 97	0.98	0 98	0.97	0.95	0 92	0.95	0 95	0.97
Wanapum	0.96	0 96	0.92	0 95	0.96	0 96	0.94	0.91	0 86	0.91	0 92	0.94
Priest Rapids	0.98	0 98	0.96	0 97	0.98	0 98	0.97	0.95	0 93	0.96	0 96	0.97
Wells	0.97	0 96	0.94	0 96	0.97	0 97	0.96	0.93	0 89	0.93	0 93	0.95
Hanford Reach	0.86	0 86	0.88	0 94	0.95	0 94	0.86	0.78	0 53	0.70	0 66	0.82

b) Technology Pessimistic

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.90	0 90	0.93	0 96	0.96	0 96	0.96	0.96	0 96	0.96	0 90	0.90
Little Goose	0.90	0 90	0.93	0 96	0.96	0 96	0.96	0.96	0 96	0.96	0 90	0.90
Lower Monumental	0.90	0 90	0.93	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 90	0.90
Ice Harbor	0.90	0 90	0.93	0 96	0.96	0 96	0.96	0.96	0 94	0.94	0 90	0.90
McNary	0.95	0 95	0.97	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.95
John Day	0.90	0 90	0.92	0 93	0.93	0 93	0.93	0.93	0 93	0.93	0 93	0.92
The Dalles	0.97	0 97	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.97
Bonneville	0.95	0 95	0.96	0 96	0.96	0 96	0.96	0.96	0 96	0.96	0 96	0.95
Rocky Reach	0.89	0 89	0.89	0 93	0.93	0 93	0.93	0.93	0 89	0.89	0 89	0.89
Rock Island	0.89	0 89	0.89	0 92	0.92	0 92	0.92	0.92	0 89	0.89	0 89	0.89
Wanapum	0.89	0 89	0.89	0 92	0.92	0 92	0.92	0.92	0 89	0.89	0 89	0.89
Priest Rapids	0.89	0 89	0.89	0 92	0.92	0 92	0.92	0.92	0 89	0.89	0 89	0.89
Wells	0.89	0 89	0.89	0 97	0.97	0 97	0.97	0.97	0 89	0.89	0 89	0.89
Reservoirs	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Lower Granite	0.87	0 87	0.89	0 94	0.95	0 95	0.82	0.78	0.49	0.71	0 68	0.84
Little Goose	0.86	0 86	0.88	0 94	0.95	0 95	0.79	0.73	0.40	0.70	0 66	0.83
Lower Monumental	0.89	0 89	0.90	0 95	0.96	0 96	0.85	0.72	0 38	0.75	0.72	0.86
Ice Harbor	0.88	0 88	0.90	0 95	0.96	0 95	0.82	0.73	0 39	0.74	0.70	0.85
McNary	0.83	0 87	0.89	0 95	0.95	0 95	0.82	0.68	0 32	0.72	0 68	0.84
John Day	0.80	0.78	0.70	0 80	0.84	0 84	0.61	0.41	0.15	0.54	0 57	0.71
The Dalles	0.93	0 92	0.89	0 93	0.95	0 94	0.86	0.76	0 55	0.82	0 84	0.90
Bonneville	0.87	0 85	0.80	0 87	0.90	0 90	0.75	0.59	0 33	0.69	0.71	0.82
Rocky Reach	0.95	0 95	0.90	0 93	0.95	0 95	0.93	0.86	0.77	0.89	0 90	0.93
Rock Island	0.98	0 97	0.95	0 97	0.98	0 98	0.96	0.93	0 88	0.94	0 95	0.96
Wanapum	0.96	0 95	0.91	0 94	0.96	0 96	0.93	0.87	0.79	0.90	0 91	0.94
Priest Rapids	0.98	0 98	0.96	0 97	0.98	0 98	0.97	0.93	0 89	0.95	0 95	0.97
Wells	0.97	0 96	0.93	0 95	0.96	0 97	0.95	0.89	0 83	0.92	0 93	0.95
Hanford Reach	0.85	0 85	0.87	0 93	0.95	0 93	0.83	0.63	0 25	0.68	0 64	0.81

c) Technology Optimistic

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.90	0 90	0.93	0 96	0.96	0 96	0.96	0.96	0 96	0.96	0 90	0.90
Little Goose	0.90	0 90	0.93	0 96	0.96	0 96	0.96	0.96	0 96	0.96	0 90	0.90
Lower Monumental	0.90	0 90	0.93	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 90	0.90
Ice Harbor	0.90	0 90	0.93	0 96	0.96	0 96	0.96	0.96	0 94	0.94	0 90	0.90
McNary	0.95	0 95	0.97	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.95
John Day	0.90	0 90	0.92	0 93	0.93	0 93	0.93	0.93	0 93	0.93	0 93	0.92
The Dalles	0.97	0 97	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.97
Bonneville	0.95	0 95	0.96	0 96	0.96	0 96	0.96	0.96	0 96	0.96	0 96	0.95
Rocky Reach	0.89	0 89	0.89	0 93	0.93	0 93	0.93	0.93	0 89	0.89	0 89	0.89
Rock Island	0.89	0 89	0.89	0 92	0.92	0 92	0.92	0.92	0 89	0.89	0 89	0.89
Wanapum	0.89	0 89	0.89	0 92	0.92	0 92	0.92	0.92	0 89	0.89	0 89	0.89
Priest Rapids	0.89	0 89	0.89	0 92	0.92	0 92	0.92	0.92	0 89	0.89	0 89	0.89
Wells	0.89	0 89	0.89	0 97	0.97	0 97	0.97	0.97	0 89	0.89	0 89	0.89
Reservoirs	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Lower Granite	0.88	0 89	0.91	0 95	0.96	0 96	0.88	0.85	0 62	0.76	0.72	0.86
Little Goose	0.87	0 88	0.90	0 95	0.96	0 95	0.86	0.82	0 57	0.74	0 69	0.84
Lower Monumental	0.90	0 90	0.92	0 96	0.97	0 96	0.90	0.84	0 60	0.79	0.76	0.88
Ice Harbor	0.89	0 89	0.91	0 96	0.96	0 96	0.88	0.84	0 59	0.77	0.73	0.87
McNary	0.85	0 89	0.91	0 95	0.96	0 96	0.88	0.84	0 59	0.76	0.72	0.86
John Day	0.82	0 81	0.75	0 84	0.87	0 87	0.75	0.65	0.40	0.61	0 62	0.75
The Dalles	0.94	0 93	0.91	0 94	0.96	0 96	0.91	0.88	0.75	0.85	0 86	0.91
Bonneville	0.89	0 88	0.83	0 90	0.92	0 92	0.84	0.78	0 59	0.74	0.75	0.84
Rocky Reach	0.96	0 95	0.93	0 95	0.96	0 96	0.95	0.92	0 88	0.91	0 92	0.94
Rock Island	0.98	0 98	0.96	0 97	0.98	0 98	0.97	0.96	0 94	0.96	0 96	0.97
Wanapum	0.96	0 96	0.93	0 95	0.97	0 97	0.95	0.93	0 89	0.92	0 92	0.95
Priest Rapids	0.98	0 98	0.97	0 98	0.98	0 98	0.98	0.97	0 94	0.96	0 96	0.97
Wells	0.97	0 97	0.95	0 96	0.97	0 97	0.96	0.94	0 91	0.94	0 94	0.96
Hanford Reach	0.86	0 86	0.89	0 94	0.95	0 95	0.88	0.82	0 55	0.72	0 67	0.83

Tables E-6a,b,c. **Yearling** survival rates by month for Snake and Columbia River Hydroelectric Projects for the **Current** condition and moderate, nature, and technology worldviews.

a) Moderate

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.90	0 90	0.93	0 98	0.98	0 98	0.95	0.95	0 95	0.95	0 90	0.90
Little Goose	0.90	0 90	0.93	0 98	0.98	0 98	0.95	0.95	0 95	0.95	0 90	0.90
Lower Monumental	0.90	0 90	0.93	0 96	0.96	0 96	0.94	0.94	0 94	0.94	0 90	0.90
Ice Harbor	0.90	0 90	0.94	0 97	0.97	0 97	0.97	0.97	0 95	0.95	0 90	0.90
McNary	0.90	0 90	0.94	0 98	0.98	0 98	0.98	0.98	0 97	0.97	0 97	0.97
John Day	0.90	0 90	0.93	0 96	0.96	0 96	0.96	0.96	0 94	0.94	0 90	0.90
The Dalles	0.90	0 90	0.94	0 98	0.98	0 98	0.98	0.98	0 90	0.90	0 90	0.90
Bonneville	0.90	0 90	0.92	0 95	0.95	0 95	0.95	0.95	0 93	0.93	0 90	0.90
Rocky Reach	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Rock Island	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Wanapum	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Priest Rapids	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Wells	0.90	0 90	0.90	0 97	0.97	0 97	0.97	0.97	0 89	0.89	0 89	0.89
Reservoirs	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Lower Granite	0.93	0 94	0.91	0 90	0.91	0 91	0.73	0.72	0 58	0.82	0 91	0.93
Little Goose	0.93	0 93	0.91	0 90	0.91	0 91	0.69	0.65	0 64	0.81	0 90	0.92
Lower Monumental	0.94	0 95	0.93	0 92	0.93	0 93	0.77	0.62	0 69	0.85	0 92	0.94
Ice Harbor	0.94	0 94	0.92	0 91	0.92	0 92	0.72	0.65	0 61	0.83	0 91	0.93
McNary	0.95	0 95	0.91	0 90	0.91	0 91	0.76	0.66	0 62	0.84	0 92	0.94
John Day	0.93	0 93	0.86	0 83	0.85	0 86	0.65	0.49	0.41	0.77	0 88	0.91
The Dalles	0.98	0 98	0.95	0 94	0.95	0 95	0.88	0.81	0.77	0.92	0 96	0.97
Bonneville	0.96	0 96	0.92	0 90	0.91	0 91	0.78	0.67	0 61	0.86	0 93	0.95
Rocky Reach	0.98	0 98	0.95	0 94	0.95	0 96	0.93	0.87	0 84	0.93	0 97	0.98
Rock Island	0.99	0 99	0.98	0 97	0.98	0 98	0.96	0.93	0 92	0.97	0 98	0.99
Wanapum	0.98	0 98	0.96	0 95	0.96	0 96	0.93	0.88	0 85	0.94	0 97	0.98
Priest Rapids	0.99	0 99	0.98	0 97	0.98	0 98	0.97	0.94	0 92	0.97	0 98	0.99
Wells	0.99	0 99	0.97	0 96	0.97	0 97	0.95	0.90	0 88	0.95	0 98	0.98
Hanford Reach	0.98	0 98	0.95	0 97	0.98	0 98	0.93	0.87	0 86	0.93	0 96	0.97

b) Technology Pessimistic

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.90	0 90	0.93	0 98	0.98	0 98	0.95	0.95	0 95	0.95	0 90	0.90
Little Goose	0.90	0 90	0.93	0 98	0.98	0 98	0.95	0.95	0 95	0.95	0 90	0.90
Lower Monumental	0.90	0 90	0.93	0 96	0.96	0 96	0.94	0.94	0 94	0.94	0 90	0.90
Ice Harbor	0.90	0 90	0.94	0 97	0.97	0 97	0.97	0.97	0 95	0.95	0 90	0.90
McNary	0.90	0 90	0.94	0 98	0.98	0 98	0.98	0.98	0 97	0.97	0 97	0.97
John Day	0.90	0 90	0.93	0 96	0.96	0 96	0.96	0.96	0 94	0.94	0 90	0.90
The Dalles	0.90	0 90	0.94	0 98	0.98	0 98	0.98	0.98	0 90	0.90	0 90	0.90
Bonneville	0.90	0 90	0.92	0 95	0.95	0 95	0.95	0.95	0 93	0.93	0 90	0.90
Rocky Reach	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Rock Island	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Wanapum	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Priest Rapids	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Wells	0.90	0 90	0.90	0 97	0.97	0 97	0.97	0.97	0 89	0.89	0 89	0.89
Reservoirs	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Lower Granite	0.77	0.78	0.71	0 81	0.83	0 83	0.58	0.56	0.41	0.58	0 69	0.75
Little Goose	0.86	0 86	0.82	0 89	0.90	0 90	0.62	0.58	0.43	0.74	0 80	0.84
Lower Monumental	0.81	0 82	0.76	0 84	0.86	0 86	0.64	0.51	0 36	0.65	0.74	0.79
Ice Harbor	0.87	0 88	0.85	0 90	0.92	0 91	0.67	0.57	0.43	0.77	0 82	0.86
McNary	0.86	0 86	0.76	0 83	0.85	0 85	0.63	0.51	0 37	0.69	0.79	0.84
John Day	0.86	0 85	0.75	0 81	0.84	0 85	0.54	0.40	0 26	0.69	0.78	0.83
The Dalles	0.92	0 92	0.85	0 89	0.90	0 91	0.78	0.70	0 99	0.98	0 87	0.90
Bonneville	0.91	0 91	0.84	0 89	0.90	0 91	0.70	0.58	0.45	0.80	0 86	0.89
Rocky Reach	0.94	0 93	0.84	0 88	0.91	0 91	0.86	0.76	0.65	0.83	0 88	0.91
Rock Island	0.97	0 97	0.92	0 94	0.95	0 96	0.93	0.87	0 81	0.91	0 94	0.96
Wanapum	0.94	0 94	0.86	0 89	0.92	0 92	0.87	0.78	0 68	0.84	0 89	0.92
Priest Rapids	0.97	0 97	0.93	0 94	0.96	0 96	0.93	0.88	0 83	0.92	0 95	0.96
Wells	0.95	0 95	0.88	0 91	0.93	0 94	0.89	0.82	0.74	0.87	0 91	0.94
Hanford Reach	0.99	0 98	0.96	0 97	0.98	0 98	0.94	0.81	0.73	0.96	0 97	0.98

c) Technology Optimistic

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.90	0 90	0.93	0 98	0.98	0 98	0.95	0.95	0 95	0.95	0 90	0.90
Little Goose	0.90	0 90	0.93	0 98	0.98	0 98	0.95	0.95	0 95	0.95	0 90	0.90
Lower Monumental	0.90	0 90	0.93	0 96	0.96	0 96	0.94	0.94	0 94	0.94	0 90	0.90
Ice Harbor	0.90	0 90	0.94	0 97	0.97	0 97	0.97	0.97	0 95	0.95	0 90	0.90
McNary	0.90	0 90	0.94	0 98	0.98	0 98	0.98	0.98	0 97	0.97	0 97	0.97
John Day	0.90	0 90	0.93	0 96	0.96	0 96	0.96	0.96	0 94	0.94	0 90	0.90
The Dalles	0.90	0 90	0.94	0 98	0.98	0 98	0.98	0.98	0 90	0.90	0 90	0.90
Bonneville	0.90	0 90	0.92	0 95	0.95	0 95	0.95	0.95	0 93	0.93	0 90	0.90
Rocky Reach	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Rock Island	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Wanapum	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Priest Rapids	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Wells	0.90	0 90	0.90	0 97	0.97	0 97	0.97	0.97	0 89	0.89	0 89	0.89
Reservoirs	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Lower Granite	0.92	0 93	0.91	0 95	0.95	0 95	0.84	0.83	0.75	0.87	0 89	0.92
Little Goose	0.92	0 92	0.91	0 94	0.95	0 95	0.81	0.78	0 69	0.86	0 89	0.91
Lower Monumental	0.94	0 94	0.93	0 96	0.96	0 96	0.86	0.78	0 69	0.89	0 91	0.93
Ice Harbor	0.93	0 93	0.92	0 95	0.96	0 95	0.83	0.79	0.70	0.88	0 90	0.93
McNary	0.95	0 95	0.92	0 94	0.95	0 95	0.85	0.80	0.71	0.89	0 92	0.94
John Day	0.92	0 92	0.87	0 90	0.92	0 92	0.78	0.68	0 57	0.83	0 88	0.90
The Dalles	0.98	0 97	0.96	0 97	0.97	0 97	0.93	0.89	0 99	0.99	0 96	0.97
Bonneville	0.95	0 95	0.92	0 94	0.95	0 95	0.87	0.80	0.73	0.90	0 92	0.94
Rocky Reach	0.98	0 98	0.95	0 97	0.97	0 98	0.96	0.92	0 88	0.95	0 96	0.97
Rock Island	0.99	0 99	0.98	0 98	0.99	0 99	0.98	0.96	0 94	0.98	0 98	0.99
Wanapum	0.98	0 98	0.96	0 97	0.98	0 98	0.96	0.93	0 89	0.96	0 97	0.98
Priest Rapids	0.99	0 99	0.98	0 98	0.99	0 99	0.98	0.96	0 95	0.98	0 98	0.99
Wells	0.99	0 98	0.97	0 98	0.98	0 98	0.97	0.94	0 91	0.96	0 97	0.98
Hanford Reach	0.99	0 99	0.98	0 98	0.99	0 99	0.97	0.94	0 91	0.98	0 98	0.99

Tables E-7a,b,c. **Yearling** survival rates by month for Snake and Columbia River Hydroelectric Projects for the **Historic** condition and moderate, nature, and technology worldviews.

a) Moderate

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Little Goose	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Lower Monumental	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Ice Harbor	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
McNary	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
John Day	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
The Dalles	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Bonneville	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Rocky Reach	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Rock Island	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Wanapum	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Priest Rapids	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Wells	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Reservoirs	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.98	0 98	0.98	0 99	0.99	0 99	0.92	0.81	0.76	0.96	0 98	0.98
Little Goose	0.98	0 98	0.98	0 99	0.99	0 99	0.90	0.75	0 84	0.96	0 98	0.98
Lower Monumental	0.98	0 99	0.98	0 99	0.99	0 99	0.92	0.79	0 89	0.97	0 98	0.98
Ice Harbor	0.98	0 99	0.98	0 99	0.99	0 99	0.90	0.74	0 81	0.97	0 98	0.98
McNary	0.97	0 97	0.96	0 98	0.99	0 99	0.91	0.74	0.76	0.95	0 97	0.97
John Day	0.94	0 95	0.93	0 96	0.98	0 98	0.86	0.63	0 58	0.91	0 94	0.94
The Dalles	0.98	0 98	0.98	0 99	0.99	0 99	0.95	0.86	0 85	0.97	0 98	0.98
Bonneville	0.97	0 97	0.96	0 97	0.99	0 99	0.92	0.76	0.73	0.94	0 97	0.97
Rocky Reach	0.98	0 98	0.97	0 99	0.99	0 99	0.98	0.93	0 91	0.97	0 98	0.98
Rock Island	0.99	0 99	0.99	0 99	1.00	1 00	0.99	0.97	0 96	0.99	0 99	0.99
Wanapum	0.98	0 98	0.98	0 99	0.99	1 00	0.98	0.94	0 92	0.97	0 98	0.98
Priest Rapids	0.99	0 99	0.99	0 99	1.00	1 00	0.99	0.97	0 96	0.99	0 99	0.99
Wells	0.98	0 99	0.98	0 99	1.00	1 00	0.99	0.95	0 94	0.98	0 99	0.99
Hanford Reach	0.98	0 98	0.97	0 99	0.99	0 99	0.98	0.93	0 92	0.97	0 98	0.98

b) Technology Pessimistic

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Little Goose	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Lower Monumental	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Ice Harbor	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
McNary	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
John Day	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
The Dalles	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Bonneville	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Rocky Reach	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Rock Island	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Wanapum	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Priest Rapids	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Wells	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Reservoirs	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.97	0 98	0.97	0 98	0.98	0 98	0.89	0.74	0.74	0.94	0 97	0.97
Little Goose	0.98	0 98	0.98	0 98	0.99	0 99	0.89	0.70	0.71	0.96	0 98	0.98
Lower Monumental	0.98	0 98	0.97	0 98	0.99	0 99	0.89	0.71	0.71	0.95	0 97	0.98
Ice Harbor	0.98	0 98	0.98	0 99	0.99	0 99	0.89	0.69	0.70	0.96	0 98	0.98
McNary	0.96	0 96	0.94	0 96	0.98	0 98	0.87	0.64	0 58	0.92	0 95	0.96
John Day	0.94	0 94	0.92	0 95	0.97	0 98	0.82	0.49	0 39	0.90	0 94	0.94
The Dalles	0.97	0 97	0.96	0 98	0.99	0 99	0.93	0.79	0 99	0.99	0 99	0.99
Bonneville	0.96	0 97	0.95	0 97	0.98	0 99	0.89	0.65	0 57	0.94	0 96	0.96
Rocky Reach	0.97	0 97	0.95	0 98	0.99	0 99	0.97	0.89	0 84	0.95	0 97	0.97
Rock Island	0.98	0 98	0.98	0 99	0.99	1 00	0.99	0.95	0 92	0.98	0 99	0.98
Wanapum	0.97	0 97	0.96	0 98	0.99	0 99	0.98	0.90	0 85	0.96	0 97	0.97
Priest Rapids	0.98	0 99	0.98	0 99	1.00	1 00	0.99	0.95	0 92	0.98	0 99	0.99
Wells	0.98	0 98	0.97	0 98	0.99	0 99	0.98	0.92	0 88	0.96	0 98	0.98
Hanford Reach	0.98	0 98	0.97	0 98	0.99	0 99	0.97	0.87	0 81	0.97	0 98	0.98

c) Technology Optimistic

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Little Goose	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Lower Monumental	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Ice Harbor	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
McNary	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
John Day	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
The Dalles	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Bonneville	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Rocky Reach	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Rock Island	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Wanapum	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Priest Rapids	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Wells	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Reservoirs	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.99	0 99	0.99	0 99	0.99	0 99	0.95	0.88	0 88	0.98	0 99	0.99
Little Goose	0.99	0 99	0.99	0 99	0.99	0 99	0.94	0.85	0 85	0.97	0 98	0.99
Lower Monumental	0.99	0 99	0.99	0 99	0.99	0 99	0.95	0.88	0 88	0.98	0 99	0.99
Ice Harbor	0.99	0 99	0.99	0 99	0.99	0 99	0.94	0.85	0 85	0.98	0 99	0.99
McNary	0.98	0 98	0.98	0 98	0.99	0 99	0.95	0.85	0 82	0.97	0 98	0.98
John Day	0.96	0 96	0.95	0 97	0.98	0 99	0.92	0.77	0.71	0.94	0 96	0.96
The Dalles	0.99	0 99	0.98	0 99	0.99	1 00	0.97	0.92	0 99	0.99	0 99	0.99
Bonneville	0.97	0 98	0.97	0 98	0.99	0 99	0.95	0.86	0 82	0.96	0 97	0.97
Rocky Reach	0.98	0 98	0.98	0 99	1.00	1 00	0.99	0.96	0 94	0.98	0 99	0.99
Rock Island	0.99	0 99	0.99	1 00	1.00	1 00	0.99	0.98	0 97	0.99	0 99	0.99
Wanapum	0.99	0 99	0.98	0 99	1.00	1 00	0.99	0.96	0 95	0.98	0 99	0.99
Priest Rapids	0.99	0 99	0.99	1 00	1.00	1 00	1.00	0.98	0 97	0.99	0 99	0.99
Wells	0.99	0 99	0.99	0 99	1.00	1 00	0.99	0.97	0 96	0.99	0 99	0.99
Hanford Reach	0.98	0 98	0.98	0 99	1.00	1 00	0.99	0.96	0 94	0.98	0 99	0.98

Tables E-8a,b,c. **Yearling** survival rates by month for Snake and Columbia River Hydroelectric Projects for **Alternative 2** and moderate, nature, and technology worldviews.

a) Moderate

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Little Goose	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Lower Monumental	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Ice Harbor	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
McNary	0.95	0 95	0.98	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.97
John Day	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
The Dalles	0.98	0 98	0.98	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.98
Bonneville	0.95	0 95	0.98	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.95
Rocky Reach	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.93
Rock Island	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.93
Wanapum	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.92
Priest Rapids	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.93
Wells	0.89	0 89	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.94
Reservoirs	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.96	0 96	0.96	0 97	0.98	0 98	0.89	0.82	0.74	0.91	0 94	0.96
Little Goose	0.96	0 96	0.95	0 97	0.98	0 98	0.88	0.76	0 82	0.90	0 94	0.95
Lower Monumental	0.97	0 97	0.96	0 98	0.98	0 98	0.90	0.75	0 86	0.92	0 95	0.96
Ice Harbor	0.96	0 96	0.96	0 98	0.98	0 98	0.89	0.75	0.78	0.91	0 95	0.96
McNary	0.93	0 93	0.90	0 93	0.94	0 94	0.83	0.71	0.71	0.85	0 90	0.93
John Day	0.92	0 92	0.89	0 92	0.93	0 94	0.75	0.57	0 54	0.84	0 89	0.92
The Dalles	0.95	0 95	0.93	0 95	0.96	0 96	0.88	0.81	0.79	0.90	0 93	0.95
Bonneville	0.93	0 94	0.91	0 93	0.95	0 95	0.81	0.70	0 67	0.86	0 91	0.93
Rocky Reach	0.96	0 96	0.93	0 95	0.96	0 96	0.94	0.88	0 86	0.91	0 94	0.96
Rock Island	0.98	0 98	0.97	0 97	0.98	0 98	0.97	0.94	0 93	0.95	0 97	0.98
Wanapum	0.96	0 96	0.94	0 95	0.96	0 97	0.94	0.89	0 87	0.92	0 94	0.96
Priest Rapids	0.98	0 98	0.97	0 98	0.98	0 98	0.97	0.95	0 94	0.96	0 97	0.98
Wells	0.97	0 97	0.95	0 96	0.97	0 97	0.95	0.91	0 90	0.93	0 96	0.97
Hanford Reach	0.98	0 98	0.97	0 98	0.98	0 98	0.96	0.91	0 92	0.96	0 97	0.98

b) Technology Pessimistic

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Little Goose	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Lower Monumental	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Ice Harbor	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
McNary	0.95	0 95	0.98	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.97
John Day	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
The Dalles	0.98	0 98	0.98	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.98
Bonneville	0.95	0 95	0.98	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.95
Rocky Reach	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.93
Rock Island	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.93
Wanapum	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.92
Priest Rapids	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.93
Wells	0.89	0 89	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.94
Reservoirs	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.93	0 93	0.92	0 95	0.96	0 96	0.84	0.75	0.70	0.84	0 90	0.93
Little Goose	0.95	0 95	0.95	0 97	0.98	0 97	0.86	0.71	0 66	0.89	0 93	0.95
Lower Monumental	0.94	0 94	0.93	0 96	0.97	0 96	0.86	0.74	0 69	0.86	0 92	0.94
Ice Harbor	0.96	0 96	0.96	0 97	0.98	0 98	0.88	0.74	0.70	0.91	0 94	0.96
McNary	0.88	0 89	0.82	0 86	0.88	0 88	0.73	0.57	0 50	0.73	0 84	0.88
John Day	0.92	0 92	0.88	0 91	0.93	0 91	0.66	0.46	0 39	0.82	0 88	0.91
The Dalles	0.90	0 90	0.86	0 89	0.91	0 92	0.79	0.71	0 94	0.93	0 93	0.95
Bonneville	0.92	0 92	0.89	0 92	0.93	0 94	0.74	0.62	0 55	0.85	0 90	0.92
Rocky Reach	0.92	0 92	0.87	0 90	0.92	0 93	0.88	0.80	0.74	0.82	0 89	0.92
Rock Island	0.96	0 96	0.93	0 95	0.96	0 96	0.94	0.89	0 86	0.91	0 94	0.96
Wanapum	0.93	0 93	0.88	0 91	0.93	0 93	0.89	0.81	0.76	0.83	0 90	0.92
Priest Rapids	0.96	0 96	0.94	0 95	0.96	0 97	0.94	0.90	0 87	0.91	0 95	0.96
Wells	0.94	0 94	0.90	0 93	0.94	0 95	0.91	0.85	0 80	0.87	0 92	0.94
Hanford Reach	0.98	0 98	0.97	0 97	0.98	0 98	0.95	0.85	0 81	0.95	0 97	0.98

c) Technology Optimistic

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Little Goose	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Lower Monumental	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
Ice Harbor	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
McNary	0.95	0 95	0.98	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.97
John Day	1.00	1 00	1.00	1 00	1.00	1 00	1.00	1.00	1 00	1.00	1 00	1.00
The Dalles	0.98	0 98	0.98	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.98
Bonneville	0.95	0 95	0.98	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.95
Rocky Reach	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.93
Rock Island	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.93
Wanapum	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.92
Priest Rapids	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.93
Wells	0.89	0 89	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.94
Reservoirs	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.98	0 98	0.97	0 98	0.99	0 99	0.94	0.90	0 88	0.95	0 96	0.97
Little Goose	0.97	0 97	0.97	0 98	0.99	0 99	0.93	0.87	0 84	0.94	0 96	0.97
Lower Monumental	0.98	0 98	0.98	0 99	0.99	0 99	0.95	0.88	0 85	0.95	0 97	0.98
Ice Harbor	0.98	0 98	0.98	0 99	0.99	0 99	0.94	0.87	0 85	0.95	0 97	0.98
McNary	0.96	0 96	0.94	0 96	0.96	0 96	0.90	0.83	0 80	0.91	0 94	0.96
John Day	0.95	0 95	0.93	0 95	0.96	0 95	0.84	0.74	0 69	0.90	0 93	0.95
The Dalles	0.97	0 97	0.96	0 97	0.97	0 98	0.93	0.90	0 98	0.98	0 98	0.98
Bonneville	0.96	0 96	0.94	0 96	0.96	0 97	0.89	0.83	0.79	0.92	0 94	0.96
Rocky Reach	0.98	0 98	0.96	0 97	0.98	0 98	0.96	0.93	0 91	0.95	0 96	0.97
Rock Island	0.99	0 99	0.98	0 99	0.99	0 99	0.98	0.97	0 96	0.97	0 98	0.99
Wanapum	0.98	0 98	0.97	0 97	0.98	0 98	0.97	0.94	0 92	0.95	0 97	0.98
Priest Rapids	0.99	0 99	0.98	0 99	0.99	0 99	0.98	0.97	0 96	0.98	0 98	0.99
Wells	0.98	0 98	0.97	0 98	0.98	0 99	0.97	0.95	0 94	0.96	0 97	0.98
Hanford Reach	0.99	0 99	0.98	0 99	0.99	0 99	0.98	0.95	0 93	0.97	0 98	0.99

Tables E-9a,b,c. **Yearling** survival rates by month for Snake and Columbia River Hydroelectric Projects for **Alternative 5** and moderate, nature, and technology worldviews.

a) Moderate

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.90	0 90	0.98	0 98	0.98	0 98	0.98	0.98	0 95	0.95	0 95	0.93
Little Goose	0.90	0 90	0.98	0 98	0.98	0 98	0.98	0.98	0 95	0.95	0 95	0.93
Lower Monumental	0.90	0 90	0.96	0 96	0.96	0 96	0.96	0.96	0 94	0.94	0 94	0.92
Ice Harbor	0.95	0 95	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.96
McNary	0.95	0 95	0.98	0 98	0.98	0 98	0.98	0.98	0 97	0.97	0 97	0.96
John Day	0.90	0 90	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.95
The Dalles	0.95	0 95	0.98	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.96
Bonneville	0.95	0 95	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.96
Rocky Reach	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.93
Rock Island	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.93
Wanapum	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.92
Priest Rapids	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.93
Wells	0.89	0 89	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.94
Reservoirs	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.93	0 93	0.92	0 95	0.96	0 95	0.76	0.74	0 61	0.87	0 90	0.92
Little Goose	0.91	0 91	0.89	0 93	0.94	0 93	0.70	0.66	0 65	0.83	0 87	0.90
Lower Monumental	0.95	0 95	0.94	0 96	0.97	0 96	0.81	0.65	0.74	0.90	0 93	0.94
Ice Harbor	0.93	0 93	0.91	0 94	0.95	0 95	0.74	0.67	0 63	0.86	0 90	0.92
McNary	0.93	0 93	0.89	0 93	0.94	0 94	0.78	0.68	0 63	0.86	0 90	0.93
John Day	0.90	0 90	0.83	0 88	0.90	0 90	0.66	0.51	0.42	0.78	0 85	0.88
The Dalles	0.96	0 96	0.93	0 96	0.96	0 96	0.88	0.82	0.77	0.92	0 94	0.96
Bonneville	0.94	0 94	0.91	0 94	0.95	0 95	0.80	0.70	0 63	0.88	0 92	0.94
Rocky Reach	0.97	0 97	0.93	0 96	0.96	0 97	0.93	0.88	0 84	0.93	0 95	0.96
Rock Island	0.98	0 98	0.97	0 98	0.98	0 98	0.96	0.94	0 92	0.96	0 97	0.98
Wanapum	0.97	0 97	0.94	0 96	0.97	0 97	0.93	0.89	0 85	0.94	0 95	0.97
Priest Rapids	0.98	0 98	0.97	0 98	0.98	0 98	0.97	0.94	0 92	0.97	0 98	0.98
Wells	0.98	0 98	0.95	0 97	0.97	0 97	0.95	0.91	0 88	0.95	0 96	0.97
Hanford Reach	0.98	0 98	0.96	0 98	0.98	0 98	0.95	0.90	0 89	0.96	0 97	0.98

b) Technology Pessimistic

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.90	0 90	0.98	0 98	0.98	0 98	0.98	0.98	0 95	0.95	0 95	0.93
Little Goose	0.90	0 90	0.98	0 98	0.98	0 98	0.98	0.98	0 95	0.95	0 95	0.93
Lower Monumental	0.90	0 90	0.96	0 96	0.96	0 96	0.96	0.96	0 94	0.94	0 94	0.92
Ice Harbor	0.95	0 95	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.96
McNary	0.95	0 95	0.98	0 98	0.98	0 98	0.98	0.98	0 97	0.97	0 97	0.96
John Day	0.90	0 90	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.95
The Dalles	0.95	0 95	0.98	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.96
Bonneville	0.95	0 95	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.96
Rocky Reach	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.93
Rock Island	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.93
Wanapum	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.92
Priest Rapids	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.93
Wells	0.89	0 89	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.94
Reservoirs	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.85	0 85	0.83	0 89	0.89	0 89	0.64	0.63	0 54	0.77	0 83	0.87
Little Goose	0.89	0 89	0.87	0 91	0.92	0 92	0.65	0.60	0.48	0.81	0 86	0.89
Lower Monumental	0.90	0 90	0.87	0 92	0.93	0 93	0.73	0.59	0.46	0.82	0 88	0.90
Ice Harbor	0.92	0 92	0.89	0 93	0.94	0 94	0.70	0.61	0.48	0.85	0 90	0.92
McNary	0.89	0 89	0.82	0 87	0.88	0 88	0.68	0.56	0.42	0.77	0 85	0.88
John Day	0.88	0 88	0.80	0 86	0.88	0 87	0.57	0.44	0 29	0.76	0 84	0.87
The Dalles	0.92	0 92	0.87	0 91	0.92	0 92	0.80	0.72	0 93	0.93	0 93	0.95
Bonneville	0.93	0 93	0.89	0 92	0.93	0 93	0.74	0.63	0.49	0.87	0 91	0.93
Rocky Reach	0.93	0 93	0.86	0 91	0.92	0 92	0.87	0.78	0 68	0.86	0 90	0.93
Rock Island	0.97	0 97	0.93	0 95	0.96	0 96	0.93	0.89	0 83	0.93	0 95	0.96
Wanapum	0.94	0 94	0.87	0 92	0.93	0 93	0.88	0.80	0.71	0.88	0 91	0.94
Priest Rapids	0.97	0 97	0.93	0 96	0.96	0 96	0.94	0.90	0 84	0.94	0 96	0.97
Wells	0.95	0 95	0.90	0 93	0.94	0 94	0.91	0.84	0.76	0.90	0 93	0.95
Hanford Reach	0.98	0 98	0.95	0 97	0.97	0 97	0.94	0.82	0.73	0.96	0 97	0.98

c) Technology Optimistic

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.90	0 90	0.98	0 98	0.98	0 98	0.98	0.98	0 95	0.95	0 95	0.93
Little Goose	0.90	0 90	0.98	0 98	0.98	0 98	0.98	0.98	0 95	0.95	0 95	0.93
Lower Monumental	0.90	0 90	0.96	0 96	0.96	0 96	0.96	0.96	0 94	0.94	0 94	0.92
Ice Harbor	0.95	0 95	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.96
McNary	0.95	0 95	0.98	0 98	0.98	0 98	0.98	0.98	0 97	0.97	0 97	0.96
John Day	0.90	0 90	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.95
The Dalles	0.95	0 95	0.98	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.96
Bonneville	0.95	0 95	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.96
Rocky Reach	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.93
Rock Island	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.93
Wanapum	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.92
Priest Rapids	0.89	0 89	0.95	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.93
Wells	0.89	0 89	0.97	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.94
Reservoirs	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.95	0 95	0.94	0 96	0.97	0 96	0.86	0.85	0 80	0.92	0 94	0.95
Little Goose	0.94	0 94	0.93	0 95	0.96	0 96	0.82	0.80	0.72	0.90	0 92	0.94
Lower Monumental	0.96	0 96	0.96	0 97	0.98	0 98	0.89	0.81	0.73	0.94	0 95	0.96
Ice Harbor	0.95	0 95	0.94	0 96	0.97	0 97	0.85	0.81	0.73	0.92	0 94	0.95
McNary	0.96	0 96	0.94	0 96	0.96	0 96	0.87	0.82	0.74	0.92	0 94	0.95
John Day	0.93	0 93	0.89	0 92	0.93	0 93	0.80	0.71	0 60	0.87	0 91	0.93
The Dalles	0.97	0 97	0.96	0 97	0.98	0 98	0.93	0.90	0 98	0.98	0 98	0.98
Bonneville	0.96	0 96	0.94	0 96	0.96	0 96	0.89	0.83	0.76	0.93	0 95	0.96
Rocky Reach	0.98	0 98	0.96	0 97	0.98	0 98	0.96	0.93	0 89	0.96	0 97	0.98
Rock Island	0.99	0 99	0.98	0 99	0.99	0 99	0.98	0.97	0 95	0.98	0 98	0.99
Wanapum	0.98	0 98	0.96	0 98	0.98	0 98	0.96	0.94	0 90	0.96	0 97	0.98
Priest Rapids	0.99	0 99	0.98	0 99	0.99	0 99	0.98	0.97	0 95	0.98	0 99	0.99
Wells	0.98	0 98	0.97	0 98	0.98	0 98	0.97	0.95	0 92	0.97	0 98	0.98
Hanford Reach	0.99	0 99	0.97	0 98	0.98	0 99	0.97	0.94	0 91	0.98	0 98	0.99

Tables E-10a,b,c. **Yearling** survival rates by month for Snake and Columbia River Hydroelectric Projects for **Alternative 6** and moderate, nature, and technology worldviews.

a) Moderate

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.90	0 90	0.94	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 90	0.90
Little Goose	0.90	0 90	0.94	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 90	0.90
Lower Monumental	0.90	0 90	0.93	0 96	0.96	0 96	0.96	0.96	0 96	0.96	0 90	0.90
Ice Harbor	0.90	0 90	0.94	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 90	0.90
McNary	0.95	0 95	0.97	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.96
John Day	0.90	0 90	0.93	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.93
The Dalles	0.98	0 98	0.98	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.98
Bonneville	0.95	0 95	0.96	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.95
Rocky Reach	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Rock Island	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Wanapum	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Priest Rapids	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Wells	0.89	0 89	0.89	0 97	0.97	0 97	0.97	0.97	0 89	0.89	0 89	0.89
Reservoirs	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Lower Granite	0.90	0 90	0.88	0 92	0.93	0 93	0.72	0.70	0 55	0.81	0 86	0.89
Little Goose	0.89	0 89	0.87	0 92	0.93	0 92	0.67	0.62	0 61	0.80	0 85	0.88
Lower Monumental	0.92	0 92	0.90	0 93	0.94	0 94	0.77	0.61	0 67	0.84	0 88	0.91
Ice Harbor	0.91	0 91	0.89	0 93	0.94	0 93	0.72	0.63	0 58	0.82	0 87	0.90
McNary	0.93	0 92	0.89	0 92	0.94	0 94	0.76	0.66	0 62	0.85	0 89	0.91
John Day	0.90	0 90	0.84	0 88	0.90	0 90	0.66	0.48	0.41	0.79	0 84	0.88
The Dalles	0.97	0 97	0.95	0 96	0.97	0 97	0.88	0.81	0.77	0.93	0 95	0.96
Bonneville	0.94	0 94	0.90	0 93	0.94	0 94	0.79	0.67	0 61	0.87	0 90	0.92
Rocky Reach	0.97	0 96	0.93	0 94	0.96	0 96	0.92	0.85	0 83	0.92	0 94	0.96
Rock Island	0.98	0 98	0.96	0 97	0.98	0 98	0.96	0.93	0 91	0.96	0 97	0.98
Wanapum	0.97	0 97	0.93	0 95	0.96	0 96	0.93	0.87	0 84	0.92	0 95	0.96
Priest Rapids	0.99	0 98	0.97	0 97	0.98	0 98	0.96	0.93	0 92	0.96	0 97	0.98
Wells	0.98	0 97	0.95	0 96	0.97	0 97	0.94	0.89	0 87	0.94	0 96	0.97
Hanford Reach	0.99	0 98	0.97	0 97	0.98	0 98	0.95	0.89	0 89	0.96	0 97	0.98

b) Technology Pessimistic

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.90	0 90	0.94	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 90	0.90
Little Goose	0.90	0 90	0.94	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 90	0.90
Lower Monumental	0.90	0 90	0.93	0 96	0.96	0 96	0.96	0.96	0 96	0.96	0 90	0.90
Ice Harbor	0.90	0 90	0.94	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 90	0.90
McNary	0.95	0 95	0.97	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.96
John Day	0.90	0 90	0.93	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.93
The Dalles	0.98	0 98	0.98	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.98
Bonneville	0.95	0 95	0.96	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.95
Rocky Reach	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Rock Island	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Wanapum	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Priest Rapids	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Wells	0.89	0 89	0.89	0 97	0.97	0 97	0.97	0.97	0 89	0.89	0 89	0.89
Reservoirs	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Lower Granite	0.79	0 80	0.75	0 84	0.85	0 84	0.58	0.55	0.44	0.66	0.75	0.80
Little Goose	0.87	0 87	0.85	0 90	0.91	0 91	0.62	0.57	0.44	0.78	0 83	0.87
Lower Monumental	0.83	0 83	0.79	0 87	0.88	0 88	0.65	0.51	0 37	0.71	0.78	0.83
Ice Harbor	0.89	0 89	0.87	0 92	0.93	0 92	0.68	0.57	0.43	0.81	0 85	0.89
McNary	0.89	0 88	0.82	0 87	0.87	0 88	0.66	0.53	0.41	0.77	0 83	0.86
John Day	0.88	0 87	0.81	0 86	0.88	0 87	0.57	0.41	0 29	0.77	0 83	0.86
The Dalles	0.93	0 93	0.89	0 92	0.93	0 93	0.80	0.72	0 93	0.93	0 93	0.95
Bonneville	0.93	0 92	0.88	0 91	0.92	0 93	0.72	0.59	0.48	0.86	0 89	0.92
Rocky Reach	0.94	0 93	0.84	0 88	0.90	0 91	0.85	0.74	0 66	0.84	0 89	0.92
Rock Island	0.97	0 96	0.92	0 94	0.95	0 95	0.92	0.87	0 82	0.92	0 95	0.96
Wanapum	0.94	0 93	0.86	0 89	0.91	0 92	0.86	0.76	0 69	0.85	0 90	0.93
Priest Rapids	0.97	0 97	0.93	0 94	0.95	0 96	0.93	0.88	0 83	0.92	0 95	0.96
Wells	0.95	0 95	0.88	0 91	0.93	0 93	0.89	0.81	0.74	0.88	0 92	0.94
Hanford Reach	0.98	0 98	0.96	0 97	0.97	0 97	0.93	0.80	0.73	0.96	0 97	0.98

c) Technology Optimistic

Dams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Granite	0.90	0 90	0.94	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 90	0.90
Little Goose	0.90	0 90	0.94	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 90	0.90
Lower Monumental	0.90	0 90	0.93	0 96	0.96	0 96	0.96	0.96	0 96	0.96	0 90	0.90
Ice Harbor	0.90	0 90	0.94	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 90	0.90
McNary	0.95	0 95	0.97	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.96
John Day	0.90	0 90	0.93	0 95	0.95	0 95	0.95	0.95	0 95	0.95	0 95	0.93
The Dalles	0.98	0 98	0.98	0 98	0.98	0 98	0.98	0.98	0 98	0.98	0 98	0.98
Bonneville	0.95	0 95	0.96	0 97	0.97	0 97	0.97	0.97	0 97	0.97	0 97	0.95
Rocky Reach	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Rock Island	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Wanapum	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Priest Rapids	0.89	0 89	0.89	0 95	0.95	0 95	0.95	0.95	0 89	0.89	0 89	0.89
Wells	0.89	0 89	0.89	0 97	0.97	0 97	0.97	0.97	0 89	0.89	0 89	0.89
Reservoirs	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Lower Granite	0.93	0 93	0.92	0 95	0.95	0 95	0.83	0.82	0.76	0.89	0 91	0.93
Little Goose	0.93	0 93	0.92	0 95	0.95	0 95	0.81	0.78	0 69	0.88	0 91	0.93
Lower Monumental	0.95	0 95	0.94	0 96	0.97	0 96	0.87	0.78	0 69	0.91	0 93	0.94
Ice Harbor	0.94	0 94	0.93	0 96	0.96	0 96	0.84	0.79	0.70	0.90	0 92	0.94
McNary	0.96	0 95	0.94	0 95	0.96	0 96	0.86	0.80	0.73	0.91	0 93	0.95
John Day	0.93	0 93	0.90	0 92	0.93	0 93	0.79	0.69	0 60	0.87	0 90	0.92
The Dalles	0.98	0 98	0.97	0 98	0.98	0 98	0.93	0.90	0 98	0.98	0 98	0.98
Bonneville	0.96	0 96	0.94	0 95	0.96	0 96	0.88	0.81	0.75	0.92	0 94	0.95
Rocky Reach	0.98	0 98	0.96	0 97	0.97	0 97	0.95	0.92	0 89	0.95	0 97	0.97
Rock Island	0.99	0 99	0.98	0 98	0.99	0 99	0.98	0.96	0 94	0.98	0 98	0.99
Wanapum	0.98	0 98	0.96	0 97	0.98	0 98	0.96	0.93	0 90	0.96	0 97	0.98
Priest Rapids	0.99	0 99	0.98	0 98	0.99	0 99	0.98	0.96	0 95	0.98	0 98	0.99
Wells	0.99	0 98	0.97	0 98	0.98	0 98	0.97	0.94	0 92	0.97	0 98	0.98
Hanford Reach	0.99	0 99	0.98	0 98	0.98	0 99	0.97	0.94	0 91	0.98	0 98	0.99

Appendix F-1

Black Bear
Habitat Assessment Method
Summary

This document summarizes the steps taken by the Northwest Habitat Institute (NHI) to produce Black Bear Habitat Condition Indexes (HCIs) for each 6^{th} Order HUC in the Columbia River Basin. These procedures were applied for the current, normative, and three alternative conditions. Streamnet's 6th Order HUC ArcInfo polygon coverage was updated with several items to produce the initial COVER, FOOD, HUMAN, and HCI variables for the Black Bear Habitat Assessment Method. The first section describes the analysis methods including equations and weights used to derive the variables. The Arc Macro Language (AML) program written to calculate the variables can easily be re-executed if the equations or weights need to be adjusted. The second section details the individual items found in the resulting coverages. Appendix A lists the 32 habitat codes and class names, and Appendix B contains NHI's Interactive Biodiversity Information System (IBIS) habitat association data for the Black Bear. Appendix C contains the Black Bear berry index.

Analysis

Preparation

A major portion of the Habitat Assessment Method depends on knowing the habitat composition of each 6^{th} Order HUC. These measurements were calculated using the NHI Current and Normative Wildlife-Habitat Types grids and Streamnet's 6^{th} Order HUC coverage. Due to its large area extent and high 25m resolution, the Current habitat grid could not be converted to a vector coverage without significant generalization of the data. Therefore, the HUC coverage was converted to a grid and an AML was written to perform a Grid analysis of the HUC and habitat data sets. This AML calculated the percentage of each habitat type in each HUC and wrote these results into the original HUC coverage as items H1PCNT - H32PCNT where 1 - 32 equals the 32 habitat type codes(see Appendix A). The remainder of the analysis was completed in ArcInfo using the updated HUC coverages.

Additionally, road density data for each alternative were compiled by Battelle and NHI (see Habitat Condition Index section). The three alternative scenarios were run using habitat data modeled by Battelle, and Salmon carcass data were provided by Mobrand Biometrics.

Habitat Assessment Method

The Habitat Assessment Method consists of two major sections. The first is a preliminary screening of all HUCS. During this screening, HUCS are either included in or excluded from further analysis based on specific criteria. The second section calculates the Habitat Condition Index (HCI) for those HUCS that pass the preliminary screening.

Preliminary Screening

The first step in the preliminary screening is to determine for each 6th order HUC if 80% or greater of the HUC is in the Black Bear's range. The Black Bear's range was established as any habitat type that has any association, 'Generally Associated' or 'Present,' with the Black Bear in the NHI Interactive Biodiversity Information System (IBIS) database (see Appendix B). Item RANGE_PCNT sums the percentages of all these-associated habitats per HUC. If RANGE_PCNT >= 80% for a HUC, item RANGE_KEEP was assigned a value of 1 for that HUC, otherwise it was assigned 0.

Since initial runs of the model on the current habitat data yielded unrealistic results (the bear range was too extensive), another preliminary step was added. This step expanded on the first by stating that only HUCS with 20 percent or greater 'Generally Associated' habitat types, and/or those with 20 percent or more 'Present' habitat types and an adjacent HUC with 20percent or more 'Generally Associated' habitat types would be kept for further analysis. If a HUC met these conditions, item PRES_KEEP was assigned a value of 1, otherwise a 0 was assigned.

Next, the data are examined to see if 90% or more of the HUC is non-urban. Item URBAN_KEEP was added and given a 1 for each HUC that met this criteria and a 0 otherwise.

Finally, each HUC is evaluated for its amount of agricultural land. HUCS with 50% or more agriculture are excluded from further analysis. If H19_PCNT < 50%, item AGRIC_KEEP was assigned a 1, otherwise a 0.

Item PRELM_KEEP was added to summarize the results of the preliminary screening. If RANGE_KEEP, PRES_KEEP, URBAN_KEEP, and AGRIC_KEEP all equaled 1, then PRELM_KEEP was assigned a value of 1, otherwise it was assigned a 0. The remainder of the analysis was only performed on HUCS where PRELM_KEEP equals 1.

Habitat Condition Index

The Habitat Condition Index consists of four main calculations: Cover, Food, Human, and the HCI itself. This section describes each of these calculations.

Cover (C) was calculated by first calculating N, weighted percent NHI IBIS occurrence index, and L, percent forest habitat present. N was calculated by adding together items ASSOC_WT and PRESENT_WT. ASSOC_WT equals the sum of the percentage of all 'Generally Associated' habitats (based on IBIS) multiplied by the weight of 1. PRESNT_WT equals the sum of the percentage of all 'Present' habitats (based on IBIS) multiplied by the weight of 0.5. L was calculated simply by adding the percentages of all forested habitat types. Item C represents Cover and was calculated as N + L / 2.

Food (F) equals (FE * B) + S/ 2. FE is the weighted percent of feeding habitat based on IBIS data. All habitats associated with Black Bear in IBIS are feeding habitats and were given a weight of 1.0 with the exception of H13 which was weighted 0 because its association type is unsure. The weighted feeding habitats for each HUC were then summed to produce FE. B in the model represent a berry index. Habitats were ranked High(1.0), Medium(0.5) or Low(0) based on the berry production potential (see Appendix C). The percentages of habitat area in each ranking were multiplied by the corresponding weight and the results added together to yield a B value for each HUC. Item S represents the absence or presence of carcasses in a HUC based on the salmon carcass data provided by Mobrand Biometrics which is summarized in item CARCASS. Any HUC with a value greater than 0 was assigned an S value of 1, otherwise a 0.

Human (H) was calculated using the equation:

H = 1- ((U + A) * RDDENS_WT).

Items U and A represent percent urban and percent agriculture, respectively. The RDDENS_WT item represents a weight based on estimated road density(ROAD_DENS) in the HUC. It is based on the following classification:

Rating	miles/sqmi.	Km/sqkm
Low - 1.0	<1	<0.621371
Med - 0.66	1-3	0.621371-1.864114
High -0.33	>3	>1.864114

The actual road density variable ROAD_DENS was provided by Battelle for the Interior Columbia River Basin. For the west side of the basin, NHI created a coverage of roads comprised mostly of 1:100,000 TIGER Census data with a small section of Washington completed with 1:24,000 roads from the Washington Department of Transportation. This coverage was then overlayed with the HUCs coverage and road densitites were calculated for the west-side HUCs. These data were then passed to Battelle who modeled road densities for the three alternatives for the entire Columbia River Basin.

The Habitat Condition Index (HCI) is calculated using the previously derived variables and the following equation:

HCI = ((C + F) / 2) * H.

Data Description

This section contains projection information and item definitions for the final SAM for Black Bear ArcInfo coverage.

Projection info of ArcInfo coverage:

```
               Description of DOUBLE precision coverage bearcurr

                                FEATURE CLASSES

                                    Number of  Attribute          Spatial
Feature Class      Subclass     Features   data (bytes)  Index?   Topology?
-------------------------------------------------------------------------
ARCS                               21779        32
POLYGONS                            7063       616                  Yes
NODES                              14720

                               SECONDARY FEATURES

Tics                                    1194
Arc Segments                          494875
Polygon Labels                          7062

                                   TOLERANCES

Fuzzy   =                1.000 V          Dangle  =                1.000 V

                               COVERAGE BOUNDARY

Xmin =              1232814.903           Xmax =              4918643.000
Ymin =                47913.910           Ymax =              2937186.250

                                     STATUS

The coverage has not been Edited since the last BUILD or CLEAN.

                          COORDINATE SYSTEM DESCRIPTION

Projection               LAMBERT
Units                       FEET           Spheroid              CLARKE1866
Parameters:
1st standard parallel                                   42 20  0.000
2nd standard parallel                                   48 40  0.000
central meridian                                      -117  0  0.00
latitude of projection's origin                         41  0  0.000
false easting (meters)                                  914401.82880
false northing (meters)                                      0.00000
```

ArcInfo coverage pat items:

ITEM NAME	DESCRIPTION
AREA	Area of polygon in square feet.
PERIMETER	Perimeter of polygon in feet.
BEAR_?#	Internal ID number.
BEAR_??-ID	User ID number.
SIXHUC	Sixth Order HUC ID number.
ECOPROV	Ecoprovince Name.
CARCASS	Carcass counts modeled by Battelle.
ROAD_DENS	Road density in HUC in miles per square mile.
EASTWEST	Delimits eastside and westside of CRB.
H1PCNT	Percentage of Habitat-1 in Sixth Order HUC.
H2PCNT	Percentage of Habitat-2 in Sixth Order HUC.
H3PCNT	Percentage of Habitat-3 in Sixth Order HUC.
H4PCNT	Percentage of Habitat-4 in Sixth Order HUC.
H5PCNT	Percentage of Habitat-5 in Sixth Order HUC.
H6PCNT	Percentage of Habitat-6 in Sixth Order HUC.
H7PCNT	Percentage of Habitat-7 in Sixth Order HUC.
H8PCNT	Percentage of Habitat-8 in Sixth Order HUC.
H9PCNT	Percentage of Habitat-9 in Sixth Order HUC.
H10PCNT	Percentage of Habitat-10 in Sixth Order HUC.
H11PCNT	Percentage of Habitat-11 in Sixth Order HUC.
H12PCNT	Percentage of Habitat-12 in Sixth Order HUC.
H13PCNT	Percentage of Habitat-13 in Sixth Order HUC.
H14PCNT	Percentage of Habitat-14 in Sixth Order HUC.
H15PCNT	Percentage of Habitat-15 in Sixth Order HUC.
H16PCNT	Percentage of Habitat-16 in Sixth Order HUC.
H17PCNT	Percentage of Habitat-17 in Sixth Order HUC.
H18PCNT	Percentage of Habitat-18 in Sixth Order HUC.
H19PCNT	Percentage of Habitat-19 in Sixth Order HUC.
H20PCNT	Percentage of Habitat-20 in Sixth Order HUC.
H21PCNT	Percentage of Habitat-21 in Sixth Order HUC.
H22PCNT	Percentage of Habitat-22 in Sixth Order HUC.
H23PCNT	Percentage of Habitat-23 in Sixth Order HUC.
H24PCNT	Percentage of Habitat-24 in Sixth Order HUC.
H25PCNT	Percentage of Habitat-25 in Sixth Order HUC.
H26PCNT	Percentage of Habitat-26 in Sixth Order HUC.
H27PCNT	Percentage of Habitat-27 in Sixth Order HUC.
H28PCNT	Percentage of Habitat-28 in Sixth Order HUC.
H29PCNT	Percentage of Habitat-29 in Sixth Order HUC.
H30PCNT	Percentage of Habitat-30 in Sixth Order HUC.
H31PCNT	Percentage of Habitat-31 in Sixth Order HUC.
H32PCNT	Percentage of Habitat-32 in Sixth Order HUC.
PRESENT	Percentage of 'Present' habitats in HUC.
ASSOC	Percentage of 'Associated' habitats in HUC.
RANGE_PCNT	% of Bear-associated (PRESENT + ASSOCIATED)habitat in HUC.
RANGE_KEEP	Binary tag to keep HUC based on associated habitats.
PRES_KEEP	Binary tag to keep HUC based on %present and %associated.
URBAN_KEEP	Binary tag to keep HUC based on amount of urban habitat.
AGRIC_KEEP	Binary tag to keep HUC based on amount of agriculture.
PRELM_KEEP	Binary tag to keep HUC based on preliminary analysis.
PRESENT_WT	Weighted IBIS 'Present' habitats in HUC.
ASSOC_WT	Weighted IBIS 'Generally Associated' habitats in HUC.
N	Weighted percent NHI IBIS Occurrence index.
L	Percent forest habitat in HUC.

C	Cover variable in Habitat Assessment Method.
FE	SAM Fe variable; weighted percent of IBIS feeding habitat.
S	SAM S variable; absence/presence of salmon carcass.
F	SAM F variable; food.
B_HIGH	Percent of HUC with High berry index habitats.
B_MED	Percent of HUC with Medium berry index habitats.
B_LOW	Percent of HUC with Low berry index habitats.
B	SAM B variable; overall berry index
RDDENS_WT	Road density weighting factor for HUC.
U	SAM U variable; percent urban in HUC.
A	SAM A variable; percent agriculture in HUC.
H	SAM H variable; human.
HCI	SAM HCI variable; Habitat Condition Index.
HCI_SHADE	HCI % used for display in ArcPlot.
C_SHADE	C % used for display in ArcPlot.
F_SHADE	F % used for display in ArcPlot.
H_SHADE	H % used for display in ArcPlot.

Appendix A

Wildlife-Habitat Type Codes and Names

1	Mesic Lowlands Conifer-Hardwood
2	Westside Oak and Dry Douglas-fir
3	Southwest Oregon Mixed Conifer-Hardwood
4	Montane Mixed Conifer
5	Interior Mixed Conifer
6	Lodgepole Pine Dominant
7	Ponderosa Pine Dominant
8	Upland Aspen
9	Subalpine Parkland
10	Alpine Grasslands and Shrublands
11	Westside Grasslands
12	Ceanothus-Manzanita Shrublands
13	Western Juniper
14	Canyon Shrublands
15	Interior Grasslands
16	Shrub-steppe
17	Dwarf shrub-steppe
18	Desert Playa and Salt Scrub
19	Agriculture, Pastures, and Mixed Environs
20	Urban and Mixed Environs
21	Open Water
22	Herbaceous Wetlands
23	Westside Riparian - Wetlands
24	Montane Coniferous Wetlands
25	Interior Riparian - Wetlands
26	Coastal Dunes and Beaches
27	Coastal Headlands and Islets
28	Bays and Estuaries
29	Inland Marine Deeper Waters
30	Marine Nearshore
31	Marine Shelf
32	Oceanic

Appendix B

IBIS Habitat Association data for Black Bear

Species	Habitat	Habitat Activity	Habitat Association	Confidence
Black Bear	1	Reproduces and Feeds	Generally Associated	3
Black Bear	10	Reproduces and Feeds	Generally Associated	3
Black Bear	11	Feeds	Present	2
Black Bear	12	Reproduces and Feeds	Generally Associated	3
Black Bear	13	Unsure	Unsure	
Black Bear	14*	Reproduces and Feeds	Generally Associated*	3
Black Bear	15	Feeds	Present	3
Black Bear	16	Feeds	Present	1
Black Bear	17	Feeds	Present	1
Black Bear	19	Feeds	Generally Associated	3
Black Bear	2	Reproduces and Feeds	Generally Associated	3
Black Bear	20	Feeds	Generally Associated	3
Black Bear	22	Feeds	Generally Associated	3
Black Bear	23	Reproduces and Feeds	Generally Associated	3
Black Bear	24	Reproduces and Feeds	Generally Associated	3
Black Bear	25	Reproduces and Feeds	Generally Associated	3
Black Bear	27	Feeds	Present	2
Black Bear	3	Reproduces and Feeds	Generally Associated	3
Black Bear	4	Reproduces and Feeds	Generally Associated	3
Black Bear	5	Reproduces and Feeds	Generally Associated	3
Black Bear	6	Reproduces and Feeds	Generally Associated	3
Black Bear	7	Reproduces and Feeds	Generally Associated	3
Black Bear	8	Reproduces and Feeds	Generally Associated	3
Black Bear	9	Reproduces and Feeds	Generally Associated	3

* Used 'Present' instead of 'Generally Associated' in Habitat Assessment Method to compensate for inadequacies of mapped habitat 14 - Canyon Shrublands.

Appendix C

Berry Index for Black Bear:

Habitat	Berry Importance Rank	Weight
1	High	1.0
2	Medium	0.5
3	Medium	0.5
4	High	1.0
5	High	1.0
6	Medium	0.5
7	Medium	0.5
8	Medium	0.5
9	Medium	0.5
10	Medium	0.5
11	Medium	0.5
12	High	1.0
13	Medium	0.5
14	Medium	0.5
15	Medium	0.5
16	Medium	0.5
17	Medium	0.5
18	Low	0
19	Medium	0.5
20	Low	0
21	Low	0
22	Medium	0.5
23	Medium	0.5
24	High	1.0
25	Medium	0.5
26	Low	0
27	Medium	0.5
28	Low	0
29	Low	0
30	Low	0
31	Low	0
32	Low	0

Appendix F-2

Bald Eagle
Habitat Assessment Method
Summary

This document summarizes the steps taken by the Northwest Habitat Institute (NHI) to produce Bald Eagle Habitat Condition Indexes (HCIs) for each 6th Order HUC in the Columbia River Basin. These procedures were applied for the current, normative, and three alternative conditions. Streamnet's 6th Order HUC ArcInfo polygon coverage was updated with several items to produce the initial COVER, FOOD, and HCI variables for the Bald Eagle Habitat Assessment Method. The first section describes the analysis methods including equations and weights used to derive the variables. The Arc Macro Language (AML) program written to calculate the variables can easily be modified and re-executed if the equations or weights need to be adjusted. The second section details the individual items found in the resulting coverages. Appendix A lists the 32 habitat codes and class names, and Appendix B contains NHI's Interactive Biodiversity Information System (IBIS) habitat association data for the Bald Eagle.

Analysis

Preparation

A major portion of the Habitat Assessment Method depends on knowing the habitat composition of each 6th Order HUC. These measurements were calculated using the NHI Current and Normative Wildlife-Habitat Types grids and Streamnet's 6th Order HUC coverage. Due to its large area extent and high 25m resolution, the Current habitat grid could not be converted to vector coverages without significant generalization of the data. Therefore, the HUC coverage was converted to a grid and an AML was written to perform a Grid analysis of the HUC and habitat data sets. This AML calculated the percentage of each habitat type in each HUC and wrote these results into the original HUC coverage as items H1PCNT - H32PCNT where 1 - 32 equals the 32 habitat type codes(see Appendix A). The remainder of the analysis was completed in ArcInfo using the updated HUC coverages. The three alternative scenarios were run using habitat data modeled by Battelle, and Salmon carcass data was provided by Mobrand Biometrics.

Habitat Assessment Method

The Habitat Assessment Method consists of two major sections. The first is a preliminary screening of all HUCS. During this screening, HUCS are either included in or excluded from further analysis based on specific criteria. The second section calculates the Habitat Condition Index (HCI) for those HUCS that pass the preliminary screening

Preliminary Screening

The preliminary screening determines, for each 6th order HUC, if 40% or greater of the HUC is in the Bald Eagle's range. The Bald Eagle's range is established as any habitat type listed as 'Generally Associated' or 'Closely Associated' with the Bald Eagle in the NHI Interactive Biodiversity Information System (IBIS) database (see Appendix B). Item RANGE_PCNT sums the percentages of all these-associated habitats per HUC. If RANGE_PCNT >= 40% for a HUC, item RANGE_KEEP is assigned a value of 1 for that HUC, otherwise its assigned 0.

Item PRELM_KEEP is added to summarize the results of the preliminary screening. If RANGE_KEEP, equals 1, then PRELM_KEEP is assigned a value of 1, otherwise its assigned a 0. The remainder of the analysis is only performed on HUCS where PRELM_KEEP equals 1.

Habitat Condition Index

The Habitat Condition Index consists of three main calculations: Cover, Food, and the HCI itself. This section describes each of these calculations.

Cover (C) is calculated by first calculating N, weighted percent NHI IBIS occurrence index. N is calculated by adding together items FCASS_WT, BGASS_WT, FGASS_WT and RGASS_WT. FCASS_WT equals the sum of the percentage of all 'Feeds' and 'Closely Associated' habitats (based on IBIS) multiplied by the weight of 1.0. BGASS_WT equals the sum of the percentage of all 'Reproduces and Feeds' and 'Generally Associated' habitats (based on IBIS) multiplied by the weight of 0.75. FGASS_WT equals the sum of the percentage of all 'Feeds' and 'Generally Associated' habitats (based on IBIS) multiplied by the weight of 0.5. RGASS_WT equals the sum of the percentage of all 'Reproduces' and 'Generally Associated' habitats (based on IBIS) multiplied by the weight of 0.25.

Next, WR, the water-riparian factor is calculated. The water-riparian factor is a weight assigned depending on the presence/absence of open water(W) and riparian(R) habitat types. For each HUC, if any amount of Open Water, Bays and Estuaries, Inland Marine Deeper Waters, or Marine Nearshore habitats are present, item W is calculated as 1, otherwise a 0. If Westside or Interior Riparian - Wetlands are present, item R is tagged with a 1, otherwise a 0. WR is then calculated for each HUC as a 1 if both W and R equaled 1, as a 0.5 if W or R is present but not both, and as 0 if both W and R equal 0.

Cover (C) is then calculated as $(N * WR)^{1/2}$.

Food (F) equals (FEED + S) / 2. FEED is the weighted percent of feeding habitat based on IBIS data. All of the 'Feeds' and 'Reproduces and Feeds' habitats associated with Bald Eagle in IBIS are given a weight of 1.0. So the percentages of each of these habitat types are summed and multiplied by 1.0 to produce FEED. . Item S represents the presence of carcasses in a HUC based on the anadromous fish data (CARCASS) provided by Mobrand Biometrics. Any HUC with a CARCASS value of 0 is assigned an S value of 0, a CARCASS value of 15 is assigned an S value of 0.1, and a CARCASS value of 900 is assigned an S value of 1.0.

The Habitat Condition Index (HCI) is calculated using the previously derived variables and the following equation:

HCI = (C + F) / 2.

Data Description

This section contains projection information and item definitions for the final SAM Bald Eagle ArcInfo coverages.

Projection info of ArcInfo coverage:

```
               Description of DOUBLE precision coverage eaglcurr

                                FEATURE CLASSES

                                    Number of  Attribute          Spatial
Feature Class      Subclass     Features   data (bytes)  Index?   Topology?
------------------------------------------------------------------------
ARCS                               21779        32
POLYGONS                            7063       616                  Yes
NODES                              14720

                               SECONDARY FEATURES

Tics                                    1194
Arc Segments                          494875
Polygon Labels                          7062

                                   TOLERANCES

Fuzzy   =                 1.000 V         Dangle  =                1.000 V

                               COVERAGE BOUNDARY

Xmin =              1232814.903           Xmax =             4918643.000
Ymin =                47913.910           Ymax =             2937186.250

                                     STATUS

The coverage has not been Edited since the last BUILD or CLEAN.

                          COORDINATE SYSTEM DESCRIPTION

Projection               LAMBERT
Units                       FEET             Spheroid             CLARKE1866
Parameters:
1st standard parallel                                       42 20  0.000
2nd standard parallel                                       48 40  0.000
central meridian                                           -117  0  0.00
latitude of projection's origin                             41  0  0.000
false easting (meters)                                      914401.82880
false northing (meters)                                          0.00000
```

ArcInfo coverage pat items:

ITEM NAME	DESCRIPTION
AREA	Area of polygon in square feet.
PERIMETER	Perimeter of polygon in feet.
EAGL????#	Internal ID number.
EAGL????-ID	User ID number.
SIXHUC	Sixth Order HUC ID number.
ECOPROV	Ecoprovince Name.
CARCASS	Carcass counts modeled by Greg Blair, Mobrand Biometrics.
H1PCNT	Percentage of Habitat-1 in Sixth Order HUC.
H2PCNT	Percentage of Habitat-2 in Sixth Order HUC.
H3PCNT	Percentage of Habitat-3 in Sixth Order HUC.
H4PCNT	Percentage of Habitat-4 in Sixth Order HUC.
H5PCNT	Percentage of Habitat-5 in Sixth Order HUC.
H6PCNT	Percentage of Habitat-6 in Sixth Order HUC.
H7PCNT	Percentage of Habitat-7 in Sixth Order HUC.
H8PCNT	Percentage of Habitat-8 in Sixth Order HUC.
H9PCNT	Percentage of Habitat-9 in Sixth Order HUC.
H10PCNT	Percentage of Habitat-10 in Sixth Order HUC.
H11PCNT	Percentage of Habitat-11 in Sixth Order HUC.
H12PCNT	Percentage of Habitat-12 in Sixth Order HUC.
H13PCNT	Percentage of Habitat-13 in Sixth Order HUC.
H14PCNT	Percentage of Habitat-14 in Sixth Order HUC.
H15PCNT	Percentage of Habitat-15 in Sixth Order HUC.
H16PCNT	Percentage of Habitat-16 in Sixth Order HUC.
H17PCNT	Percentage of Habitat-17 in Sixth Order HUC.
H18PCNT	Percentage of Habitat-18 in Sixth Order HUC.
H19PCNT	Percentage of Habitat-19 in Sixth Order HUC.
H20PCNT	Percentage of Habitat-20 in Sixth Order HUC.
H21PCNT	Percentage of Habitat-21 in Sixth Order HUC.
H22PCNT	Percentage of Habitat-22 in Sixth Order HUC.
H23PCNT	Percentage of Habitat-23 in Sixth Order HUC.
H24PCNT	Percentage of Habitat-24 in Sixth Order HUC.
H25PCNT	Percentage of Habitat-25 in Sixth Order HUC.
H26PCNT	Percentage of Habitat-26 in Sixth Order HUC.
H27PCNT	Percentage of Habitat-27 in Sixth Order HUC.
H28PCNT	Percentage of Habitat-28 in Sixth Order HUC.
H29PCNT	Percentage of Habitat-29 in Sixth Order HUC.
H30PCNT	Percentage of Habitat-30 in Sixth Order HUC.
H31PCNT	Percentage of Habitat-31 in Sixth Order HUC.
H32PCNT	Percentage of Habitat-32 in Sixth Order HUC.
RANGE_PCNT	Percent of Bald Eagle associated habitat in HUC.
RANGE_KEEP	Binary tag to keep HUC based on associated habitats.
PRELM_KEEP	Binary tag to keep HUC based on preliminary analysis.
FCASS_WT	Weighted Feeds / Closely Associated habitats
BGASS_WT	Weighted Reproduces and Feeds / Generally Associated habitats
FGASS_WT	Weighted Feeds / Generally Associated habitats
RGASS_WT	Weighted Reproduces / Generally Associated habitats
N	Weighted percent NHI IBIS Occurrence index.
W	Binary tag for HUCs with open water habitats.
R	Binary tag for HUCs with riparian habitats
WR	Water-Riparian factor for HUC.
C	Cover variable in Habitat Assessment Method.
FEED	SAM Fe variable; weighted percent of IBIS feeding habitat.

S	SAM S variable; Weighted presence of salmon carcasses.
F	SAM F variable; food.
HCI	SAM HCI variable; Habitat Condition Index.
HCI_SHADE	HCI % used for display in ArcPlot.
C_SHADE	C % used for display in ArcPlot.
F_SHADE	F % used for display in ArcPlot.

Appendix A

Wildlife-Habitat Type Codes and Names

1	Mesic Lowlands Conifer-Hardwood
2	Westside Oak and Dry Douglas-fir
3	Southwest Oregon Mixed Conifer-Hardwood
4	Montane Mixed Conifer
5	Interior Mixed Conifer
6	Lodgepole Pine Dominant
7	Ponderosa Pine Dominant
8	Upland Aspen
9	Subalpine Parkland
10	Alpine Grasslands and Shrublands
11	Westside Grasslands
12	Ceanothus-Manzanita Shrublands
13	Western Juniper
14	Canyon Shrublands
15	Interior Grasslands
16	Shrub-steppe
17	Dwarf shrub-steppe
18	Desert Playa and Salt Scrub
19	Agriculture, Pastures, and Mixed Environs
20	Urban and Mixed Environs
21	Open Water
22	Herbaceous Wetlands
23	Westside Riparian - Wetlands
24	Montane Coniferous Wetlands
25	Interior Riparian - Wetlands
26	Coastal Dunes and Beaches
27	Coastal Headlands and Islets
28	Bays and Estuaries
29	Inland Marine Deeper Waters
30	Marine Nearshore
31	Marine Shelf
32	Oceanic

Appendix B

IBIS Habitat Association data for Bald Eagle

Species	Habitat	Habitat Activity	Habitat Association	Confidence
Bald Eagle	1	Reproduces	Generally Associated	3
Bald Eagle	2	Reproduces	Generally Associated	3
Bald Eagle	3	Reproduces	Generally Associated	3
Bald Eagle	4	Reproduces	Generally Associated	3
Bald Eagle	5	Reproduces	Generally Associated	3
Bald Eagle	6	Reproduces	Generally Associated	3
Bald Eagle	7	Reproduces	Generally Associated	3
Bald Eagle	11	Feeds	Present	1
Bald Eagle	16	Reproduces	Present	3
Bald Eagle	17	Reproduces	Present	3
Bald Eagle	18	Feeds	Present	3
Bald Eagle	19	Feeds	Generally Associated	3
Bald Eagle	20	Reproduces and Feeds	Generally Associated	3
Bald Eagle	21	Feeds	Closely Associated	3
Bald Eagle	22	Feeds	Generally Associated	3
Bald Eagle	23	Reproduces and Feeds	Generally Associated	3
Bald Eagle	25	Reproduces and Feeds	Generally Associated	2
Bald Eagle	26	Feeds	Present	3
Bald Eagle	27	Reproduces and Feeds	Generally Associated	3
Bald Eagle	28	Reproduces and Feeds	Generally Associated	3
Bald Eagle	29	Feeds	Generally Associated	3
Bald Eagle	30	Feeds	Generally Associated	3
Bald Eagle	31	Feeds	Present	2

Appendix F-3

American Beaver
Habitat Assessment Method
Summary

This document summarizes the steps taken by the Northwest Habitat Institute (NHI) to produce American Beaver Habitat Condition Indexes (HCIs) for each 6^{th} Order HUC in the Columbia River Basin. These procedures were applied for the current, normative, and three alternative conditions. Streamnet's 6th Order HUC ArcInfo polygon coverage was updated with several items to produce the initial COVER, FOOD, PHYSICAL CONDITION, and HCI variables for the American Beaver Habitat Assessment Method. The first section describes the analysis methods including equations and weights used to derive the variables. The Arc Macro Language (AML) program written to calculate the variables can easily be modified and re-executed if the equations or weights need to be adjusted. The second section details the individual items found in the resulting coverages. Appendix A lists the 32 habitat codes and class names, and Appendix B contains NHI's Interactive Biodiversity Information System (IBIS) habitat association data for the American Beaver.

Analysis

Preparation

A major portion of the Habitat Assessment Method depends on knowing the habitat composition of each 6^{th} Order HUC. These measurements were calculated using the NHI Current and Normative Wildlife-Habitat Types grids and Streamnet's 6^{th} Order HUC coverage. Due to its large area extent and high 25m resolution, the Current habitat grid could not be converted to a vector coverage without significant generalization of the data. Therefore, the HUC coverage was converted to a grid and an AML was written to perform a Grid analysis of the HUC and habitat data sets. This AML calculated the percentage of each habitat type in each HUC and wrote these results into the original HUC coverage as items H1PCNT - H32PCNT where 1 - 32 equals the 32 habitat type codes(see Appendix A). The remainder of the analysis was completed in ArcInfo using the updated HUC coverages.

Flow and sinuosity data were compiled and supplied to NHI by Battelle as well(see Habitat Condition Index section). Additionally, the three alternative scenarios were run using habitat data modeled by Battelle.

Habitat Assessment Method

The Habitat Assessment Method consists of two major sections. The first is a preliminary screening of all HUCS. During this screening, HUCS are either included in or excluded from further analysis based on specific criteria. The second section calculates the Habitat Condition Index (HCI) for those HUCS that pass the preliminary screening.

Preliminary Screening

The first step in the preliminary screening is to determine for each 6^{th} order HUC if any of the HUC is in the American Beaver's range. The American Beaver's range was established as any habitat type that has a 'Generally Associated' or 'Closely Associated,' ranking with the American Beaver in the NHI Interactive Biodiversity Information System (IBIS) database (see Appendix B). Habitats having a 'Present' association were not included to minimize commission errors. Item RANGE_PCNT sums the percentages of all the-associated habitats per HUC; RANGE_KEEP sums only the 'Generally Associated' and 'Closely Associated' habitats. If RANGE_KEEP > 0% for a HUC, item PRELM_KEEP was assigned a value of 1 for that HUC, otherwise it was assigned 0. The remainder of the analysis was only performed on HUCS where PRELM_KEEP equals 1.

Habitat Condition Index

The Habitat Condition Index consists of four main calculations: Cover, Food, Physical Condition, and the HCI itself. This section describes each of these calculations.

Cover (C) was calculated by first calculating N, weighted percent NHI IBIS occurrence index, and L, a landscape factor. N was calculated by adding together items CLOSASC_WT, GENASC_WT and PRESENT_WT. CLOSASC_WT equals the sum of the percentage of all 'Closely Associated' habitats (based on IBIS) multiplied by the weight of 1. GENASC_WT equals the sum of the percentage of all 'Generally Associated' habitats (based on IBIS) multiplied by the weight of 0.66. PRESNT_WT equals the sum of the percentage of all 'Present' habitats (based on IBIS) multiplied by the weight of 0.33. To account for the negative impacts of agriculture and urban habitats on beaver, the landscape factor L was calculated as 1 minus the sum of urban(H20PCNT) and agricultural(H19PCNT) habitat. Item C represents Cover and was calculated as $(L * N)^{1/2}$.

Food (F) equals the sum of the percentages of all feeding habitats based on IBIS data. All habitats associated with American Beaver in IBIS are feeding habitats with the exception of H21, Open Water. Therefore, F is calculated as RANGE_PCNT minus H21PCNT.

Physical Condition (P) is calculated as:

P = (FL + SI_WT) / 2.

Items FL and SI_WT represent flow and sinuosity, respectively. Flow is derived as :

FL = (AMFL_WT + FLWTYP_WT) / 2

AMFL_WT is a weighted average monthly flow estimate. Monthly flow for each HUC was provided by Batelle for each alternative. These flows were averaged(AVG_MF) and then rated on a scale of 0-1 using the following:

Average Monthly Flow	Weight
>=3000	0
>=1000 & <3000	0.25
>=600 & <1000	0.5
>=300 & <600	1.0

>=100 & <300	0.5
>0 & <100	0.25
0	0

FLWTYP_WT is a weighting of the FLOW_TYPE (or Environment Type) that was provided by Batelle. The following chart explains the applied weighting system:

FLOW TYPE	**Description**	**Weight**
0	*No type specified*	0
1	Headwater	0.5
2	Low Stream Order	1.0
3	Mid Stream Order	0.5
4	High Stream Order	0.25

SI_WT contains weighted values derived from the SINUOSITY index values provided by Batelle. The following chart explains these values.

Sinuosity Index	**Weight**
>=6	0.25
>=4 & <6	0.5
>=2 & <4	1.0
>=1 & <2	0.5
>0 & <1	0.25
0	0

The Habitat Condition Index (HCI) is calculated using the previously derived variables and the following equation:

HCI = (C + F + P) / 3).

Data Description

This section contains projection information and item definitions for the final SAM for American Beaver ArcInfo coverage.

Projection info of ArcInfo coverage:

```
               Description of DOUBLE precision coverage beavcurr

                                FEATURE CLASSES

                                    Number of  Attribute          Spatial
Feature Class      Subclass     Features   data (bytes)  Index?   Topology?
--------------------------------------------------------------------------
ARCS                               21779        32
POLYGONS                            7063       616                  Yes
NODES                              14720

                               SECONDARY FEATURES

Tics                                    1194
Arc Segments                          494875
Polygon Labels                          7062

                                   TOLERANCES

Fuzzy   =                 1.000 V          Dangle  =                 1.000 V

                               COVERAGE BOUNDARY

Xmin =               1232814.903           Xmax =               4918643.000
Ymin =                 47913.910           Ymax =               2937186.250

                                     STATUS

The coverage has not been Edited since the last BUILD or CLEAN.

                          COORDINATE SYSTEM DESCRIPTION

Projection              LAMBERT
Units                      FEET             Spheroid              CLARKE1866
Parameters:
1st standard parallel                                   42 20  0.000
2nd standard parallel                                   48 40  0.000
central meridian                                      -117  0  0.00
latitude of projection's origin                         41  0  0.000
false easting (meters)                                  914401.82880
false northing (meters)                                      0.00000
```

ArcInfo coverage pat items:

ITEM NAME	DESCRIPTION
AREA	Area of polygon in square feet.
PERIMETER	Perimeter of polygon in feet.
BEAV????#	Internal ID number.
BEAV????-ID	User ID number.
SIXHUC	Sixth Order HUC ID number.
ECOPROV	Ecoprovince Name.
CARCASS	Carcass counts modeled by Battelle.
ROAD_DENS	Road density in HUC in miles per square mile.
EASTWEST	Delimits eastside and westside of CRB.
H1PCNT	Percentage of Habitat-1 in Sixth Order HUC.
H2PCNT	Percentage of Habitat-2 in Sixth Order HUC.
H3PCNT	Percentage of Habitat-3 in Sixth Order HUC.
H4PCNT	Percentage of Habitat-4 in Sixth Order HUC.
H5PCNT	Percentage of Habitat-5 in Sixth Order HUC.
H6PCNT	Percentage of Habitat-6 in Sixth Order HUC.
H7PCNT	Percentage of Habitat-7 in Sixth Order HUC.
H8PCNT	Percentage of Habitat-8 in Sixth Order HUC.
H9PCNT	Percentage of Habitat-9 in Sixth Order HUC.
H10PCNT	Percentage of Habitat-10 in Sixth Order HUC.
H11PCNT	Percentage of Habitat-11 in Sixth Order HUC.
H12PCNT	Percentage of Habitat-12 in Sixth Order HUC.
H13PCNT	Percentage of Habitat-13 in Sixth Order HUC.
H14PCNT	Percentage of Habitat-14 in Sixth Order HUC.
H15PCNT	Percentage of Habitat-15 in Sixth Order HUC.
H16PCNT	Percentage of Habitat-16 in Sixth Order HUC.
H17PCNT	Percentage of Habitat-17 in Sixth Order HUC.
H18PCNT	Percentage of Habitat-18 in Sixth Order HUC.
H19PCNT	Percentage of Habitat-19 in Sixth Order HUC.
H20PCNT	Percentage of Habitat-20 in Sixth Order HUC.
H21PCNT	Percentage of Habitat-21 in Sixth Order HUC.
H22PCNT	Percentage of Habitat-22 in Sixth Order HUC.
H23PCNT	Percentage of Habitat-23 in Sixth Order HUC.
H24PCNT	Percentage of Habitat-24 in Sixth Order HUC.
H25PCNT	Percentage of Habitat-25 in Sixth Order HUC.
H26PCNT	Percentage of Habitat-26 in Sixth Order HUC.
H27PCNT	Percentage of Habitat-27 in Sixth Order HUC.
H28PCNT	Percentage of Habitat-28 in Sixth Order HUC.
H29PCNT	Percentage of Habitat-29 in Sixth Order HUC.
H30PCNT	Percentage of Habitat-30 in Sixth Order HUC.
H31PCNT	Percentage of Habitat-31 in Sixth Order HUC.
H32PCNT	Percentage of Habitat-32 in Sixth Order HUC.
SINUOSITY	Sinuosity Index from Batelle.
AVG_MF	Average monthly flow from Batelle
FLOW_TYPE	Environment Type from Batelle
PRESENT	Percentage of 'Present' habitats in HUC.
GENASC	Percentage of 'Generally Associated' habitats in HUC.
CLOSASC	Percentage of 'Closely Associated' habitats in HUC.
RANGE_PCNT	% of Beaver-associated (PRESENT + GENASC + CLOSASC)habitat.
RANGE_KEEP	GENASC + CLOSASC habitats in HUC.
PRELM_KEEP	Binary tag to keep HUC based on preliminary analysis.
PRESENT_WT	Weighted IBIS 'Present' habitats in HUC.
GENASC_WT	Weighted IBIS 'Generally Associated' habitats in HUC.
CLOSAC_WT	Weighted IBIS 'Closely Associated' habitats in HUC.

L	Landuse -Percent Ag habitat in HUC..
N	Weighted percent NHI IBIS Occurrence index.
C	Cover variable in Habitat Assessment Method.
F	SAM F variable; food.
FL	SAM FL variable; Flow variable.
AMFL_WT	Average Monthly flow weighted.
FLWTYP_WT	Environmental Type weighted.
SI_WT	Sinuosity Index weighted.
P	P in Habitat Assessment Method - Physical Condition variable.
HCI	SAM HCI variable; Habitat Condition Index.
HCI_SHADE	HCI % used for display in ArcPlot.
C_SHADE	C % used for display in ArcPlot.
F_SHADE	F % used for display in ArcPlot.
P_SHADE	P % used for display in ArcPlot.

Appendix A

Wildlife-Habitat Type Codes and Names

1	Mesic Lowlands Conifer-Hardwood
2	Westside Oak and Dry Douglas-fir
3	Southwest Oregon Mixed Conifer-Hardwood
4	Montane Mixed Conifer
5	Interior Mixed Conifer
6	Lodgepole Pine Dominant
7	Ponderosa Pine Dominant
8	Upland Aspen
9	Subalpine Parkland
10	Alpine Grasslands and Shrublands
11	Westside Grasslands
12	Ceanothus-Manzanita Shrublands
13	Western Juniper
14	Canyon Shrublands
15	Interior Grasslands
16	Shrub-steppe
17	Dwarf shrub-steppe
18	Desert Playa and Salt Scrub
19	Agriculture, Pastures, and Mixed Environs
20	Urban and Mixed Environs
21	Open Water
22	Herbaceous Wetlands
23	Westside Riparian - Wetlands
24	Montane Coniferous Wetlands
25	Interior Riparian - Wetlands
26	Coastal Dunes and Beaches
27	Coastal Headlands and Islets
28	Bays and Estuaries
29	Inland Marine Deeper Waters
30	Marine Nearshore
31	Marine Shelf
32	Oceanic

Appendix B

IBIS Habitat Association data for American Beaver

Species	Habitat	Habitat Activity	Habitat Association	Confidence
American Beaver	1	Feeds	Generally Associated	3
American Beaver	2	Feeds	Generally Associated	3
American Beaver	3	Feeds	Generally Associated	3
American Beaver	4	Feeds	Generally Associated	3
American Beaver	5	Feeds	Generally Associated	3
American Beaver	6	Feeds	Generally Associated*	3
American Beaver	7	Feeds	Generally Associated	3
American Beaver	8	Feeds	Present	3
American Beaver	13	Feeds	Present	1
American Beaver	19	Feeds	Present	2
American Beaver	20	Feeds	Present	2
American Beaver	21	Reproduces	Closely Associated	3
American Beaver	22	Reproduces and Feeds	Closely Associated	3
American Beaver	23	Reproduces and Feeds	Closely Associated	3
American Beaver	24	Reproduces and Feeds	Generally Associated	3
American Beaver	25	Reproduces and Feeds	Closely Associated	3

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		**Level 2 Ecological Attribute:**								
Code	**Strategy Name**	Alkalinity	Bed scour	Ben hos diversity and production	Channel length	Channel width - month maximum width (ft)	Channel width - month minimum width (ft)	Confinement - Hydro-modifications	Confinement - natural	Dissolved oxygen
Hab-1.0	Reduce agricultural impacts to ripanian/ aquatic ecosystem		1	1		2	1	2		
Hab-2.0	Competitor control									
Hab-3.0	Sediment reduction		1	1						
Hab-4.0	Floodplain corridor reconnection		2							
Hab-5.0	Regulate tributary storage releases to provide normative flows.						2			
Hab-6.0	Reduce forestry impacts to ripanian/ aqua ic ecosystem		1					1		
Hab-7.0	Agricultural water conserva ion						2			
Hab-8.0	Irrigation waste water treatment			1						
Hab-9.0	Irrigation withdrawals screening									
Hab-10.0	Municipal waste management			1						1
Hab-11.0	Nutrient and pa hogen load reduction from grazing/agriculture			1						
Hab-12.0	Obstruction passage improvement									
Hab-13.0	Obstruction removal									
Hab-14.0	Pesticide/herbicide reduction			2						
Hab-15.0	Reintroduction of species									
Hab-16.0	Predator control									
Hab-16.1	Control predatory fish									
Hab-16.2	Control predatory birds									
Hab-16.3	Control mammalian predators									
Hab-17.0	Reduce grazing impacts to ripanian/ aqua ic ecosystem		1	1		2	1	2		
Hab-18.0	Establish aquatic reserves, preserves, refugia									
Hab-18.1	Establish terrestrial reserves, preserves, refugia									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		**Level 2 Ecological Attribute:**								
Code	**Strategy Name**	Embeddedness	Fine sediment	Fish community richness	Fish pa hogens	Fish species introductions	Flow - change in interannual variability in high flows	Flow - changes in interannual variability in low flows	Flow - Intra daily (diel) varia ion	Flow - intra-annual flow pattern
Hab-1.0	Reduce agricultural impacts to ripanian/ aquatic ecosystem	1	1				1	1		1
Hab-2.0	Competitor control									
Hab-3.0	Sediment reduction	1	1							
Hab-4.0	Floodplain corridor reconnection		2							
Hab-5.0	Regulate tributary storage releases to provide normative flows.							2		
Hab-6.0	Reduce forestry impacts to ripanian/ aqua ic ecosystem	1	1				1			
Hab-7.0	Agricultural water conserva ion							2		
Hab-8.0	Irrigation waste water treatment	2	2							
Hab-9.0	Irrigation withdrawals screening									
Hab-10.0	Municipal waste management									
Hab-11.0	Nutrient and pa hogen load reduction from grazing/agriculture									
Hab-12.0	Obstruction passage improvement									
Hab-13.0	Obstruction removal									
Hab-14.0	Pesticide/herbicide reduction									
Hab-15.0	Reintroduction of species									
Hab-16.0	Predator control									
Hab-16.1	Control predatory fish									
Hab-16.2	Control predatory birds									
Hab-16.3	Control mammalian predators									
Hab-17.0	Reduce grazing impacts to ripanian/ aqua ic ecosystem	2	2				1	1		1
Hab-18.0	Establish aquatic reserves, preserves, refugia									
Hab-18.1	Establish terrestrial reserves, preserves, refugia									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		**Level 2 Ecological Attribute:**								
Code	**Strategy Name**	Gradient	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - large cobble/boulder riffles	Habitat type - off-channel habitat factor	Habitat type - pool tailouts/glides	Habitat type - primary pools	Habitat type - small cobble/gravel riffles	Harassment
Hab-1.0	Reduce agricultural impacts to ripanian/ aquatic ecosystem		1	1		1	1	1	1	
Hab-2.0	Competitor control									
Hab-3.0	Sediment reduction									
Hab-4.0	Floodplain corridor reconnection		2	2		2				
Hab-5.0	Regulate tributary storage releases to provide normative flows.									
Hab-6.0	Reduce forestry impacts to ripanian/ aqua ic ecosystem		1			1		1		
Hab-7.0	Agricultural water conserva ion									
Hab-8.0	Irrigation waste water treatment									
Hab-9.0	Irrigation withdrawals screening									
Hab-10.0	Municipal waste management									
Hab-11.0	Nutrient and pa hogen load reduction from grazing/agriculture									
Hab-12.0	Obstruction passage improvement									
Hab-13.0	Obstruction removal									
Hab-14.0	Pesticide/herbicide reduction									
Hab-15.0	Reintroduction of species									
Hab-16.0	Predator control									
Hab-16.1	Control predatory fish									
Hab-16.2	Control predatory birds									
Hab-16.3	Control mammalian predators									
Hab-17.0	Reduce grazing impacts to ripanian/ aqua ic ecosystem		1	1		1	1	1	2	
Hab-18.0	Establish aquatic reserves, preserves, refugia		1	1		1				
Hab-18.1	Establish terrestrial reserves, preserves, refugia									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		**Level 2 Ecological Attribute:**								
Code	**Strategy Name**	Hatchery fish outplants	Hydrologic regime - natural	Hydrologic regime - regulated	Icing	Metals/Pollutants - in sediments/soils	Metals - in water column	Miscellaneous toxic pollutants - water column	Nutrient enrichment	Obstructions to fish migration
Hab-1.0	Reduce agricultural impacts to ripanian/ aquatic ecosystem				2				1	
Hab-2.0	Competitor control	2								
Hab-3.0	Sediment reduction									
Hab-4.0	Floodplain corridor reconnection									
Hab-5.0	Regulate tributary storage releases to provide normative flows.									
Hab-6.0	Reduce forestry impacts to ripanian/ aqua ic ecosystem									
Hab-7.0	Agricultural water conserva ion									
Hab-8.0	Irrigation waste water treatment							1	1	
Hab-9.0	Irrigation withdrawals screening									
Hab-10.0	Municipal waste management							1	1	
Hab-11.0	Nutrient and pa hogen load reduction from grazing/agriculture							1	1	
Hab-12.0	Obstruction passage improvement									3
Hab-13.0	Obstruction removal									4
Hab-14.0	Pesticide/herbicide reduction							2		
Hab-15.0	Reintroduction of species									
Hab-16.0	Predator control									
Hab-16.1	Control predatory fish									
Hab-16.2	Control predatory birds									
Hab-16.3	Control mammalian predators									
Hab-17.0	Reduce grazing impacts to ripanian/ aqua ic ecosystem				2				1	
Hab-18.0	Establish aquatic reserves, preserves, refugia									
Hab-18.1	Establish terrestrial reserves, preserves, refugia									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		**Level 2 Ecological Attribute:**								
Code	**Strategy Name**	Predation risk	Riparian func ion	Salmon Carcasses	Temperature - daily maximum (by month)	Temperature - daily minimum (by month)	Temperature - spatial variation	Turbidity	Water withdrawals	Wood
Hab-1.0	Reduce agricultural impacts to ripanian/ aquatic ecosystem		1		1	1	1	1	1	1
Hab-2.0	Competitor control									
Hab-3.0	Sediment reduction									
Hab-4.0	Floodplain corridor reconnection		2		2	2	2	2		2
Hab-5.0	Regulate tributary storage releases to provide normative flows.									
Hab-6.0	Reduce forestry impacts to ripanian/ aqua ic ecosystem		1		1	1	1	1		1
Hab-7.0	Agricultural water conserva ion									
Hab-8.0	Irrigation waste water treatment							2		
Hab-9.0	Irrigation withdrawals screening								3	
Hab-10.0	Municipal waste management									
Hab-11.0	Nutrient and pa hogen load reduction from grazing/agriculture									
Hab-12.0	Obstruction passage improvement									
Hab-13.0	Obstruction removal									
Hab-14.0	Pesticide/herbicide reduction									
Hab-15.0	Reintroduction of species									
Hab-16.0	Predator control									
Hab-16.1	Control predatory fish	2								
Hab-16.2	Control predatory birds	2								
Hab-16.3	Control mammalian predators	2								
Hab-17.0	Reduce grazing impacts to ripanian/ aqua ic ecosystem		2		2	2	2	2	2	2
Hab-18.0	Establish aquatic reserves, preserves, refugia		1				1			1
Hab-18.1	Establish terrestrial reserves, preserves, refugia									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		Level 2 Ecological Attribute:								
Code	**Strategy Name**	Alkalinity	Bed scour	Ben hos diversity and production	Channel length	Channel width - month maximum width (ft)	Channel width - month minimum width (ft)	Confinement - Hydro-modifications	Confinement - natural	Dissolved oxygen
Hab-19.0	Manage land use and riparian conditions to maintain water quality		1	1						
Hab-20.0	Road management		1	1				2		
Hab-21.0	Habitat fertilization			1						
Hab-22.0	Tributary gravel supply enhancment									
Hab-23.0	Tributary wood supply enhancement									
Hab-24.0	Urban storm runoff control		1							
Hab-25.0	Groundwater management to maintain flow									
Hab-26.0	Connect lower tributaries and mainstem habitat						1			
Hab-27.0	Link terrestrial and aquatic preserves and refugia									
Hab-28.0	Protect high quality aquatic habitat on tribal and public lands while allowing restricted use.									
Hab-29.0	Protect high quality aquatic habitat on private lands while allowing restricted use.									
Hab-30.0	Passive habitat restoration.		2							
Hab-31.0	Ac ive habitat restoration		1							
Hab-32.0	Halt new water withdrawal permits									
Hab-33.0	Reduce existing permits for water withdrawal									
Hab-34.0	Encourage cul ivation of less water-intensive crops									
Hab-35.0	and o her measures to restore estuarine habitats.							2		
Hab-36.0	Manage dredging toavoid increasing predation.									
Hab-37.0	Develop habitats to link terrestrial preserves and refugia									
Hab-38.0	Protect high quality terrestrial habitats while allowing restricted use.									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		**Level 2 Ecological Attribute:**								
Code	**Strategy Name**	Embeddedness	Fine sediment	Fish community richness	Fish pa hogens	Fish species introductions	Flow - change in interannual variability in high flows	Flow - changes in interannual variability in low flows	Flow - Intra daily (diel) varia ion	Flow - intra-annual flow pattern
Hab-19.0	Manage land use and riparian conditions to maintain water quality		2							
Hab-20.0	Road management	2	2				1	1		
Hab-21.0	Habitat fertilization									
Hab-22.0	Tributary gravel supply enhancment									
Hab-23.0	Tributary wood supply enhancement									
Hab-24.0	Urban storm runoff control	1	1				2			2
Hab-25.0	Groundwater management to maintain flow							1		
Hab-26.0	Connect lower tributaries and mainstem habitat							2		
Hab-27.0	Link terrestrial and aquatic preserves and refugia									
Hab-28.0	Protect high quality aquatic habitat on tribal and public lands while allowing restricted use.									
Hab-29.0	Protect high quality aquatic habitat on private lands while allowing restricted use.									
Hab-30.0	Passive habitat restoration.	2	2							
Hab-31.0	Ac ive habitat restoration	1	1							
Hab-32.0	Halt new water withdrawal permits									
Hab-33.0	Reduce existing permits for water withdrawal							1		
Hab-34.0	Encourage cul ivation of less water-intensive crops	1	1					1		
Hab-35.0	and o her measures to restore estuarine habitats.									
Hab-36.0	Manage dredging toavoid increasing predation.									
Hab-37.0	Develop habitats to link terrestrial preserves and refugia									
Hab-38.0	Protect high quality terrestrial habitats while allowing restricted use.									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		Level 2 Ecological Attribute:								
Code	**Strategy Name**	Gradient	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - large cobble/boulder riffles	Habitat type - off-channel habitat factor	Habitat type - pool tailouts/glides	Habitat type - primary pools	Habitat type - small cobble/gravel riffles	Harassment
Hab-19.0	Manage land use and riparian conditions to maintain water quality		1	1		1				
Hab-20.0	Road management									
Hab-21.0	Habitat fertilization									
Hab-22.0	Tributary gravel supply enhancment								2	
Hab-23.0	Tributary wood supply enhancement		2			2	2	2	2	
Hab-24.0	Urban storm runoff control									
Hab-25.0	Groundwater management to maintain flow									
Hab-26.0	Connect lower tributaries and mainstem habitat									
Hab-27.0	Link terrestrial and aquatic preserves and refugia									
Hab-28.0	Protect high quality aquatic habitat on tribal and public lands while allowing restricted use.									
Hab-29.0	Protect high quality aquatic habitat on private lands while allowing restricted use.									
Hab-30.0	Passive habitat restoration.		2	2		2	2	2	2	
Hab-31.0	Ac ive habitat restoration		1	1		1	1	1	1	
Hab-32.0	Halt new water withdrawal permits									
Hab-33.0	Reduce existing permits for water withdrawal									
Hab-34.0	Encourage cul ivation of less water-intensive crops									
Hab-35.0	and o her measures to restore estuarine habitats.		2			2				
Hab-36.0	Manage dredging toavoid increasing predation.									
Hab-37.0	Develop habitats to link terrestrial preserves and refugia									
Hab-38.0	Protect high quality terrestrial habitats while allowing restricted use.									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		Level 2 Ecological Attribute:								
Code	**Strategy Name**	Hatchery fish outplants	Hydrologic regime - natural	Hydrologic regime - regulated	Icing	Metals/Pollutants - in sediments/soils	Metals - in water column	Miscellaneous toxic pollutants - water column	Nutrient enrichment	Obstructions to fish migration
Hab-19.0	Manage land use and riparian conditions to maintain water quality							2	2	
Hab-20.0	Road management									
Hab-21.0	Habitat fertilization									
Hab-22.0	Tributary gravel supply enhancment									
Hab-23.0	Tributary wood supply enhancement									
Hab-24.0	Urban storm runoff control									
Hab-25.0	Groundwater management to maintain flow									
Hab-26.0	Connect lower tributaries and mainstem habitat									
Hab-27.0	Link terrestrial and aquatic preserves and refugia									
Hab-28.0	Protect high quality aquatic habitat on tribal and public lands while allowing restricted use.									
Hab-29.0	Protect high quality aquatic habitat on private lands while allowing restricted use.									
Hab-30.0	Passive habitat restoration.									
Hab-31.0	Ac ive habitat restoration									
Hab-32.0	Halt new water withdrawal permits									
Hab-33.0	Reduce existing permits for water withdrawal									
Hab-34.0	Encourage cul ivation of less water-intensive crops									
Hab-35.0	and o her measures to restore estuarine habitats.									
Hab-36.0	Manage dredging toavoid increasing predation.									
Hab-37.0	Develop habitats to link terrestrial preserves and refugia									
Hab-38.0	Protect high quality terrestrial habitats while allowing restricted use.									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		Level 2 Ecological Attribute:								
Code	**Strategy Name**	Predation risk	Riparian func ion	Salmon Carcasses	Temperature - daily maximum (by month)	Temperature - daily minimum (by month)	Temperature - spatial variation	Turbidity	Water withdrawals	Wood
Hab-19.0	Manage land use and riparian conditions to maintain water quality		2		2	2	2	2		1
Hab-20.0	Road management		1				2	2		
Hab-21.0	Habitat fertilization			1						
Hab-22.0	Tributary gravel supply enhancment									
Hab-23.0	Tributary wood supply enhancement									2
Hab-24.0	Urban storm runoff control									
Hab-25.0	Groundwater management to maintain flow				1	1	1			
Hab-26.0	Connect lower tributaries and mainstem habitat				2		2			
Hab-27.0	Link terrestrial and aquatic preserves and refugia		1				1			1
Hab-28.0	Protect high quality aquatic habitat on tribal and public lands while allowing restricted use.		1				1			1
Hab-29.0	Protect high quality aquatic habitat on private lands while allowing restricted use.		1				1			1
Hab-30.0	Passive habitat restoration.									2
Hab-31.0	Ac ive habitat restoration		1							1
Hab-32.0	Halt new water withdrawal permits									
Hab-33.0	Reduce existing permits for water withdrawal				1		1		1	
Hab-34.0	Encourage cul ivation of less water-intensive crops				1		1		1	
Hab-35.0	and o her measures to restore estuarine habitats.									
Hab-36.0	Manage dredging toavoid increasing predation.	2								
Hab-37.0	Develop habitats to link terrestrial preserves and refugia									
Hab-38.0	Protect high quality terrestrial habitats while allowing restricted use.		1							1

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		Level 2 Ecological Attribute:								
Code	**Strategy Name**	Alkalinity	Bed scour	Ben hos diversity and production	Channel length	Channel width - month maximum width (ft)	Channel width - month minimum width (ft)	Confinement - Hydro-modifications	Confinement - natural	Dissolved oxygen
Hab-39.0	Limit size and frequency of clearcuts		2							
Hab-40.0	Normative fire frequency									
Hab-41.0	Develop normative forest age structure and species composition									
Hab-42.0	Provide gradual forest ecotones									
Hab-43.0	Reduce forest road density		1							
Hab-44.0	Build storage reservoir to provide downstream flow									
Hab-45.0	Improve mining discharges									
Hab-46.0	Improve mining practices									
Hab-47.0	Rehabilitate marginal and closed mines									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		**Level 2 Ecological Attribute:**								
Code	**Strategy Name**	Embeddedness	Fine sediment	Fish community richness	Fish pa hogens	Fish species introductions	Flow - change in interannual variability in high flows	Flow - changes in interannual variability in low flows	Flow - Intra daily (diel) varia ion	Flow - intra-annual flow pattern
Hab-39.0	Limit size and frequency of clearcuts	2	2				2	2		2
Hab-40.0	Normative fire frequency	1	1				1	1		1
Hab-41.0	Develop normative forest age structure and species composition									
Hab-42.0	Provide gradual forest ecotones									
Hab-43.0	Reduce forest road density	1	1							
Hab-44.0	Build storage reservoir to provide downstream flow						1	1		1
Hab-45.0	Improve mining discharges									
Hab-46.0	Improve mining practices									
Hab-47.0	Rehabilitate marginal and closed mines									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		Level 2 Ecological Attribute:								
Code	**Strategy Name**	Gradient	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - large cobble/boulder riffles	Habitat type - off-channel habitat factor	Habitat type - pool tailouts/glides	Habitat type - primary pools	Habitat type - small cobble/gravel riffles	Harassment
Hab-39.0	Limit size and frequency of clearcuts									
Hab-40.0	Normative fire frequency									
Hab-41.0	Develop normative forest age structure and species composition		2	2		2	2	2		
Hab-42.0	Provide gradual forest ecotones									
Hab-43.0	Reduce forest road density									
Hab-44.0	Build storage reservoir to provide downstream flow									
Hab-45.0	Improve mining discharges									
Hab-46.0	Improve mining practices									
Hab-47.0	Rehabilitate marginal and closed mines									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		Level 2 Ecological Attribute:								
Code	**Strategy Name**	Hatchery fish outplants	Hydrologic regime - natural	Hydrologic regime - regulated	Icing	Metals/Pollutants - in sediments/soils	Metals - in water column	Miscellaneous toxic pollutants - water column	Nutrient enrichment	Obstructions to fish migration
Hab-39.0	Limit size and frequency of clearcuts									
Hab-40.0	Normative fire frequency									
Hab-41.0	Develop normative forest age structure and species composition									
Hab-42.0	Provide gradual forest ecotones									
Hab-43.0	Reduce forest road density									
Hab-44.0	Build storage reservoir to provide downstream flow									
Hab-45.0	Improve mining discharges									
Hab-46.0	Improve mining practices									
Hab-47.0	Rehabilitate marginal and closed mines									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		**Level 2 Ecological Attribute:**								
Code	**Strategy Name**	Predation risk	Riparian func ion	Salmon Carcasses	Temperature - daily maximum (by month)	Temperature - daily minimum (by month)	Temperature - spatial variation	Turbidity	Water withdrawals	Wood
Hab-39.0	Limit size and frequency of clearcuts							2		2
Hab-40.0	Normative fire frequency							1		1
Hab-41.0	Develop normative forest age structure and species composition									2
Hab-42.0	Provide gradual forest ecotones		1							
Hab-43.0	Reduce forest road density						1	1		
Hab-44.0	Build storage reservoir to provide downstream flow									
Hab-45.0	Improve mining discharges									
Hab-46.0	Improve mining practices									
Hab-47.0	Rehabilitate marginal and closed mines									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		Level 2 Ecological Attribute:								
Code	**Strategy Name**	Alkalinity	Bed scour	Ben hos diversity and production	Channel length	Channel width - month maximum width (ft)	Channel width - month minimum width (ft)	Confinement - Hydro-modifications	Confinement - natural	Dissolved oxygen
Har-1.0	Harvest elimination									
Har-2.0	Harvest reduction									
Har-3.0	MSY harvest management									
Har-4.0	Selective fisheries									
Har-5.0	Focus sport or C&S fisheries									
Har-6.0	Weakest population harvest rate									
Har-7.0	Weakest metapopulation harvest rate									
Har-8.0	Manage overall harvest rate to meet escapement needs									
Har-9.0	Use "new" harvest techniques									
Har-10.0	Develop aquaculture									
Har-11.0	Weakest aggregate harvest rate									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		Level 2 Ecological Attribute:								
Code	**Strategy Name**	Embeddedness	Fine sediment	Fish community richness	Fish pa hogens	Fish species introductions	Flow - change in interannual variability in high flows	Flow - changes in interannual variability in low flows	Flow - Intra daily (diel) varia ion	Flow - intra-annual flow pattern
Har-1.0	Harvest elimination									
Har-2.0	Harvest reduction									
Har-3.0	MSY harvest management									
Har-4.0	Selective fisheries									
Har-5.0	Focus sport or C&S fisheries									
Har-6.0	Weakest population harvest rate									
Har-7.0	Weakest metapopulation harvest rate									
Har-8.0	Manage overall harvest rate to meet escapement needs									
Har-9.0	Use "new" harvest techniques									
Har-10.0	Develop aquaculture									
Har-11.0	Weakest aggregate harvest rate									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		**Level 2 Ecological Attribute:**								
Code	**Strategy Name**	Gradient	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - large cobble/boulder riffles	Habitat type - off-channel habitat factor	Habitat type - pool tailouts/glides	Habitat type - primary pools	Habitat type - small cobble/gravel riffles	Harassment
Har-1.0	Harvest elimination									
Har-2.0	Harvest reduction									
Har-3.0	MSY harvest management									
Har-4.0	Selective fisheries									
Har-5.0	Focus sport or C&S fisheries									
Har-6.0	Weakest population harvest rate									
Har-7.0	Weakest metapopulation harvest rate									
Har-8.0	Manage overall harvest rate to meet escapement needs									
Har-9.0	Use "new" harvest techniques									
Har-10.0	Develop aquaculture									
Har-11.0	Weakest aggregate harvest rate									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		**Level 2 Ecological Attribute:**								
Code	**Strategy Name**	Hatchery fish outplants	Hydrologic regime - natural	Hydrologic regime - regulated	Icing	Metals/Pollutants - in sediments/soils	Metals - in water column	Miscellaneous toxic pollutants - water column	Nutrient enrichment	Obstructions to fish migration
Har-1.0	Harvest elimination									
Har-2.0	Harvest reduction									
Har-3.0	MSY harvest management									
Har-4.0	Selective fisheries									
Har-5.0	Focus sport or C&S fisheries									
Har-6.0	Weakest population harvest rate									
Har-7.0	Weakest metapopulation harvest rate									
Har-8.0	Manage overall harvest rate to meet escapement needs									
Har-9.0	Use "new" harvest techniques									
Har-10.0	Develop aquaculture									
Har-11.0	Weakest aggregate harvest rate									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		Level 2 Ecological Attribute:								
Code	**Strategy Name**	Predation risk	Riparian func ion	Salmon Carcasses	Temperature - daily maximum (by month)	Temperature - daily minimum (by month)	Temperature - spatial variation	Turbidity	Water withdrawals	Wood
Har-1.0	Harvest elimination									
Har-2.0	Harvest reduction									
Har-3.0	MSY harvest management									
Har-4.0	Selective fisheries									
Har-5.0	Focus sport or C&S fisheries									
Har-6.0	Weakest population harvest rate									
Har-7.0	Weakest metapopulation harvest rate									
Har-8.0	Manage overall harvest rate to meet escapement needs									
Har-9.0	Use "new" harvest techniques									
Har-10.0	Develop aquaculture									
Har-11.0	Weakest aggregate harvest rate									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		Level 2 Ecological Attribute:								
Code	**Strategy Name**	Alkalinity	Bed scour	Ben hos diversity and production	Channel length	Channel width - month maximum width (ft)	Channel width - month minimum width (ft)	Confinement - Hydro-modifications	Confinement - natural	Dissolved oxygen
Hat-1.0	Incorporate wild fish into hatchery broodstocks									
Hat-2.0	Use natural population as a template for hatchery.									
Hat-3.0	Provide emergency preservation of gene ic resources									
Hat-4.0	Phase out hatchery production									
Hat-5.0	Expand hatchery production									
Hat-6.0	Reduce hatchery production									
Hat-7.0	Use wild fish emulation techniques in hatchery.									
Hat-8.0	Reduce spread of hatchery pathogens to wild									
Hat-9.0	Supplement natural production									
Hat-10.0	Reintroduce progeny of captive brood fish back into habitat									
Hat-11.0	Provide mi iga ion hatcheries									
Hat-12.0	Deveop augmenta ion hatchery.									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		Level 2 Ecological Attribute:								
Code	Strategy Name	Embeddedness	Fine sediment	Fish community richness	Fish pa hogens	Fish species introductions	Flow - change in interannual variability in high flows	Flow - changes in interannual variability in low flows	Flow - Intra daily (diel) varia ion	Flow - intra-annual flow pattern
Hat-1.0	Incorporate wild fish into hatchery broodstocks									
Hat-2.0	Use natural population as a template for hatchery.									
Hat-3.0	Provide emergency preservation of gene ic resources									
Hat-4.0	Phase out hatchery production									
Hat-5.0	Expand hatchery production									
Hat-6.0	Reduce hatchery production									
Hat-7.0	Use wild fish emulation techniques in hatchery.									
Hat-8.0	Reduce spread of hatchery pathogens to wild									
Hat-9.0	Supplement natural production									
Hat-10.0	Reintroduce progeny of captive brood fish back into habitat									
Hat-11.0	Provide mi iga ion hatcheries									
Hat-12.0	Deveop augmenta ion hatchery.									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		Level 2 Ecological Attribute:								
Code	**Strategy Name**	Gradient	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - large cobble/boulder riffles	Habitat type - off-channel habitat factor	Habitat type - pool tailouts/glides	Habitat type - primary pools	Habitat type - small cobble/gravel riffles	Harassment
Hat-1.0	Incorporate wild fish into hatchery broodstocks									
Hat-2.0	Use natural population as a template for hatchery.									
Hat-3.0	Provide emergency preservation of gene ic resources									
Hat-4.0	Phase out hatchery production									
Hat-5.0	Expand hatchery production									
Hat-6.0	Reduce hatchery production									
Hat-7.0	Use wild fish emulation techniques in hatchery.									
Hat-8.0	Reduce spread of hatchery pathogens to wild									
Hat-9.0	Supplement natural production									
Hat-10.0	Reintroduce progeny of captive brood fish back into habitat									
Hat-11.0	Provide mi iga ion hatcheries									
Hat-12.0	Deveop augmenta ion hatchery.									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		Level 2 Ecological Attribute:								
Code	Strategy Name	Hatchery fish outplants	Hydrologic regime - natural	Hydrologic regime - regulated	Icing	Metals/Pollutants - in sediments/soils	Metals - in water column	Miscellaneous toxic pollutants - water column	Nutrient enrichment	Obstructions to fish migration
Hat-1.0	Incorporate wild fish into hatchery broodstocks									
Hat-2.0	Use natural population as a template for hatchery.									
Hat-3.0	Provide emergency preservation of gene ic resources									
Hat-4.0	Phase out hatchery production									
Hat-5.0	Expand hatchery production									
Hat-6.0	Reduce hatchery production									
Hat-7.0	Use wild fish emulation techniques in hatchery.									
Hat-8.0	Reduce spread of hatchery pathogens to wild									
Hat-9.0	Supplement natural production	-5								
Hat-10.0	Reintroduce progeny of captive brood fish back into habitat									
Hat-11.0	Provide mi iga ion hatcheries	-5								
Hat-12.0	Deveop augmenta ion hatchery.	-5								

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		**Level 2 Ecological Attribute:**								
Code	**Strategy Name**	Predation risk	Riparian func ion	Salmon Carcasses	Temperature - daily maximum (by month)	Temperature - daily minimum (by month)	Temperature - spatial variation	Turbidity	Water withdrawals	Wood
Hat-1.0	Incorporate wild fish into hatchery broodstocks									
Hat-2.0	Use natural population as a template for hatchery.									
Hat-3.0	Provide emergency preservation of gene ic resources									
Hat-4.0	Phase out hatchery production									
Hat-5.0	Expand hatchery production									
Hat-6.0	Reduce hatchery production									
Hat-7.0	Use wild fish emulation techniques in hatchery.									
Hat-8.0	Reduce spread of hatchery pathogens to wild									
Hat-9.0	Supplement natural production									
Hat-10.0	Reintroduce progeny of captive brood fish back into habitat									
Hat-11.0	Provide mi iga ion hatcheries									
Hat-12.0	Deveop augmenta ion hatchery.									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		Level 2 Ecological Attribute:								
Code	**Strategy Name**	Alkalinity	Bed scour	Ben hos diversity and production	Channel length	Channel width - month maximum width (ft)	Channel width - month minimum width (ft)	Confinement - Hydro-modifications	Confinement - natural	Dissolved oxygen
Hyd-1.0	Channel maintenance flows below dam									
Hyd-2.0	Convert storage reservoir to run-of-river reservoir									
Hyd-3.0	Breach a dam									
Hyd-4.0	Provide alternative fish passage structures and operations to minimize life history selection									
Hyd-5.0	Discourage proliferation of shad via adult passage facilities									
Hyd-6.0	Operate juvenile fish passage facilities year round									
Hyd-7.0	Dam drawdwon									
Hyd-8.0	Manage spill to minimize dissolved gas									
Hyd-9.0	Minimize daily flow fluctuations									
Hyd-10.0	Normative seasonal flow and flooding			1						
Hyd-11.0	Provide gravel and organic debris in unimpounded mainstem areas									
Hyd-12.0	Design and implement bypass structures to reflect biological characteristics									
Hyd-13.0	Operate adult passage facilities year-round									
Hyd-14.0	Provide flow to re-establish normative estuarine and plume and salinity conditions.									
Hyd-15.0	Remove economically marginal dams on tributaries that block anadromous passage									
Hyd-16.0	Restore passage for anadromous fish above blockages									
Hyd-17.0	Operate adult passage facilities on an extended schedule									
Hyd-18.0	Operate juvenile passage facilities on an extended schedule									
Hyd-19.0	Maximize transport downstream juvenile salmonid migrants									
Hyd-20.0	Use "Share the risk" transportation policy for juvenile salmonids									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		**Level 2 Ecological Attribute:**								
Code	**Strategy Name**	Embeddedness	Fine sediment	Fish community richness	Fish pa hogens	Fish species introductions	Flow - change in interannual variability in high flows	Flow - changes in interannual variability in low flows	Flow - Intra daily (diel) varia ion	Flow - intra-annual flow pattern
Hyd-1.0	Channel maintenance flows below dam									
Hyd-2.0	Convert storage reservoir to run-of-river reservoir									
Hyd-3.0	Breach a dam									
Hyd-4.0	Provide alternative fish passage structures and operations to minimize life history selection									
Hyd-5.0	Discourage proliferation of shad via adult passage facilities									
Hyd-6.0	Operate juvenile fish passage facilities year round									
Hyd-7.0	Dam drawdwon									
Hyd-8.0	Manage spill to minimize dissolved gas									
Hyd-9.0	Minimize daily flow fluctuations								3	
Hyd-10.0	Normative seasonal flow and flooding									
Hyd-11.0	Provide gravel and organic debris in unimpounded mainstem areas									
Hyd-12.0	Design and implement bypass structures to reflect biological characteristics									
Hyd-13.0	Operate adult passage facilities year-round									
Hyd-14.0	Provide flow to re-establish normative estuarine and plume and salinity conditions.									
Hyd-15.0	Remove economically marginal dams on tributaries that block anadromous passage									
Hyd-16.0	Restore passage for anadromous fish above blockages									
Hyd-17.0	Operate adult passage facilities on an extended schedule									
Hyd-18.0	Operate juvenile passage facilities on an extended schedule									
Hyd-19.0	Maximize transport downstream juvenile salmonid migrants									
Hyd-20.0	Use "Share the risk" transportation policy for juvenile salmonids									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		Level 2 Ecological Attribute:								
Code	**Strategy Name**	Gradient	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - large cobble/boulder riffles	Habitat type - off-channel habitat factor	Habitat type - pool tailouts/glides	Habitat type - primary pools	Habitat type - small cobble/gravel riffles	Harassment
Hyd-1.0	Channel maintenance flows below dam									
Hyd-2.0	Convert storage reservoir to run-of-river reservoir									
Hyd-3.0	Breach a dam									
Hyd-4.0	Provide alternative fish passage structures and operations to minimize life history selection									
Hyd-5.0	Discourage proliferation of shad via adult passage facilities									
Hyd-6.0	Operate juvenile fish passage facilities year round									
Hyd-7.0	Dam drawdwon									
Hyd-8.0	Manage spill to minimize dissolved gas									
Hyd-9.0	Minimize daily flow fluctuations									
Hyd-10.0	Normative seasonal flow and flooding		2			2				
Hyd-11.0	Provide gravel and organic debris in unimpounded mainstem areas								1	
Hyd-12.0	Design and implement bypass structures to reflect biological characteristics									
Hyd-13.0	Operate adult passage facilities year-round									
Hyd-14.0	Provide flow to re-establish normative estuarine and plume and salinity conditions.									
Hyd-15.0	Remove economically marginal dams on tributaries that block anadromous passage									
Hyd-16.0	Restore passage for anadromous fish above blockages									
Hyd-17.0	Operate adult passage facilities on an extended schedule									
Hyd-18.0	Operate juvenile passage facilities on an extended schedule									
Hyd-19.0	Maximize transport downstream juvenile salmonid migrants									
Hyd-20.0	Use "Share the risk" transportation policy for juvenile salmonids									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		**Level 2 Ecological Attribute:**								
Code	**Strategy Name**	Hatchery fish outplants	Hydrologic regime - natural	Hydrologic regime - regulated	Icing	Metals/Pollutants - in sediments/soils	Metals - in water column	Miscellaneous toxic pollutants - water column	Nutrient enrichment	Obstructions to fish migration
Hyd-1.0	Channel maintenance flows below dam									
Hyd-2.0	Convert storage reservoir to run-of-river reservoir									
Hyd-3.0	Breach a dam									
Hyd-4.0	Provide alternative fish passage structures and operations to minimize life history selection									
Hyd-5.0	Discourage proliferation of shad via adult passage facilities									
Hyd-6.0	Operate juvenile fish passage facilities year round									
Hyd-7.0	Dam drawdwon									
Hyd-8.0	Manage spill to minimize dissolved gas									
Hyd-9.0	Minimize daily flow fluctuations									
Hyd-10.0	Normative seasonal flow and flooding									
Hyd-11.0	Provide gravel and organic debris in unimpounded mainstem areas									
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Hyd-15.0	Remove economically marginal dams on tributaries that block anadromous passage									
Hyd-16.0	Restore passage for anadromous fish above blockages									
Hyd-17.0	Operate adult passage facilities on an extended schedule									
Hyd-18.0	Operate juvenile passage facilities on an extended schedule									
Hyd-19.0	Maximize transport downstream juvenile salmonid migrants									
Hyd-20.0	Use "Share the risk" transportation policy for juvenile salmonids									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		Level 2 Ecological Attribute:								
Code	**Strategy Name**	Predation risk	Riparian func ion	Salmon Carcasses	Temperature - daily maximum (by month)	Temperature - daily minimum (by month)	Temperature - spatial variation	Turbidity	Water withdrawals	Wood
Hyd-1.0	Channel maintenance flows below dam									
Hyd-2.0	Convert storage reservoir to run-of-river reservoir									
Hyd-3.0	Breach a dam									
Hyd-4.0	Provide alternative fish passage structures and operations to minimize life history selection									
Hyd-5.0	Discourage proliferation of shad via adult passage facilities									
Hyd-6.0	Operate juvenile fish passage facilities year round									
Hyd-7.0	Dam drawdwon									
Hyd-8.0	Manage spill to minimize dissolved gas									
Hyd-9.0	Minimize daily flow fluctuations									
Hyd-10.0	Normative seasonal flow and flooding									
Hyd-11.0	Provide gravel and organic debris in unimpounded mainstem areas									
Hyd-12.0	Design and implement bypass structures to reflect biological characteristics									
Hyd-13.0	Operate adult passage facilities year-round									
Hyd-14.0	Provide flow to re-establish normative estuarine and plume and salinity conditions.									
Hyd-15.0	Remove economically marginal dams on tributaries that block anadromous passage									
Hyd-16.0	Restore passage for anadromous fish above blockages									
Hyd-17.0	Operate adult passage facilities on an extended schedule									
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Hyd-19.0	Maximize transport downstream juvenile salmonid migrants									
Hyd-20.0	Use "Share the risk" transportation policy for juvenile salmonids									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		**Level 2 Ecological Attribute:**								
Code	**Strategy Name**	Alkalinity	Bed scour	Ben hos diversity and production	Channel length	Channel width - month maximum width (ft)	Channel width - month minimum width (ft)	Confinement - Hydro-modifications	Confinement - natural	Dissolved oxygen
Hyd-21.0	Use transportation as an emergency measure									
Hyd-22.0	Eliminate transporta ion									
Hyd-23.0	Use barges only for transportation									
Hyd-24.0	Install extended length screens at collector projects									
Hyd-25.0	Eliminate use of extended length screens at all projects									
Hyd-26.0	Provide flow to provide normative downsteam temperatures									
Hyd-27.0	Locate bypass outfalls to reduce predation									
Hyd-28.0	Remove bank armoring		1					2		
Hyd-29.0	Connect backwaters and sloughs		1					1		
Hyd-30.0	Manage flow to promote mainstem spawning below dams.									
Hyd-31.0	BiOp Flows									
Hyd-32.0	IRCs									
Hyd-33.0	Shift spring flow to summer									
Hyd-34.0	Install surface bypass									
Hyd-35.0	Install "Fish friendly" turbines									
Hyd-36.0	Pre-WB flow									
Hyd-37.0	BRCs									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		Level 2 Ecological Attribute:								
Code	**Strategy Name**	Embeddedness	Fine sediment	Fish community richness	Fish pa hogens	Fish species introductions	Flow - change in interannual variability in high flows	Flow - changes in interannual variability in low flows	Flow - Intra daily (diel) varia ion	Flow - intra-annual flow pattern
Hyd-21.0	Use transportation as an emergency measure									
Hyd-22.0	Eliminate transporta ion									
Hyd-23.0	Use barges only for transportation									
Hyd-24.0	Install extended length screens at collector projects									
Hyd-25.0	Eliminate use of extended length screens at all projects									
Hyd-26.0	Provide flow to provide normative downsteam temperatures									
Hyd-27.0	Locate bypass outfalls to reduce predation									
Hyd-28.0	Remove bank armoring									
Hyd-29.0	Connect backwaters and sloughs									
Hyd-30.0	Manage flow to promote mainstem spawning below dams.									
Hyd-31.0	BiOp Flows									
Hyd-32.0	IRCs									
Hyd-33.0	Shift spring flow to summer									
Hyd-34.0	Install surface bypass									
Hyd-35.0	Install "Fish friendly" turbines									
Hyd-36.0	Pre-WB flow									
Hyd-37.0	BRCs									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		**Level 2 Ecological Attribute:**								
Code	**Strategy Name**	Gradient	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - large cobble/boulder riffles	Habitat type - off-channel habitat factor	Habitat type - pool tailouts/glides	Habitat type - primary pools	Habitat type - small cobble/gravel riffles	Harassment
Hyd-21.0	Use transportation as an emergency measure									
Hyd-22.0	Eliminate transporta ion									
Hyd-23.0	Use barges only for transportation									
Hyd-24.0	Install extended length screens at collector projects									
Hyd-25.0	Eliminate use of extended length screens at all projects									
Hyd-26.0	Provide flow to provide normative downsteam temperatures									
Hyd-27.0	Locate bypass outfalls to reduce predation									
Hyd-28.0	Remove bank armoring		2			2				
Hyd-29.0	Connect backwaters and sloughs		2			2				
Hyd-30.0	Manage flow to promote mainstem spawning below dams.									
Hyd-31.0	BiOp Flows									
Hyd-32.0	IRCs									
Hyd-33.0	Shift spring flow to summer									
Hyd-34.0	Install surface bypass									
Hyd-35.0	Install "Fish friendly" turbines									
Hyd-36.0	Pre-WB flow									
Hyd-37.0	BRCs									

Strategy effectiveness assumptions applied in analyzing alternative basin plans.
Effectiveness codes are: blank = nil (0%); 1 = low (10%); 2 = moderate (25%); 3 = high (55%); 4 = full (100%)

Strategy		**Level 2 Ecological Attribute:**								
Code	**Strategy Name**	Hatchery fish outplants	Hydrologic regime - natural	Hydrologic regime - regulated	Icing	Metals/Pollutants - in sediments/soils	Metals - in water column	Miscellaneous toxic pollutants - water column	Nutrient enrichment	Obstructions to fish migration
Hyd-21.0	Use transportation as an emergency measure									
Hyd-22.0	Eliminate transporta ion									
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Hyd-33.0	Shift spring flow to summer									
Hyd-34.0	Install surface bypass									
Hyd-35.0	Install "Fish friendly" turbines									
Hyd-36.0	Pre-WB flow									
Hyd-37.0	BRCs									

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Strategy		**Level 2 Ecological Attribute:**								
Code	**Strategy Name**	Predation risk	Riparian func ion	Salmon Carcasses	Temperature - daily maximum (by month)	Temperature - daily minimum (by month)	Temperature - spatial variation	Turbidity	Water withdrawals	Wood
Hyd-21.0	Use transportation as an emergency measure									
Hyd-22.0	Eliminate transporta ion									
Hyd-23.0	Use barges only for transportation									
Hyd-24.0	Install extended length screens at collector projects									
Hyd-25.0	Eliminate use of extended length screens at all projects									
Hyd-26.0	Provide flow to provide normative downsteam temperatures									
Hyd-27.0	Locate bypass outfalls to reduce predation									
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Hyd-30.0	Manage flow to promote mainstem spawning below dams.									
Hyd-31.0	BiOp Flows									
Hyd-32.0	IRCs									
Hyd-33.0	Shift spring flow to summer									
Hyd-34.0	Install surface bypass									
Hyd-35.0	Install "Fish friendly" turbines									
Hyd-36.0	Pre-WB flow									
Hyd-37.0	BRCs									

Habitat stategies incorporated into each alternative in the Blue Mountains Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hab-2.0 Competitor control	Hab-3.0 Sediment reduction	Hab-4.0 Floodplain corridor reconnection	Hab-5.0 Regulate tributary storage releases to provide normative flows.	Hab-6.0 Reduce forestry impacts to ripanian/ aquatic ecosystem	Hab-7.0 Agricultural water conservation	Hab-8.0 Irrigation waste water treatment	Hab-9.0 Irrigation withdrawals screening	Hab-10.0 Municipal waste management	Hab-11.0 Nutrient and pathogen load reduction from grazing/agriculture	Hab-12.0 Obstruction passage improvement	Hab-13.0 Obstruction removal	Hab-14.0 Pesticide/herbicide reduction	Hab-15.0 Reintroduction of species	Hab-16.1 Control predatory fish	Hab-16 2 Control predatory birds	Hab-16 3 Control mammalian predators	Hab-17.0 Reduce grazing impacts to ripanian/ aquatic ecosystem	Hab-18.0 Establish aquatic reserves, preserves, refugia	Hab-18.1 Establish terrestrial reserves, preserves, refugia	Hab-19.0 Manage land use and riparian conditions to maintain water quality	Hab-20.0 Road management	Hab-21.0 Habitat fertilization	Hab-22.0 Tributary gravel supply enhancment	Hab-23.0 Tributary wood supply enhancement
Blue Mountains	1	1-3			X		X	X	X	X	X	X	X	X	X					X	X	X	X	X			
	2	2-3			X		X	X	X	X	X	X	X	X	X					X	X	X	X	X			
	3	3-3			X		X	X	X	X	X	X	X	X	X					X	X	X	X	X			
	4	4-3					X			X	X	X	X	X	X					X			X	X	X		X
	5	5-3			X		X	X	X	X	X	X	X	X	X					X	X	X	X	X	X		
	6	6-3			X		X	X	X	X	X	X	X	X	X					X	X	X	X	X	X		X
	7	7-3						X	X	X	X	X	X	X						X			X	X			

Habitat stategies incorporated into each alternative in the Blue Mountains Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hab-24.0 Urban storm runoff control	Hab-25.0 Groundwater management to maintain flow	Hab-26.0 Connect lower tributaries and mainstem habitat	Hab-27.0 Link terrestrial and aquatic preserves and refugia	Hab-28.0 Protect high quality aquatic habitat on tribal and public lands while	Hab-29.0 Protect high quality aquatic habitat on private lands while allowing	Hab-30.0 Passive habitat restoration.	Hab-31.0 Active habitat restoration	Hab-32.0 Halt new water withdrawal permits	Hab-33.0 Reduce existing permits for water withdrawal	Hab-34.0 Encourage cultivation of less water-intensive crops	Hab-35.0 Remove dikes and manage dredging and other measures to	Hab-36.0 Manage dredging toavoid increasing predation.	Hab-37.0 Develop habitats to link terrestrial preserves and refugia	Hab-38.0 Protect high quality terrestrial habitats while allowing restricted	Hab-39.0 Limit size and frequency of clearcuts	Hab-40.0 Normative fire frequency	Hab-41.0 Develop normative forest age structure and species composition	Hab-42.0 Provide gradual forest ecotones	Hab-43.0 Reduce forest road density	Hab-44.0 Build storage reservoir to provide downstream flow	Hab-45.0 Improve mining discharges	Hab-46.0 Improve mining practices	Hab-47.0 Rehabilitate marginal and closed mines
Blue Mountains	1	1-3		X	X	X	X	X	X		X	X	X			X	X	X	X	X	X	X				
	2	2-3		X	X	X	X	X	X		X		X			X	X	X	X	X	X	X				
	3	3-3		X	X	X	X	X	X		X		X			X	X	X	X	X	X	X				
	4	4-3						X	X	X							X									
	5	5-3		X		X	X	X	X	X	X	X	X			X	X	X	X	X	X	X				
	6	6-3		X		X	X	X	X	X	X					X	X	X	X	X	X	X				
	7	7-3		X			X	X	X							X	X									

Harvest and Hatchery stategies incorporated into each alternative in the Blue Mountains Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Har-1.0 Harvest elimination	Har-2.0 Harvest reduction	Har-3.0 MSY harvest management	Har-4.0 Selective fisheries	Har-5.0 Focus sport or C&S fisheries	Har-6.0 Weakest population harvest rate	Har-7.0 Weakest metapopulation harvest rate	Har-9.0 Use "new" harvest techniques	Har-10.0 Develop aquaculture	Har-11.0 Weakest aggregate harvest rate	Hat-2.0 Use natural population as a template for hatchery.	Hat-3.0 Provide emergency preservation of genetic resources	Hat-4.0 Phase out hatchery production	Hat-5.0 Expand hatchery production	Hat-6.0 Reduce hatchery production	Hat-7.0 Use wild fish emulation techniques in hatchery.	Hat-8.0 Reduce spread of hatchery pathogens to wild	Hat-9.0 Supplement natural production	Hat-10.0 Reintroduce progeny of captive brood fish back into habitat	Hat-11.0 Provide mitigation hatcheries	Hat-12.0 Deveop augmentation hatchery.
Blue Mountains	1	1-3					X	X					X	X	X			X			X		
	2	2-3					X		X				X	X	X			X		X	X	X	
	3	3-3					X		X				X	X	X			X		X		X	
	4	4-3					X					X	X	X				X		X	X		
	5	5-3					X		X				X	X	X			X	X	X		X	X
	6	6-3					X					X						X	X	X		X	X
	7	7-3					X					X								X			

Hydro stategies incorporated into each alternative in the Blue Mountains Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hyd-1.0 Channel maintenance flows below dam	Hyd-2.0 Convert storage reservoir to run-of-river reservoir	Hyd-3.0 Breach a dam	Hyd-4.0 Provide alternative fish passage structures and operations to	Hyd-5.0 Discourage proliferation of shad via adult passage facilities.	Hyd-6.0 Operate juvenile fish passage facilities year round.	Hyd-7.0 Dam drawdwon	Hyd-8.0 Manage spill to minimize dissolved gas	Hyd-9.0 Minimize daily flow fluctuations	Hyd-10.0 Normative seasonal flow and flooding	Hyd-11.0 Provide gravel and organic debris in unimpounded mainstem areas	Hyd-12.0 Design and implement bypass structures to reflect biological	Hyd-13.0 Operate adult passage facilities year-round	Hyd-14.0 Provide flow to re-establish normative estuarine and plume and	Hyd-15.0 Remove economically marginal dams on tributaries that block	Hyd-16.0 Restore passage for anadromous fish above blockages	Hyd-17.0 Operate adult passage facilities on an extended schedule	Hyd-18.0 Operate juvenile passage facilities on an extended schedule	Hyd-19.0 Maximize transport downstream juvenile salmonid migrants	Hyd-20.0 Use "Share the risk" transportation policy for juvenile salmonids.	Hyd-21.0 Use transportation as an emergency measure	Hyd-22.0 Eliminate transportation	Hyd-23.0 Use barges only for transportation.
Blue Mountains	1	1-3									X	X	X												
	2	2-3									X	X	X												
	3	3-3									X	X	X												
	4	4-3									X														
	5	5-3									X														
	6	6-3																							
	7	7-3																							

Hydro stategies incorporated into each alternative in the Blue Mountains Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hyd-24.0 Install extended length screens at collector projects	Hyd-25.0 Eliminate use of extended length screens at all projects	Hyd-26.0 Provide flow to provide normative downsteam temperatures.	Hyd-27.0 Locate bypass outfalls to reduce predation	Hyd-28.0 Remove bank armoring	Hyd-29.0 Connect backwaters and sloughs	Hyd-30.0 Manage flow to promote mainstem spawning below dams.	Hyd-31.0 BiOp Flows	Hyd-32.0 IRCs	Hyd-33.0 Shift spring flow to summer	Hyd-34.0 Install surface bypass	Hyd-35.0 Install "Fish friendly" turbines	Hyd-36.0 Pre-WB flow	Hyd-37.0 BRCs
Blue Mountains	1	1-3			X											X
	2	2-3			X						X					
	3	3-3			X		X	X	X		X					
	4	4-3								X						
	5	5-3					X	X	X	X	X					
	6	6-3										X				
	7	7-3													X	

Habitat stategies incorporated into each alternative in the Cascade Columbia Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hab-2.0 Competitor control	Hab-3.0 Sediment reduction	Hab-4.0 Floodplain corridor reconnection	Hab-5.0 Regulate tributary storage releases to provide normative flows.	Hab-6.0 Reduce forestry impacts to riparian/ aquatic ecosystem	Hab-7.0 Agricultural water conservation	Hab-8.0 Irrigation waste water treatment	Hab-9.0 Irrigation withdrawals screening	Hab-10.0 Municipal waste management	Hab-11.0 Nutrient and pathogen load reduction from grazing/agriculture	Hab-12.0 Obstruction passage improvement	Hab-13.0 Obstruction removal	Hab-14.0 Pesticide/herbicide reduction	Hab-15.0 Reintroduction of species	Hab-16.1 Control predatory fish	Hab-16.2 Control predatory birds	Hab-16.3 Control mammalian predators	Hab-17.0 Reduce grazing impacts to riparian/ aquatic ecosystem	Hab-18.0 Establish aquatic reserves, preserves, refugia	Hab-18.1 Establish terrestrial reserves, preserves, refugia	Hab-19.0 Manage land use and riparian conditions to maintain water quality	Hab-20.0 Road management	Hab-21.0 Habitat fertilization	Hab-22.0 Tributary gravel supply enhancment	Hab-23.0 Tributary wood supply enhancement
Cascade Columbia	1	1-6			X		X	X	X	X	X	X	X	X	X					X	X	X	X	X			
	2	2-6			X		X	X	X	X	X	X	X	X	X					X	X	X	X	X			
	3	3-6			X		X	X	X	X	X	X	X	X	X					X	X	X	X	X			
	4	4-6					X			X	X	X	X	X	X					X			X	X	X		X
	5	5-6			X		X	X	X	X	X	X	X	X	X					X	X	X	X	X	X		
	6	6-6			X		X	X	X	X	X	X	X	X	X					X	X	X	X	X	X		X
	7	7-6						X	X	X	X	X	X	X						X			X	X			

Habitat stategies incorporated into each alternative in the Cascade Columbia Province.

Description of Alternatives by Strategy Block

Comment | Define Criteria | Edit Criteria

Province	Alternative	Index	Hab-24.0 Urban storm runoff control	Hab-25.0 Groundwater management to maintain flow	Hab-26.0 Connect lower tributaries and mainstem habitat	Hab-27.0 Link terrestrial and aquatic preserves and refugia	Hab-28.0 Protect high quality aquatic habitat on tribal and public lands while	Hab-29.0 Protect high quality aquatic habitat on private lands while allowing	Hab-30.0 Passive habitat restoration.	Hab-31.0 Active habitat restoration	Hab-32.0 Halt new water withdrawal permits	Hab-33.0 Reduce existing permits for water withdrawal	Hab-34.0 Encourage cultivation of less water-intensive crops	Hab-35.0 Remove dikes and manage dredging and other measures to	Hab-36.0 Manage dredging toavoid increasing predation.	Hab-37.0 Develop habitats to link terrestrial preserves and refugia	Hab-38.0 Protect high quality terrestrial habitats while allowing restricted	Hab-39.0 Limit size and frequency of clearcuts	Hab-40.0 Normative fire frequency	Hab-41.0 Develop normative forest age structure and species composition	Hab-42.0 Provide gradual forest ecotones	Hab-43.0 Reduce forest road density	Hab-44.0 Build storage reservoir to provide downstream flow	Hab-45.0 Improve mining discharges	Hab-46.0 Improve mining practices	Hab-47.0 Rehabilitate marginal and closed mines
Cascade Columbia	1	1-6		X	X	X	X	X	X		X	X				X	X	X	X	X	X	X		X	X	X
	2	2-6		X	X	X	X	X	X		X					X	X	X	X	X	X	X		X	X	X
	3	3-6		X	X	X	X	X	X		X					X	X	X	X	X	X	X		X	X	X
	4	4-6						X	X	X							X									
	5	5-6		X		X	X	X	X	X	X	X				X	X	X	X	X	X	X		X	X	X
	6	6-6		X		X	X	X	X	X	X					X	X	X	X	X	X	X		X	X	X
	7	7-6		X			X	X	X							X	X									

Harvest and Hatchery stategies incorporated into each alternative in the Cascade Columbia Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Har-1.0 Harvest elimination	Har-2.0 Harvest reduction	Har-3.0 MSY harvest management	Har-4.0 Selective fisheries	Har-5.0 Focus sport or C&S fisheries	Har-6.0 Weakest population harvest rate	Har-7.0 Weakest metapopulation harvest rate	Har-9.0 Use "new" harvest techniques	Har-10.0 Develop aquaculture	Har-11.0 Weakest aggregate harvest rate	Hat-2.0 Use natural population as a template for hatchery.	Hat-3.0 Provide emergency preservation of genetic resources	Hat-4.0 Phase out hatchery production	Hat-5.0 Expand hatchery production	Hat-6.0 Reduce hatchery production	Hat-7.0 Use wild fish emulation techniques in hatchery.	Hat-8.0 Reduce spread of hatchery pathogens to wild	Hat-9.0 Supplement natural production	Hat-10.0 Reintroduce progeny of captive brood fish back into habitat	Hat-11.0 Provide mitigation hatcheries	Hat-12.0 Deveop augmentation hatchery.
Cascade Columbia	1	1-6					X	X					X	X	X			X			X		
	2	2-6					X		X				X	X	X			X		X	X	X	
	3	3-6					X		X				X	X	X			X		X	X	X	
	4	4-6					X		X				X					X		X			
	5	5-6					X		X				X		X			X	X	X		X	
	6	6-6					X					X	X					X	X	X		X	
	7	7-6					X					X								X			

Hydro stategies incorporated into each alternative in the Cascade Columbia Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hyd-2.0 Convert storage reservoir to run-of-river reservoir	Hyd-3.0 Breach a dam	Hyd-4.0 Provide alternative fish passage structures and operations to	Hyd-5.0 Discourage proliferation of shad via adult passage facilities.	Hyd-6.0 Operate juvenile fish passage facilities year round.	Hyd-7.0 Dam drawdwon	Hyd-8.0 Manage spill to minimize dissolved gas	Hyd-9.0 Minimize daily flow fluctuations	Hyd-10.0 Normative seasonal flow and flooding	Hyd-11.0 Provide gravel and organic debris in unimpounded mainstem areas	Hyd-12.0 Design and implement bypass structures to reflect biological	Hyd-13.0 Operate adult passage facilities year-round	Hyd-14.0 Provide flow to re-establish normative estuarine and plume and	Hyd-15.0 Remove economically marginal dams on tributaries that block	Hyd-16.0 Restore passage for anadromous fish above blockages	Hyd-17.0 Operate adult passage facilities on an extended schedule	Hyd-18.0 Operate juvenile passage facilities on an extended schedule	Hyd-19.0 Maximize transport downstream juvenile salmonid migrants	Hyd-20.0 Use "Share the risk" transportation policy for juvenile salmonids.	Hyd-21.0 Use transportation as an emergency measure	Hyd-22.0 Eliminate transportation	Hyd-23.0 Use barges only for transportation.
Cascade Columbia	1	1-6			X	X	X		X		X		X	X		X								
	2	2-6			X	X			X		X		X			X		X	X					
	3	3-6			X	X			X		X		X			X		X	X					
	4	4-6							X				X											
	5	5-6			X	X			X				X			X		X	X					
	6	6-6				X			X															
	7	7-6							X				X											

Hydro stategies incorporated into each alternative in the Cascade Columbia Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hyd-24.0 Install extended length screens at collector projects	Hyd-25.0 Eliminate use of extended length screens at all projects	Hyd-26.0 Provide flow to provide normative downsteam temperatures.	Hyd-27.0 Locate bypass outfalls to reduce predation	Hyd-28.0 Remove bank armoring	Hyd-29.0 Connect backwaters and sloughs	Hyd-30.0 Manage flow to promote mainstem spawning below dams.	Hyd-31.0 BiOp Flows	Hyd-32.0 IRCs	Hyd-33.0 Shift spring flow to summer	Hyd-34.0 Install surface bypass	Hyd-35.0 Install "Fish friendly" turbines	Hyd-36.0 Pre-WB flow	Hyd-37.0 BRCs
Cascade Columbia	1	1-6				X								X		X
	2	2-6				X					X			X		
	3	3-6				X	X	X	X		X			X		
	4	4-6				X				X				X		
	5	5-6				X	X	X	X	X	X			X		
	6	6-6				X						X	X			
	7	7-6				X									X	

Habitat stategies incorporated into each alternative in the Columbia Gorge Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hab-2.0 Competitor control	Hab-3.0 Sediment reduction	Hab-4.0 Floodplain corridor reconnection	Hab-5.0 Regulate tributary storage releases to provide normative flows.	Hab-6.0 Reduce forestry impacts to riparian/ aquatic ecosystem	Hab-7.0 Agricultural water conservation	Hab-8.0 Irrigation waste water treatment	Hab-9.0 Irrigation withdrawals screening	Hab-10.0 Municipal waste management	Hab-11.0 Nutrient and pathogen load reduction from grazing/agriculture	Hab-12.0 Obstruction passage improvement	Hab-13.0 Obstruction removal	Hab-14.0 Pesticide/herbicide reduction	Hab-15.0 Reintroduction of species	Hab-16.1 Control predatory fish	Hab-16.2 Control predatory birds	Hab-16.3 Control mammalian predators	Hab-17.0 Reduce grazing impacts to riparian/ aquatic ecosystem	Hab-18.0 Establish aquatic reserves, preserves, refugia	Hab-18.1 Establish terrestrial reserves, preserves, refugia	Hab-19.0 Manage land use and riparian conditions to maintain water quality	Hab-20.0 Road management	Hab-21.0 Habitat fertilization	Hab-22.0 Tributary gravel supply enhancment	Hab-23.0 Tributary wood supply enhancement
Columbia Gorge	1	1-5			X	X	X	X	X	X	X	X	X	X	X	X				X	X	X	X	X			
	2	2-5			X	X	X	X	X	X	X	X	X	X	X	X				X	X	X	X	X			
	3	3-5			X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X			
	4	4-5				X	X			X	X	X	X	X	X	X	X	X		X			X	X	X		X
	5	5-5			X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X		
	6	6-5			X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X		X
	7	7-5					X	X	X	X	X	X	X	X			X	X		X			X	X			X

Habitat stategies incorporated into each alternative in the Columbia Gorge Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hab-24.0 Urban storm runoff control	Hab-25.0 Groundwater management to maintain flow	Hab-26.0 Connect lower tributaries and mainstem habitat	Hab-27.0 Link terrestrial and aquatic preserves and refugia	Hab-28.0 Protect high quality aquatic habitat on tribal and public lands while	Hab-29.0 Protect high quality aquatic habitat on private lands while allowing	Hab-30.0 Passive habitat restoration.	Hab-31.0 Active habitat restoration	Hab-32.0 Halt new water withdrawal permits	Hab-33.0 Reduce existing permits for water withdrawal	Hab-34.0 Encourage cultivation of less water-intensive crops	Hab-35.0 Remove dikes and manage dredging and other measures to	Hab-36.0 Manage dredging toavoid increasing predation.	Hab-37.0 Develop habitats to link terrestrial preserves and refugia	Hab-38.0 Protect high quality terrestrial habitats while allowing restricted	Hab-39.0 Limit size and frequency of clearcuts	Hab-40.0 Normative fire frequency	Hab-41.0 Develop normative forest age structure and species composition	Hab-42.0 Provide gradual forest ecotones	Hab-43.0 Reduce forest road density	Hab-44.0 Build storage reservoir to provide downstream flow	Hab-45.0 Improve mining discharges	Hab-46.0 Improve mining practices	Hab-47.0 Rehabilitate marginal and closed mines
Columbia Gorge	1	1-5		X		X	X	X	X		X	X				X	X	X	X	X	X	X				
	2	2-5		X		X	X	X	X		X					X	X	X	X	X	X	X				
	3	3-5		X		X	X	X	X		X					X	X	X	X	X	X	X				
	4	4-5						X	X	X							X									
	5	5-5		X		X	X	X	X	X	X	X				X	X	X	X	X	X	X				
	6	6-5		X		X	X	X	X	X	X					X	X	X	X	X	X	X				
	7	7-5		X			X	X	X								X									

Harvest and Hatchery stategies incorporated into each alternative in the Columbia Gorge Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Har-1.0 Harvest elimination	Har-2.0 Harvest reduction	Har-3.0 MSY harvest management	Har-4.0 Selective fisheries	Har-5.0 Focus sport or C&S fisheries	Har-6.0 Weakest population harvest rate	Har-7.0 Weakest metapopulation harvest rate	Har-9.0 Use "new" harvest techniques	Har-10.0 Develop aquaculture	Har-11.0 Weakest aggregate harvest rate	Hat-2.0 Use natural population as a template for hatchery.	Hat-3.0 Provide emergency preservation of genetic resources	Hat-4.0 Phase out hatchery production	Hat-5.0 Expand hatchery production	Hat-6.0 Reduce hatchery production	Hat-7.0 Use wild fish emulation techniques in hatchery.	Hat-8.0 Reduce spread of hatchery pathogens to wild	Hat-9.0 Supplement natural production	Hat-10.0 Reintroduce progeny of captive brood fish back into habitat	Hat-11.0 Develop mitigation hatchery	Hat-12.0 Deveop augmentation hatchery.
Columbia Gorge	1	1-5					X	X					X		X			X					
	2	2-5					X		X				X		X			X	X			X	
	3	3-5					X		X				X		X	X		X	X			X	
	4	4-5					X					X	X					X		X			
	5	5-5				X	X		X				X		X	X		X	X	X		X	X
	6	6-5				X	X					X	X			X		X	X	X		X	X
	7	7-5				X	X					X				X				X			

Hydro stategies incorporated into each alternative in the Columbia Gorge Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hyd-1.0 Channel maintenance flows below dam	Hyd-2.0 Convert storage reservoir to run-of-river reservoir	Hyd-3.0 Breach a dam	Hyd-4.0 Provide alternative fish passage structures and operations to	Hyd-5.0 Discourage proliferation of shad via adult passage facilities.	Hyd-6.0 Operate juvenile fish passage facilities year round.	Hyd-7.0 Dam drawdwon	Hyd-8.0 Manage spill to minimize dissolved gas	Hyd-9.0 Minimize daily flow fluctuations	Hyd-10.0 Normative seasonal flow and flooding	Hyd-11.0 Provide gravel and organic debris in unimpounded mainstem areas	Hyd-12.0 Design and implement bypass structures to reflect biological	Hyd-13.0 Operate adult passage facilities year-round	Hyd-14.0 Provide flow to re-establish normative estuarine and plume and	Hyd-15.0 Remove economically marginal dams on tributaries that block	Hyd-16.0 Restore passage for anadromous fish above blockages	Hyd-17.0 Operate adult passage facilities on an extended schedule	Hyd-18.0 Operate juvenile passage facilities on an extended schedule	Hyd-19.0 Maximize transport downstream juvenile salmonid migrants	Hyd-20.0 Use "Share the risk" transportation policy for juvenile salmonids.	Hyd-21.0 Use transportation as an emergency measure	Hyd-22.0 Eliminate transportation	Hyd-23.0 Use barges only for transportation.
Columbia Gorge	1	1-5				X	X	X		X		X		X	X		X								
	2	2-5				X	X			X		X		X			X		X	X					
	3	3-5				X	X			X				X			X		X	X					
	4	4-5								X				X											
	5	5-5				X	X			X				X			X		X	X					
	6	6-5					X			X															
	7	7-5								X				X											

Hydro stategies incorporated into each alternative in the Columbia Gorge Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hyd-24.0 Install extended length screens at collector projects	Hyd-25.0 Eliminate use of extended length screens at all projects	Hyd-26.0 Provide flow to provide normative downsteam temperatures.	Hyd-27.0 Locate bypass outfalls to reduce predation	Hyd-28.0 Remove bank armoring	Hyd-29.0 Connect backwaters and sloughs	Hyd-30.0 Manage flow to promote mainstem spawning below dams.	Hyd-31.0 BiOp Flows	Hyd-32.0 IRCs	Hyd-33.0 Shift spring flow to summer	Hyd-34.0 Install surface bypass	Hyd-35.0 Install "Fish friendly" turbines	Hyd-36.0 Pre-WB flow	Hyd-37.0 BRCs
Columbia Gorge	1	1-5		X	X				X					X		X
	2	2-5		X	X	X			X		X			X		
	3	3-5		X	X	X	X	X	X	X	X			X		
	4	4-5				X				X				X		
	5	5-5				X	X	X	X	X	X		X	X		
	6	6-5	X			X						X	X			
	7	7-5				X										

Habitat stategies incorporated into each alternative in the Columbia River Plateau Province.

Description of Alternatives
by Strategy Block

Comment

Define Criteria

Edit Criteria

Strategy Block:

Province	Alternative	Index	Hab-2.0 Competitor control	Hab-3.0 Sediment reduction	Hab-4.0 Floodplain corridor reconnection	Hab-5.0 Regulate tributary storage releases to provide normative flows.	Hab-6.0 Reduce forestry impacts to riparian/ aquatic ecosystem	Hab-7.0 Agricultural water conservation	Hab-8.0 Irrigation waste water treatment	Hab-9.0 Irrigation withdrawals screening	Hab-10.0 Municipal waste management	Hab-11.0 Nutrient and pathogen load reduction from grazing/agriculture	Hab-12.0 Obstruction passage improvement	Hab-13.0 Obstruction removal	Hab-14.0 Pesticide/herbicide reduction	Hab-15.0 Reintroduction of species	Hab-16.1 Control predatory fish	Hab-16.2 Control predatory birds	Hab-16.3 Control mammalian predators	Hab-17.0 Reduce grazing impacts to riparian/ aquatic ecosystem	Hab-18.0 Establish aquatic reserves, preserves, refugia	Hab-18.1 Establish terrestrial reserves, preserves, refugia	Hab-19.0 Manage land use and riparian conditions to maintain water quality	Hab-20.0 Road management	Hab-21.0 Habitat fertilization	Hab-22.0 Tributary gravel supply enhancment	Hab-23.0 Tributary wood supply enhancement
Columbia River Plateau	1	1-2			X	X	X	X	X	X	X	X	X	X	X	X				X	X	X	X	X			
	2	2-2			X	X	X	X	X	X	X	X	X	X	X	X				X	X	X	X	X			
	3	3-2			X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X			
	4	4-2				X	X			X	X	X	X	X	X	X	X	X		X			X	X	X		X
	5	5-2			X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X		
	6	6-2			X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X		X
	7	7-2						X	X	X	X	X	X	X			X	X		X			X	X			

Habitat stategies incorporated into each alternative in the Columbia River Plateau Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hab-24.0 Urban storm runoff control	Hab-25.0 Groundwater management to maintain flow	Hab-26.0 Connect lower tributaries and mainstem habitat	Hab-27.0 Link terrestrial and aquatic preserves and refugia	Hab-28.0 Protect high quality aquatic habitat on tribal and public lands while	Hab-29.0 Protect high quality aquatic habitat on private lands while allowing	Hab-30.0 Passive habitat restoration.	Hab-31.0 Active habitat restoration	Hab-32.0 Halt new water withdrawal permits	Hab-33.0 Reduce existing permits for water withdrawal	Hab-34.0 Encourage cultivation of less water-intensive crops	Hab-35.0 Remove dikes and manage dredging and other measures to	Hab-36.0 Manage dredging toavoid increasing predation.	Hab-37.0 Develop habitats to link terrestrial preserves and refugia	Hab-38.0 Protect high quality terrestrial habitats while allowing restricted	Hab-39.0 Limit size and frequency of clearcuts	Hab-40.0 Normative fire frequency	Hab-41.0 Develop normative forest age structure and species composition	Hab-42.0 Provide gradual forest ecotones	Hab-43.0 Reduce forest road density	Hab-44.0 Build storage reservoir to provide downstream flow	Hab-45.0 Improve mining discharges	Hab-46.0 Improve mining practices	Hab-47.0 Rehabilitate marginal and closed mines
Columbia River Plateau	1	1-2	X	X	X	X	X	X	X		X	X	X			X	X	X	X	X	X	X				
	2	2-2	X	X	X	X	X	X	X		X		X			X	X	X	X	X	X	X				
	3	3-2	X	X	X	X	X	X	X		X		X			X	X	X	X	X	X	X				
	4	4-2						X	X	X							X									
	5	5-2	X	X		X	X	X	X	X	X	X	X			X	X	X	X	X	X	X				
	6	6-2	X	X		X	X	X	X	X	X					X	X	X	X	X	X	X				
	7	7-2	X	X			X	X	X							X	X									

Harvest and Hatchery stategies incorporated into each alternative in the Columbia River Plateau Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Har-1.0 Harvest elimination	Har-2.0 Harvest reduction	Har-3.0 MSY harvest management	Har-4.0 Selective fisheries	Har-5.0 Focus sport or C&S fisheries	Har-6.0 Weakest population harvest rate	Har-7.0 Weakest metapopulation harvest rate	Har-9.0 Use "new" harvest techniques	Har-10.0 Develop aquaculture	Har-11.0 Weakest aggregate harvest rate	Hat-2.0 Use natural population as a template for hatchery.	Hat-3.0 Provide emergency preservation of genetic resources	Hat-4.0 Phase out hatchery production	Hat-5.0 Expand hatchery production	Hat-6.0 Reduce hatchery production	Hat-7.0 Use wild fish emulation techniques in hatchery.	Hat-8.0 Reduce spread of hatchery pathogens to wild	Hat-9.0 Supplement natural production	Hat-10.0 Reintroduce progeny of captive brood fish back into habitat	Hat-11.0 Provide mitigation hatcheries	Hat-12.0 Deveop augmentation hatchery.
Columbia River Plateau	1	1-2					X	X		X			X	X	X			X			X		
	2	2-2					X		X	X			X	X	X			X		X	X	X	
	3	3-2					X		X				X	X	X			X		X	X	X	
	4	4-2					X					X	X	X				X		X	X		
	5	5-2				X	X		X				X	X	X			X	X	X		X	X
	6	6-2				X	X					X						X	X	X		X	X
	7	7-2				X	X					X								X			

Hydro stategies incorporated into each alternative in the Columbia River Plateau Province.

Description of Alternatives by Strategy Block

Comment | Define Criteria | Edit Criteria

Province	Alternative	Index	Hyd-2.0 Convert storage reservoir to run-of-river reservoir	Hyd-3.0 Breach a dam	Hyd-4.0 Provide alternative fish passage structures and operations to	Hyd-5.0 Discourage proliferation of shad via adult passage facilities.	Hyd-6.0 Operate juvenile fish passage facilities year round.	Hyd-7.0 Dam drawdwon	Hyd-8.0 Manage spill to minimize dissolved gas	Hyd-9.0 Minimize daily flow fluctuations	Hyd-10.0 Normative seasonal flow and flooding	Hyd-11.0 Provide gravel and organic debris in unimpounded mainstem areas	Hyd-12.0 Design and implement bypass structures to reflect biological	Hyd-13.0 Operate adult passage facilities year-round	Hyd-14.0 Provide flow to re-establish normative estuarine and plume and	Hyd-15.0 Remove economically marginal dams on tributaries that block	Hyd-16.0 Restore passage for anadromous fish above blockages	Hyd-17.0 Operate adult passage facilities on an extended schedule	Hyd-18.0 Operate juvenile passage facilities on an extended schedule	Hyd-19.0 Maximize transport downstream juvenile salmonid migrants	Hyd-20.0 Use "Share the risk" transportation policy for juvenile salmonids.	Hyd-21.0 Use transportation as an emergency measure	Hyd-22.0 Eliminate transportation	Hyd-23.0 Use barges only for transportation.
Columbia River Plateau	1	1-2		X	X	X	X		X	X	X	X	X	X		X	X						X	
	2	2-2		X	X	X		X	X	X	X	X	X			X	X	X	X				X	
	3	3-2		X	X	X		X	X	X	X	X	X			X	X	X	X				X	
	4	4-2							X	X			X				X				X			
	5	5-2			X	X		X	X	X			X				X	X	X			X		X
	6	6-2				X			X								X			X				
	7	7-2							X				X							X				

Hydro stategies incorporated into each alternative in the Columbia River Plateau Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hyd-24.0 Install extended length screens at collector projects	Hyd-25.0 Eliminate use of extended length screens at all projects	Hyd-26.0 Provide flow to provide normative downsteam temperatures.	Hyd-27.0 Locate bypass outfalls to reduce predation	Hyd-28.0 Remove bank armoring	Hyd-29.0 Connect backwaters and sloughs	Hyd-30.0 Manage flow to promote mainstem spawning below dams.	Hyd-31.0 BiOp Flows	Hyd-32.0 IRCs	Hyd-33.0 Shift spring flow to summer	Hyd-34.0 Install surface bypass	Hyd-35.0 Install "Fish friendly" turbines	Hyd-36.0 Pre-WB flow	Hyd-37.0 BRCs
Columbia River Plateau	1	1-2		X	X									X		X
	2	2-2		X	X	X					X			X		
	3	3-2			X	X	X	X	X	X	X			X		
	4	4-2				X				X				X		
	5	5-2				X	X	X	X	X	X		X	X		
	6	6-2	X			X						X	X			
	7	7-2				X									X	

Habitat stategies incorporated into each alternative in the Intermountain Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hab-2.0 Competitor control	Hab-3.0 Sediment reduction	Hab-4.0 Floodplain corridor reconnection	Hab-5.0 Regulate tributary storage releases to provide normative flows.	Hab-6.0 Reduce forestry impacts to riparian/ aquatic ecosystem	Hab-7.0 Agricultural water conservation	Hab-8.0 Irrigation waste water treatment	Hab-9.0 Irrigation withdrawals screening	Hab-10.0 Municipal waste management	Hab-11.0 Nutrient and pathogen load reduction from grazing/agriculture	Hab-12.0 Obstruction passage improvement	Hab-13.0 Obstruction removal	Hab-14.0 Pesticide/herbicide reduction	Hab-15.0 Reintroduction of species	Hab-16.1 Control predatory fish	Hab-16.2 Control predatory birds	Hab-16.3 Control mammalian predators	Hab-17.0 Reduce grazing impacts to riparian/ aquatic ecosystem	Hab-18.0 Establish aquatic reserves, preserves, refugia	Hab-18.1 Establish terrestrial reserves, preserves, refugia	Hab-19.0 Manage land use and riparian conditions to maintain water quality	Hab-20.0 Road management	Hab-21.0 Habitat fertilization	Hab-22.0 Tributary gravel supply enhancment	Hab-23.0 Tributary wood supply enhancement
Intermountain	1	1-7	X		X		X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X			
	2	2-7	X		X		X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X			
	3	3-7	X		X		X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X			
	4	4-7			X		X			X	X	X	X	X	X	X				X			X	X			X
	5	5-7	X		X		X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X			
	6	6-7			X		X	X	X	X	X	X	X	X	X	X				X	X	X	X	X			X
	7	7-7						X	X	X	X	X	X	X						X	X	X	X	X			

Habitat stategies incorporated into each alternative in the Intermountain Province.

Description of Alternatives by Strategy Block

Comment | Define Criteria | Edit Criteria

Province	Alternative	Index	Hab-24.0 Urban storm runoff control	Hab-25.0 Groundwater management to maintain flow	Hab-26.0 Connect lower tributaries and mainstem habitat	Hab-27.0 Link terrestrial and aquatic preserves and refugia	Hab-28.0 Protect high quality aquatic habitat on tribal and public lands while	Hab-29.0 Protect high quality aquatic habitat on private lands while allowing	Hab-30.0 Passive habitat restoration.	Hab-31.0 Active habitat restoration	Hab-32.0 Halt new water withdrawal permits	Hab-33.0 Reduce existing permits for water withdrawal	Hab-34.0 Encourage cultivation of less water-intensive crops	Hab-35.0 Remove dikes and manage dredging and other measures to	Hab-36.0 Manage dredging toavoid increasing predation.	Hab-37.0 Develop habitats to link terrestrial preserves and refugia	Hab-38.0 Protect high quality terrestrial habitats while allowing restricted	Hab-39.0 Limit size and frequency of clearcuts	Hab-40.0 Normative fire frequency	Hab-41.0 Develop normative forest age structure and species composition	Hab-42.0 Provide gradual forest ecotones	Hab-43.0 Reduce forest road density	Hab-44.0 Build storage reservoir to provide downstream flow	Hab-45.0 Improve mining discharges	Hab-46.0 Improve mining practices	Hab-47.0 Rehabilitate marginal and closed mines
Intermountain	1	1-7	X	X		X	X	X	X		X	X				X	X	X	X	X	X	X		X	X	X
	2	2-7	X	X		X	X	X	X		X					X	X	X	X	X	X	X		X	X	X
	3	3-7	X	X		X	X	X	X		X					X	X	X	X	X	X	X		X	X	X
	4	4-7						X	X	X							X									
	5	5-7	X	X		X	X	X	X	X	X	X				X	X	X	X	X	X	X		X	X	X
	6	6-7	X	X		X	X	X	X	X	X					X	X	X	X	X	X	X		X	X	X
	7	7-7	X	X			X	X	X							X	X									

Harvest and Hatchery stategies incorporated into each alternative in the Intermountain Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Har-1.0 Harvest elimination	Har-2.0 Harvest reduction	Har-3.0 MSY harvest management	Har-4.0 Selective fisheries	Har-5.0 Focus sport or C&S fisheries	Har-6.0 Weakest population harvest rate	Har-7.0 Weakest metapopulation harvest rate	Har-9.0 Use "new" harvest techniques	Har-10.0 Develop aquaculture	Har-11.0 Weakest aggregate harvest rate	Hat-2.0 Use natural population as a template for hatchery.	Hat-3.0 Provide emergency preservation of genetic resources	Hat-4.0 Phase out hatchery production	Hat-5.0 Expand hatchery production	Hat-6.0 Reduce hatchery production	Hat-7.0 Use wild fish emulation techniques in hatchery.	Hat-8.0 Reduce spread of hatchery pathogens to wild	Hat-9.0 Supplement natural production	Hat-10.0 Reintroduce progeny of captive brood fish back into habitat	Hat-11.0 Provide mitigation hatcheries	Hat-12.0 Deveop augmentation hatchery.
Intermountain	1	1-7					X	X					X		X	X		X					
	2	2-7											X		X			X		X		X	
	3	3-7											X		X			X		X		X	
	4	4-7											X					X		X		X	
	5	5-7											X		X	X		X	X	X		X	
	6	6-7											X			X		X	X	X		X	
	7	7-7																				X	

Hydro stategies incorporated into each alternative in the Intermountain Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hyd-2.0 Convert storage reservoir to run-of-river reservoir	Hyd-3.0 Breach a dam	Hyd-4.0 Provide alternative fish passage structures and operations to	Hyd-5.0 Discourage proliferation of shad via adult passage facilities.	Hyd-6.0 Operate juvenile fish passage facilities year round.	Hyd-7.0 Dam drawdwon	Hyd-8.0 Manage spill to minimize dissolved gas	Hyd-9.0 Minimize daily flow fluctuations	Hyd-10.0 Normative seasonal flow and flooding	Hyd-11.0 Provide gravel and organic debris in unimpounded mainstem areas	Hyd-12.0 Design and implement bypass structures to reflect biological	Hyd-13.0 Operate adult passage facilities year-round	Hyd-14.0 Provide flow to re-establish normative estuarine and plume and	Hyd-15.0 Remove economically marginal dams on tributaries that block	Hyd-16.0 Restore passage for anadromous fish above blockages	Hyd-17.0 Operate adult passage facilities on an extended schedule	Hyd-18.0 Operate juvenile passage facilities on an extended schedule	Hyd-19.0 Maximize transport downstream juvenile salmonid migrants	Hyd-20.0 Use "Share the risk" transportation policy for juvenile salmonids.	Hyd-21.0 Use transportation as an emergency measure	Hyd-22.0 Eliminate transportation	Hyd-23.0 Use barges only for transportation.
Intermountain	1	1-7			X		X		X				X	X			X							
	2	2-7																						
	3	3-7																						
	4	4-7																						
	5	5-7																						
	6	6-7																						
	7	7-7																						

Hydro stategies incorporated into each alternative in the Intermountain Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hyd-24.0 Install extended length screens at collector projects	Hyd-25.0 Eliminate use of extended length screens at all projects	Hyd-26.0 Provide flow to provide normative downsteam temperatures.	Hyd-27.0 Locate bypass outfalls to reduce predation	Hyd-28.0 Remove bank armoring	Hyd-29.0 Connect backwaters and sloughs	Hyd-30.0 Manage flow to promote mainstem spawning below dams.	Hyd-31.0 BiOp Flows	Hyd-32.0 IRCs	Hyd-33.0 Shift spring flow to summer	Hyd-34.0 Install surface bypass	Hyd-35.0 Install "Fish friendly" turbines	Hyd-36.0 Pre-WB flow	Hyd-37.0 BRCs
Intermountain	1	1-7			X	X	X	X						X		X
	2	2-7			X		X	X			X					
	3	3-7			X		X	X		X	X					
	4	4-7								X						
	5	5-7			X		X	X		X	X					
	6	6-7										X				
	7	7-7													X	

Habitat stategies incorporated into each alternative in the Lower Columbia Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hab-2.0 Competitor control	Hab-3.0 Sediment reduction	Hab-4.0 Floodplain corridor reconnection	Hab-5.0 Regulate tributary storage releases to provide normative flows.	Hab-6.0 Reduce forestry impacts to ripanian/ aquatic ecosystem	Hab-7.0 Agricultural water conservation	Hab-8.0 Irrigation waste water treatment	Hab-9.0 Irrigation withdrawals screening	Hab-10.0 Municipal waste management	Hab-11.0 Nutrient and pathogen load reduction rom grazing/agriculture	Hab-12.0 Obstruction passage improvement	Hab-13.0 Obstruction removal	Hab-14.0 Pesticide/herbicide reduction	Hab-15.0 Reintroduction of species	Hab-16.0 Predator control	Hab-16.1 Control predatory fish	Hab-16.2 Control predatory birds	Hab-16.3 Control mammalian predators	Hab-17.0 Reduce grazing impacts to ripanian/ aquatic ecosystem	Hab-18.0 Establish aquatic reserves, preserves, refugia	Hab-18.1 Establish terrestrial reserves, preserves, refugia	Hab-19.0 Manage land use and riparian conditions to maintain water quality	Hab-20.0 Road management	Hab-21.0 Habitat fertilization	Hab-22.0 Tributary gravel supply enhancment	Hab-23.0 Tributary wood supply enhancement
Lower Columbia	1	1-1			X	X	X				X	X	X	X	X				X			X	X	X	X			
	2	2-1			X	X	X				X	X	X	X	X				X			X	X	X	X			
	3	3-1			X	X	X				X	X	X	X	X				X			X	X	X	X			
	4	4-1				X	X				X	X	X	X	X				X					X	X	X		
	5	5-1			X	X	X				X	X	X	X	X				X			X	X	X	X	X		
	6	6-1			X	X	X				X	X	X	X	X				X	X		X	X	X	X	X		
	7	7-1									X	X	X	X					X	X				X	X			

Habitat stategies incorporated into each alternative in the Lower Columbia Province.

Description of Alternatives by Strategy Block

c

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hab-24.0 Urban storm runoff control	Hab-25.0 Groundwater management to maintain flow	Hab-26.0 Connect lower tributaries and mainstem habitat	Hab-27.0 Link terrestrial and aquatic preserves and refugia	Hab-28.0 Protect high quality aquatic habitat on ribal and public lands while allowing	Hab-29.0 Protect high quality aquatic habitat on private lands while allowing restricted	Hab-30.0 Passive habitat restoration.	Hab-31.0 Active habitat restoration	Hab-32.0 Halt new water withdrawal permits	Hab-33.0 Reduce existing permits for water withdrawal	Hab-34.0 Encourage cultivation of less water-ntensive crops	Hab-35.0 Remove dikes and manage dredging and other measures to restore	Hab-36.0 Manage dredging toavoid increasing predation.	Hab-37.0 Develop habitats to link terrestrial preserves and refugia	Hab-38.0 Protect high quality terrestrial habitats while allowing restricted use.	Hab-39.0 Limit size and frequency of clearcuts	Hab-40.0 Normative fire frequency	Hab-41.0 Develop normative forest age structure and species composition	Hab-42.0 Provide gradual forest ecotones	Hab-43.0 Reduce forest road density	Hyd-36.0 Pre-WB flow	Hab-44.0 Build storage reservoir to provide downstream flow	Hab-45.0 Improve mining discharges	Hab-46.0 Improve mining practices	Hab-47.0 Rehabilitate marginal and closed mines
Lower Columbia	1	1-1	X			X	X	X	X					X	X	X	X	X	X	X	X	X					
	2	2-1	X			X	X	X	X					X	X	X	X	X	X	X	X	X					
	3	3-1	X			X	X	X	X					X	X	X	X	X	X	X	X	X					
	4	4-1	X					X	X	X							X										
	5	5-1	X			X	X	X	X	X				X	X	X	X	X	X	X	X	X					
	6	6-1	X			X	X	X	X	X				X	X	X	X	X	X	X	X	X					
	7	7-1	X				X	X	X								X										

Harvest and Hatchery stategies incorporated into each alternative in the Lower Columbia Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Har-1.0 Harvest elimination	Har-2.0 Harvest reduction	Har-3.0 MSY harvest management	Har-4.0 Selective fisheries	Har-5.0 Focus sport or C&S fisheries	Har-6.0 Population unit escapement goals	Har-7.0 Population aggregate escapement goals	Har-9.0 Use "new" harvest techniques	Har-10.0 Develop aquaculture	Har-11.0 Weakest aggregate harvest rate	Hat-2.0 Use natural population as a template or hatchery.	Hat-3.0 Provide emergency preservation of genetic resources	Hat-4.0 Phase out hatchery production	Hat-5.0 Expand hatchery production	Hat-6.0 Reduce hatchery production	Hat-7.0 Use wild fish emulation techniques in hatchery.	Hat-8.0 Reduce spread of hatchery pathogens to wild	Hat-9.0 Supplement natural production	Hat-10.0 Reintroduce progeny of captive brood ish back into habitat	Hat-11.0 Develop mitigation hatchery	Hat-12.0 Deveop augmentation hatchery.
Lower Columbia	1	1-1				X	X	X					X		X			X	X				
	2	2-1				X	X		X				X		X			X	X			X	
	3	3-1				X	X		X				X		X			X	X			X	
	4	4-1					X					X	X					X		X			
	5	5-1				X	X		X				X		X			X	X	X		X	X
	6	6-1				X	X				X	X	X			X		X	X	X		X	X
	7	7-1				X	X				X	X				X				X			X

Hydro stategies incorporated into each alternative in the Lower Columbia Province.

Description of Alternatives by Strategy Block

Comment | Define Criteria | Edit Criteria

Province	Alternative	Index	Hyd-1.0 Channel maintenance flows below dam	Hyd-2.0 Convert storage reservoir to run-of-iver reservoir	Hyd-3.0 Breach a dam	Hyd-4.0 Provide alternative fish passage structures and operations to	Hyd-5.0 Discourage proliferation of shad via adult passage facilities.	Hyd-6.0 Operate juvenile fish passage acilities year round.	Hyd-7.0 Dam drawdwon	Hyd-8.0 Manage spill to minimize dissolved gas	Hyd-9.0 Minimize daily flow fluctuations	Hyd-10.0 Normative seasonal flow and looding	Hyd-11.0 Provide gravel and organic debris in unimpounded mainstem areas	Hyd-12.0 Design and implement bypass structures to reflect biological	Hyd-13.0 Operate adult passage facilities year-ound	Hyd-14.0 Provide flow to re-establish normative estuarine and plume and salinity	Hyd-15.0 Remove economically marginal dams on tributaries that block anadromous	Hyd-16.0 Restore passage for anadromous fish above blockages	Hyd-17.0 Operate adult passage facilities on an extended schedule	Hyd-18.0 Operate juvenile passage facilities on an extended schedule	Hyd-19.0 Maximize transport downstream uvenile salmonid migrants	Hyd-20.0 Use "Share the risk" transportation policy for juvenile salmonids.	Hyd-21.0 Use transportation as an emergency measure	Hyd-22.0 Eliminate transportation	Hyd-23.0 Use barges only for transportation.
Lower Columbia	1	1-1				X		X		X	X	X		X	X	X	X	X							
	2	2-1				X				X	X	X		X		X	X	X	X	X					
	3	3-1				X				X	X	X		X		X	X	X	X	X					
	4	4-1															X								
	5	5-1				X				X	X	X		X		X	X	X	X	X					
	6	6-1																							
	7	7-1																							

Hydro stategies incorporated into each alternative in the Lower Columbia Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hyd-24.0 Install extended length screens at collector projects	Hyd-25.0 Eliminate use of extended length screens at all projects	Hyd-26.0 Provide flow to provide normative downsteam temperatures.	Hyd-27.0 Locate bypass outfalls to reduce predation	Hyd-28.0 Remove bank armoring	Hyd-29.0 Connect backwaters and sloughs	Hyd-30.0 Manage flow to promote mainstem spawning below dams.	Hyd-31.0 BiOp Flows	Hyd-32.0 IRCs	Hyd-33.0 Shift spring flow to summer	Hyd-34.0 Install surface bypass	Hyd-35.0 Install "Fish friendly" turbines	Hyd-37.0 BRCs
Lower Columbia	1	1-1			X		X	X					X	X	X
	2	2-1			X		X	X			X		X	X	
	3	3-1			X		X	X			X		X	X	
	4	4-1													
	5	5-1			X		X	X			X		X	X	
	6	6-1													
	7	7-1													

Habitat stategies incorporated into each alternative in the Mountain Columbia Province.

Description of Alternatives by Strategy Block

Comment | Define Criteria | Edit Criteria

Province	Alternative	Index	Hab-2.0 Competitor control	Hab-3.0 Sediment reduction	Hab-4.0 Floodplain corridor reconnection	Hab-5.0 Regulate tributary storage releases to provide normative flows.	Hab-6.0 Reduce forestry impacts to riparian/ aquatic ecosystem	Hab-7.0 Agricultural water conservation	Hab-8.0 Irrigation waste water treatment	Hab-9.0 Irrigation withdrawals screening	Hab-10.0 Municipal waste management	Hab-11.0 Nutrient and pathogen load reduction from grazing/agriculture	Hab-12.0 Obstruction passage improvement	Hab-13.0 Obstruction removal	Hab-14.0 Pesticide/herbicide reduction	Hab-15.0 Reintroduction of species	Hab-16.1 Control predatory fish	Hab-16.2 Control predatory birds	Hab-16.3 Control mammalian predators	Hab-17.0 Reduce grazing impacts to riparian/ aquatic ecosystem	Hab-18.0 Establish aquatic reserves, preserves, refugia	Hab-18.1 Establish terrestrial reserves, preserves, refugia	Hab-19.0 Manage land use and riparian conditions to maintain water quality	Hab-20.0 Road management	Hab-21.0 Habitat fertilization	Hab-22.0 Tributary gravel supply enhancment	Hab-23.0 Tributary wood supply enhancement
Mountain Columbia	1	1-7	X		X		X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X			
	2	2-7	X		X		X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X			
	3	3-7	X		X		X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X			
	4	4-7			X		X			X	X	X	X	X	X	X				X			X	X			X
	5	5-7	X		X		X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X			
	6	6-7			X		X	X	X	X	X	X	X	X	X	X				X	X	X	X	X			X
	7	7-7						X	X	X	X	X	X	X						X	X	X	X	X			

Habitat stategies incorporated into each alternative in the Mountain Columbia Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hab-24.0 Urban storm runoff control	Hab-25.0 Groundwater management to maintain flow	Hab-26.0 Connect lower tributaries and mainstem habitat	Hab-27.0 Link terrestrial and aquatic preserves and refugia	Hab-28.0 Protect high quality aquatic habitat on tribal and public lands while	Hab-29.0 Protect high quality aquatic habitat on private lands while allowing	Hab-30.0 Passive habitat restoration.	Hab-31.0 Active habitat restoration	Hab-32.0 Halt new water withdrawal permits	Hab-33.0 Reduce existing permits for water withdrawal	Hab-34.0 Encourage cultivation of less water-intensive crops	Hab-35.0 Remove dikes and manage dredging and other measures to	Hab-36.0 Manage dredging toavoid increasing predation.	Hab-37.0 Develop habitats to link terrestrial preserves and refugia	Hab-38.0 Protect high quality terrestrial habitats while allowing restricted	Hab-39.0 Limit size and frequency of clearcuts	Hab-40.0 Normative fire frequency	Hab-41.0 Develop normative forest age structure and species composition	Hab-42.0 Provide gradual forest ecotones	Hab-43.0 Reduce forest road density	Hab-44.0 Build storage reservoir to provide downstream flow	Hab-45.0 Improve mining discharges	Hab-46.0 Improve mining practices	Hab-47.0 Rehabilitate marginal and closed mines
Mountain Columbia	1	1-7	X	X		X	X	X	X		X	X				X	X	X	X	X	X	X		X	X	X
	2	2-7	X	X		X	X	X	X		X					X	X	X	X	X	X	X		X	X	X
	3	3-7	X	X		X	X	X	X		X					X	X	X	X	X	X	X		X	X	X
	4	4-7						X	X	X							X									
	5	5-7	X	X		X	X	X	X	X	X	X				X	X	X	X	X	X	X		X	X	X
	6	6-7	X	X		X	X	X	X	X	X					X	X	X	X	X	X	X		X	X	X
	7	7-7	X	X			X	X	X							X	X									

Harvest and Hatchery stategies incorporated into each alternative in the Mountain Columbia Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Har-1.0 Harvest elimination	Har-2.0 Harvest reduction	Har-3.0 MSY harvest management	Har-4.0 Selective fisheries	Har-5.0 Focus sport or C&S fisheries	Har-6.0 Weakest population harvest rate	Har-7.0 Weakest metapopulation harvest rate	Har-9.0 Use "new" harvest techniques	Har-10.0 Develop aquaculture	Har-11.0 Weakest aggregate harvest rate	Hat-2.0 Use natural population as a template for hatchery.	Hat-3.0 Provide emergency preservation of genetic resources	Hat-4.0 Phase out hatchery production	Hat-5.0 Expand hatchery production	Hat-6.0 Reduce hatchery production	Hat-7.0 Use wild fish emulation techniques in hatchery.	Hat-8.0 Reduce spread of hatchery pathogens to wild	Hat-9.0 Supplement natural production	Hat-10.0 Reintroduce progeny of captive brood fish back into habitat	Hat-11.0 Provide mitigation hatcheries	Hat-12.0 Deveop augmentation hatchery.
Mountain Columbia	1	1-7													X								
	2	2-7											X		X			X		X		X	
	3	3-7											X		X			X		X		X	
	4	4-7																				X	
	5	5-7											X		X	X		X	X	X		X	
	6	6-7											X			X		X	X	X		X	
	7	7-7																				X	

Hydro stategies incorporated into each alternative in the Mountain Columbia Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hyd-2.0 Convert storage reservoir to run-of-river reservoir	Hyd-3.0 Breach a dam	Hyd-4.0 Provide alternative fish passage structures and operations to	Hyd-5.0 Discourage proliferation of shad via adult passage facilities.	Hyd-6.0 Operate juvenile fish passage facilities year round.	Hyd-7.0 Dam drawdwon	Hyd-8.0 Manage spill to minimize dissolved gas	Hyd-9.0 Minimize daily flow fluctuations	Hyd-10.0 Normative seasonal flow and flooding	Hyd-11.0 Provide gravel and organic debris in unimpounded mainstem areas	Hyd-12.0 Design and implement bypass structures to reflect biological	Hyd-13.0 Operate adult passage facilities year-round	Hyd-14.0 Provide flow to re-establish normative estuarine and plume and	Hyd-15.0 Remove economically marginal dams on tributaries that block	Hyd-16.0 Restore passage for anadromous fish above blockages	Hyd-17.0 Operate adult passage facilities on an extended schedule	Hyd-18.0 Operate juvenile passage facilities on an extended schedule	Hyd-19.0 Maximize transport downstream juvenile salmonid migrants	Hyd-20.0 Use "Share the risk" transportation policy for juvenile salmonids.	Hyd-21.0 Use transportation as an emergency measure	Hyd-22.0 Eliminate transportation	Hyd-23.0 Use barges only for transportation.
Mountain Columbia	1	1-7																						
	2	2-7																						
	3	3-7																						
	4	4-7																						
	5	5-7																						
	6	6-7																						
	7	7-7																						

Hydro stategies incorporated into each alternative in the Mountain Columbia Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hyd-24.0 Install extended length screens at collector projects	Hyd-25.0 Eliminate use of extended length screens at all projects	Hyd-26.0 Provide flow to provide normative downsteam temperatures.	Hyd-27.0 Locate bypass outfalls to reduce predation	Hyd-28.0 Remove bank armoring	Hyd-29.0 Connect backwaters and sloughs	Hyd-30.0 Manage flow to promote mainstem spawning below dams.	Hyd-31.0 BiOp Flows	Hyd-32.0 IRCs	Hyd-33.0 Shift spring flow to summer	Hyd-34.0 Install surface bypass	Hyd-35.0 Install "Fish friendly" turbines	Hyd-36.0 Pre-WB flow	Hyd-37.0 BRCs
Mountain Columbia	1	1-7			X		X	X								X
	2	2-7			X		X	X			X					
	3	3-7			X		X	X		X	X					
	4	4-7								X						
	5	5-7			X		X	X		X	X					
	6	6-7										X				
	7	7-7													X	

Habitat stategies incorporated into each alternative in the Mountain Snake Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hab-2.0 Competitor control	Hab-3.0 Sediment reduction	Hab-4.0 Floodplain corridor reconnection	Hab-5.0 Regulate tributary storage releases to provide normative flows.	Hab-6.0 Reduce forestry impacts to riparian/ aquatic ecosystem	Hab-7.0 Agricultural water conservation	Hab-8.0 Irrigation waste water treatment	Hab-9.0 Irrigation withdrawals screening	Hab-10.0 Municipal waste management	Hab-11.0 Nutrient and pathogen load reduction rom grazing/agriculture	Hab-12.0 Obstruction passage improvement	Hab-13.0 Obstruction removal	Hab-14.0 Pesticide/herbicide reduction	Hab-15.0 Reintroduction of species	Hab-16.0 Predator control	Hab-16.1 Control predatory fish	Hab-16.2 Control predatory birds	Hab-16.3 Control mammalian predators	Hab-17.0 Reduce grazing impacts to riparian/ aquatic ecosystem	Hab-18.0 Establish aquatic reserves, preserves, refugia	Hab-18.1 Establish terrestrial reserves, preserves, refugia	Hab-19.0 Manage land use and riparian conditions to maintain water quality	Hab-20.0 Road management	Hab-21.0 Habitat fertilization	Hab-22.0 Tributary gravel supply enhancment	Hab-23.0 Tributary wood supply enhancement
Mountain Snake	1	1-4			X	X	X	X	X	X	X	X	X	X	X	X					X	X	X	X	X			
	2	2-4			X	X	X	X	X	X	X	X	X	X	X	X					X	X	X	X	X			
	3	3-4			X	X	X	X	X	X	X	X	X	X	X	X					X	X	X	X	X			
	4	4-4					X			X	X	X	X	X	X						X			X	X	X		X
	5	5-4			X	X	X	X	X	X	X	X	X	X	X	X					X	X	X	X	X	X		
	6	6-4			X		X	X	X	X	X	X	X	X	X						X	X	X	X	X	X		X
	7	7-4					X	X	X	X	X	X	X	X							X			X	X			X

Habitat stategies incorporated into each alternative in the Mountain Snake Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hab-24.0 Urban storm runoff control	Hab-25.0 Groundwater management to maintain flow	Hab-26.0 Connect lower tributaries and mainstem habitat	Hab-27.0 Link terrestrial and aquatic preserves and refugia	Hab-28.0 Protect high quality aquatic habitat on ribal and public lands while allowing	Hab-29.0 Protect high quality aquatic habitat on private lands while allowing restricted	Hab-30.0 Passive habitat restoration.	Hab-31.0 Active habitat restoration	Hab-32.0 Halt new water withdrawal permits	Hab-33.0 Reduce existing permits for water withdrawal	Hab-34.0 Encourage cultivation of less water-ntensive crops	Hab-35.0 Remove dikes and manage dredging and other measures to restore	Hab-36.0 Manage dredging toavoid increasing predation.	Hab-37.0 Develop habitats to link terrestrial preserves and refugia	Hab-38.0 Protect high quality terrestrial habitats while allowing restricted use.	Hab-39.0 Limit size and frequency of clearcuts	Hab-40.0 Normative fire frequency	Hab-41.0 Develop normative forest age structure and species composition	Hab-42.0 Provide gradual forest ecotones	Hab-43.0 Reduce forest road density	Hab-44.0 Build storage reservoir to provide downstream flow	Hab-45.0 Improve mining discharges	Hab-46.0 Improve mining practices	Hab-47.0 Rehabilitate marginal and closed mines
Mountain Snake	1	1-4			X	X	X	X	X		X					X	X	X	X	X	X	X		X	X	X
	2	2-4			X	X	X	X	X		X					X	X	X	X	X	X	X		X	X	X
	3	3-4			X	X	X	X	X		X					X	X	X	X	X	X	X		X	X	X
	4	4-4						X	X	X							X									
	5	5-4				X	X	X	X	X	X					X	X	X	X	X	X	X		X	X	X
	6	6-4				X	X	X	X	X	X					X	X	X	X	X	X	X				
	7	7-4					X	X	X							X	X									

Harvest and Hatchery stategies incorporated into each alternative in the Mountain Snake Province.

Description of Alternatives by Strategy Block

Comment | Define Criteria | Edit Criteria

Province	Alternative	Index	Har-1.0 Harvest elimination	Har-2.0 Harvest reduction	Har-3.0 MSY harvest management	Har-4.0 Selective fisheries	Har-5.0 Focus sport or C&S fisheries	Har-6.0 Weakest population harvest rate	Har-7.0 Weakest metapopulation harvest rate	Har-9.0 Use "new" harvest techniques	Har-10.0 Develop aquaculture	Har-11.0 Weakest aggregate harvest rate	Hat-2.0 Use natural population as a template or hatchery.	Hat-3.0 Provide emergency preservation of genetic resources	Hat-4.0 Phase out hatchery production	Hat-5.0 Expand hatchery production	Hat-6.0 Reduce hatchery production	Hat-7.0 Use wild fish emulation techniques in hatchery.	Hat-8.0 Reduce spread of hatchery pathogens to wild	Hat-9.0 Supplement natural production	Hat-10.0 Reintroduce progeny of captive brood ish back into habitat	Hat-11.0 Provide mitigation hatcheries	Hat-12.0 Deveop augmentation hatchery.
Mountain Snake	1	1-4					X	X					X	X	X			X			X		
	2	2-4					X		X				X	X	X			X		X	X	X	
	3	3-4					X		X				X	X	X			X		X		X	
	4	4-4					X					X	X	X				X		X	X		
	5	5-4					X		X				X	X	X			X	X	X		X	X
	6	6-4					X					X						X	X	X		X	X
	7	7-4					X					X								X			

Hydro stategies incorporated into each alternative in the Mountain Snake Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hyd-1.0 Channel maintenance flows below dam	Hyd-2.0 Convert storage reservoir to run-of-iver reservoir	Hyd-3.0 Breach a dam	Hyd-4.0 Provide alternative fish passage structures and operations to	Hyd-5.0 Discourage proliferation of shad via adult passage facilities.	Hyd-6.0 Operate juvenile fish passage acilities year round.	Hyd-7.0 Dam drawdwon	Hyd-8.0 Manage spill to minimize dissolved gas	Hyd-9.0 Minimize daily flow fluctuations	Hyd-10.0 Normative seasonal flow and looding	Hyd-11.0 Provide gravel and organic debris in unimpounded mainstem areas	Hyd-12.0 Design and implement bypass structures to reflect biological	Hyd-13.0 Operate adult passage facilities year-ound	Hyd-14.0 Provide flow to re-establish normative estuarine and plume and salinity	Hyd-15.0 Remove economically marginal dams on tributaries that block anadromous	Hyd-16.0 Restore passage for anadromous fish above blockages	Hyd-17.0 Operate adult passage facilities on an extended schedule	Hyd-18.0 Operate juvenile passage facilities on an extended schedule	Hyd-19.0 Maximize transport downstream uvenile salmonid migrants	Hyd-20.0 Use "Share the risk" transportation policy for juvenile salmonids.	Hyd-21.0 Use transportation as an emergency measure	Hyd-22.0 Eliminate transportation	Hyd-23.0 Use barges only for transportation.
Mountain Snake	1	1-4									X	X						X							
	2	2-4									X	X						X							
	3	3-4									X	X						X							
	4	4-4									X														
	5	5-4									X							X							
	6	6-4																							
	7	7-4																							

Hydro stategies incorporated into each alternative in the Mountain Snake Province.

Description of Alternatives by Strategy Block

Comment

Define Criteria

Edit Criteria

Province	Alternative	Index	Hyd-24.0 Install extended length screens at collector projects	Hyd-25.0 Eliminate use of extended length screens at all projects	Hyd-26.0 Provide flow to provide normative downsteam temperatures.	Hyd-27.0 Locate bypass outfalls to reduce predation	Hyd-28.0 Remove bank armoring	Hyd-29.0 Connect backwaters and sloughs	Hyd-30.0 Manage flow to promote mainstem spawning below dams.	Hyd-31.0 BiOp Flows	Hyd-32.0 IRCs	Hyd-33.0 Shift spring flow to summer	Hyd-34.0 Install surface bypass	Hyd-35.0 Install "Fish friendly" turbines	Hyd-36.0 Pre-WB flow	Hyd-37.0 BRCs
Mountain Snake	1	1-4			X											X
	2	2-4			X						X					
	3	3-4			X		X	X	X		X					
	4	4-4								X						
	5	5-4					X	X	X	X	X					
	6	6-4										X				
	7	7-4													X	

Appendix I

Scientific Principles

Principle 1: The abundance, productivity and diversity of organisms are integrally linked to the characteristics of their ecosystems.

Discussion**:** An ecosystem is the organized complex of physical and biological components that make up the world we observe every day (Tansley 1935). The physical and biological components are inseparably related to produce the diversity, abundance and productivity of plant and animal species including humans (Odum 1971). Because of the pervasive impact of human actions on ecological systems (Vitousek and others 1997), achieving goals for individual species of commercial, cultural or other human interest will require managing human activities to support ecological processes (Christensen and others 1996).

Although we may have an intuitive feel for what constitutes an ecosystem, management goals are frequently couched in terms of individual species. Because of this, management actions typically focus on the needs of individual species. As environments have been altered by human action, we have attempted to prop-up species of commercial and cultural concern. These efforts have met with sporadic success. There is increasing recognition of the need for multiple species management and the integration of land management with fish and wildlife management (Christensen and others 1996, Dale and others 2000). This means recognizing the processes that form the necessary habitats for species and the functions that species provide to the ecosystem. The combination of suitable habitats and needed ecological functions combine to form the ecosystems needed to provide the desired abundance and productivity of specific species.

Local climate, hydrology and geomorphologic factors as well as species interactions strongly affect ecological processes and the abundance distribution of species at any one place (Dale and others 2000). Life histories, physical features and diversity of individual species are shaped by climate, physical structure of their habitat and by biological interactions . Change in physical or biological features of the ecosystem, either natural or human-induced, will affect the capacity, productivity and diversity of fish and wildlife species.

Implications: Management of species in isolation at best provides an incomplete picture, and at worst misleads by not accounting for the context and mechanisms that control species abundance, capacity and diversity. This principle notes the integral relationship between species and their environment and the role that species themselves play in maintaining that environment. It couples ecological conditions to the productivity and abundance of species including those of management interest.

Natural resource management, especially fisheries management, often isolates species from their environment to protect them from habitat loss or other impacts of human actions (Bottom 1997). In the Columbia River we have tried to develop a protected corridor for salmon within limited parts of the life cycle while allowing the ecological support system to be dramatically altered. This neglects the role of biological and physical factors of the ecosystem in shaping individuals, populations and species through natural selection. These efforts also do not replace the habitats themselves or the ecological function that species provide. For salmon, the reality has been that, although large numbers of individuals are released into the system and protected through their freshwater phase, fewer and fewer fish return to spawn.

Principle 2. Ecosystems are dynamic, resilient and develop over time.

Discussion**:** Although ecosystems have definable structures and characteristics, their behavior is highly dynamic, constantly changing in response to internal and external factors (Dale and others 2000). The system we see today is the product of its biological, human and geological legacy. Disturbance and change are normal ecological processes and essential to the structure and maintenance of habitats (Bisson and others 1997). For example, floods structure aquatic habitat and fires structure terrestrial habitats (Reeves and others 1995).

Disturbance can be the result of natural processes such as fire, flood or insect outbreaks, or human activities such as timber harvest or agriculture. Natural disturbance patterns create a mosaic of habitats across the landscape and through time (Reeves and others 1995). At the same time, ecosystems maintain characteristic features and support definable communities of organisms. Habitat-forming processes resulting from the underlying geology, climate and hydrology and species ecological functions of the individual species impart a degree of resilience to the system allowing it to accommodate change and maintain essential characteristics (Holling 1973). Depending on the degree of perturbation and the resilience of the system, the ecosystem may eventually resemble its previous condition once the disturbance dissipates. There are limits to the ability of an ecosystem to absorb change and retain its original characteristics (Holling 1973, Reice and others 1990). The system is not destroyed but instead shifts into a new configuration. Different species will be favored and new biological and physical interactions will develop.

A normal ecosystem will show describable, if not generally predictable, patterns of change over time (Odum 1969). Forests, for example, have successional patterns characterized by the change from pioneer to mature species. A forest, like other ecosystems, may appear stable when we observe it at one point in time, but it changes over broader time frames. Similarly, lakes and streams mature with dramatically different ecological character at various points in time (Cummins and others 1984). Natural disturbances can interrupt succession locally leading to a mosaic of habitats across the landscape (Reeves and others 1995). More widespread and pervasive disturbance including many human activities can stop or reset ecological succession patterns and prevent formation of habitats and processes that may be essential to continuation and abundance of some species.

Implications: Many natural resource management actions are designed to control the environment, reduce variability and achieve a stable and predictable yield from a highly dynamic system (Holling and Meffe 1996). For example, hatcheries were conceived, in part, to smooth out natural variation in fish populations and to sustain harvest over time (Bottom 1997). Dams and other structures dampen seasonal variation in water flow, while banks are stabilized and diked. Hatchery production and fish passage measures are timed and engineered to provide a predictable fish migration with minimal conflict with human uses of the river. Fires are suppressed leading to altered forest succession and species composition as well as insect outbreaks (Quigley and others 1996).

This principle encourages a departure from attempts to freeze the system in a certain constant state and manage for constant yields. Natural resource management programs should anticipate and accommodate change. Expectations of constant abundance or yield from natural resources are unrealistic and ignore fundamental features of ecological systems. Disturbance should be recognized as a strategy for development and maintenance of habitat. Efforts to stabilize the environment and reduce disturbance will fundamentally alter habitats to the detriment of capacity, productivity and diversity of target species.

Principle 3. Biological systems are organized hierarchically.

Discussion: Ecosystems, landscapes, communities and populations are usefully described as hierarchies of nested components (Allen and Hoekstra 1992). Levels within these hierarchies are distinguished by their appropriate spatial and time scales. A higher level addresses larger areas that fluctuate at relatively long time intervals, whereas lower levels encompass smaller areas and fluctuate at higher frequencies. Expansive ecological patterns and processes constrain, and in turn reflect, localized patterns and processes (Wiens 1989). By analogy to a camera lens, we can zoom in to address fine details and pan out to consider the system as a whole.

The definition of the hierarchy and scale is dependent on the question asked (Levin 1992). There is no single, intrinsically correct description, only one that usefully addresses the problem. The description should clarify the higher level constraints as well as the localized mechanisms behind the problem.

This suggests neither a top-down nor a bottom-up approach, but integrates both. Depending on the question, it may be necessary to focus on the higher level constraints on a level or to consider how performance at lower levels combines to produce the result we see (Weins 1989). Performance at any level reflects both the synergistic effect of actions at local scales and the constraints imposed by higher level factors (Allen and Hoekstra 1992); that is, it is useful to look at the next level up to understand the context, and the next level down to understand the mechanisms.

Viewing ecosystems as hierarchies is useful for depicting the underlying structure of many ecological components. Regional climates vary through time on scales ranging from millennial to inter annual (Greenland 1998). Disturbance regimes within ecosystems can be described at a variety of spatial and temporal scales (Delcourt and others 1983) that can affect life history patterns and genetic structure (Wissmar and Simenstad 1998). Frissell and others (1986) structured aquatic habitats describe a hierarchical classification system that reflects underlying geomorphic hierarchies.

Implications: If ecosystems are viewed as nested hierarchies, it is necessary to define appropriate scales for their management and study (Holling and Meffe 1996). To solve problems regarding the entire Columbia River Basin, we need to filter out some more localized data. On the other hand, questions concerning localized components (e.g. subbasins) cannot be addressed by looking at the entire basin. Understanding basin-level problems requires knowledge of actions and processes that take place in subbasins, while subbasin level actions will be successful only when considered in the context of factors operating at basin and regional levels.

This principle provides an ecologically based way to structure fish and wildlife recovery (Quigley and others 1996). Such a structure should reflect ecological pattern within the system while providing a useful organizational device for recovery efforts. A necessary first step is to define the ecosystem at the point in the ecological continuum appropriate to the problem. The ecosystem at that point reflects the characteristics of the features nested within and higher level constraints on performance.

Principle 4. Environments and habitats develop, and are maintained, by processes related to climate, geology and hydrology.

Discussion: Habitat refers to the resources and conditions present in an area that allow a species or a group of species to exist and thrive (Hall and others 1997). Habitats are created, altered and maintained by processes that operate over at a range of scales (Allen and Hoekstra 1992). Habitat forming processes include runoff patterns, heating/cooling, forest succession, and erosion/deposition (Imhof and others 1996). At the local scale, habitats are created and maintained by processes that encompass aquatic and terrestrial factors throughout the watershed reflecting hydrology and geology. Regional climatic conditions in turn control temperatures and precipitation that are important in the development of habitats. Locally observed conditions often reflect more expansive or non-local processes and influences, including human actions. The presence of essential habitat features created by these processes determines the abundance, productivity and diversity of species and communities (Morrison and others 1998).

The active agent of many aquatic habitat-forming processes is water acting with the underlying geology, topography and climate. The hydrologic linking of habitat processes means that the impacts of actions can radiate and accumulate downstream. Habitat conditions such as water temperature or sediment can be the result of actions and conditions that occur upstream. Aquatic habitat conditions are affected by terrestrial conditions and actions that accumulate as water moves downslope.

Terrestrial habitats are often described in terms of food, water and cover. Formation of these features is related to vegetational patterns that result from environmental needs of individual plant species, succession and patterns of human-caused and natural disturbance (Whittaker 1975). In turn, vegetation pattern is related to local geology, topography and climate in the context of regional factors such as climate.

<u>Implications</u>: Understanding the processes that create and maintain aquatic and terrestrial habitats are key to the management of human impacts on those habitats (Imhof and others 1996). These processes can only be appreciated by consideration of habitats at watershed or subbasin scales even though the perceived problem is localized. Often our efforts are focused on correcting symptoms of habitat degradation and loss rather than on causes. We try to “fix” the problem by engineering localized solutions. In most cases, these efforts prove futile because the process and conditions creating the problem are still active (Kauffman and others 1997). For example, logging practices in the upper parts of watersheds may affect water temperatures and sediment levels and negate efforts to correct habitat problems lower in the system. Livestock grazing may preclude development of normal vegetational succession in riparian areas with downstream impacts on flow, temperature and sediments. Management to achieve goals for specific species implies allowing normal habitat forming processes to operate and develop an appropriate environment.

This principle stresses the need to understand and address habitat forming processes in order to restore and maintain aquatic and terrestrial habitats. Habitat restoration actions undertaken without appreciation of the underlying Land use practices affect habitats through processes similar to those structuring natural habitats. Relating practices to process is key to ensuring that habitats are available to support biological communities and species of interest.

Principle 5. Species play key roles in maintaining ecological conditions.

Discussion: Organisms do not act as passive residents of their habitats. Instead, each species has one or more ecological functions that may be key to the development and maintenance of ecological conditions (Walker 1995). Species, in effect, have a distinct job or occupation that is essential to the diversity, sustainability and productivity of the ecosystem over time (Morrison and others 1998). For example, plant, animal and bacterial species structure habitats, cycle energy and control species abundance and diversity. The existence, productivity and abundance of species depend on these functions. To varying degrees, similar ecological functions may be performed by different species. Promoting or maintaining a diversity of species that have similar "occupations" enhances the resilience of the ecosystem in the face of disturbance or environmental variation (Walker 1995).

However, some ecological functions lack redundancy and are performed by a limited number of species. Removal or declines of such species can have significant impacts on their associated ecological function, the ecosystem and its species. In Pacific Northwest ecosystems, for example, salmon often have a key role in cycling of substantial amounts of nutrients and energy from the marine environment to freshwater and terrestrial habitats (Cederholm and others 2000). Removal of salmon from these systems results in ecological changes that can have far reaching impacts on a variety of aquatic and terrestrial plant and animal species (Willson and Halupka 1995, Cederholm and others 2000).

Implications: Traditional natural resource management has viewed species largely as passive functions of their habitat, separate and distinct from their ecosystems. This principle affirms the integral relationship between species and their ecosystems and the need to consider actions in the context of species ecological function. Many of our actions serve to isolate and protect species such as salmon even as the surrounding ecosystem is altered in fundamental ways. Salmon hatcheries, for example, may provide harvest benefits to some human users when habitats have been altered or destroyed, but they do not replace the ecological role that salmon play in the ecosystem. The result can be significant ecological change affecting the presence and abundance of other aquatic and terrestrial species (Cederholm and others 2000). Actions such as hatcheries may continue to play a role in natural resource management, but they must be used not only to bolster survival and capacity of salmon, but also to restore or replace the function that salmon play in their ecosystem.

Principle 6. Biological diversity allows species to accommodate environmental variation.

Discussion: The physical and biological template of the environment shapes species, populations and individuals (Southwood 1977). Variation in the template over time and space, as well as the structure of the environment, results in an organization of biological variation among species, races, demes and individuals. Generally speaking, greater diversity between and within species leads to greater ecological stability (Odum 1971). Greater biological diversity between species leads to redundancy in ecological function that provides alternatives as species wax and wane with environmental variation (Walker 1995, Morrison and others 1998). Within a species, variation in biological characteristics among populations and individuals is the fuel by which adaptation occurs in response to environmental variation. A more diverse species has a greater range of possible solutions to the challenges posed by variation and changes in its environment. Within the spectrum of populations that comprises a species (chinook salmon in the Columbia River, for example) there is a variation in survival as the environment shifts over time. As some populations suffer under an environmental extreme such as an El Nino condition, others might fare better. The species survives, bolstered by its ability to respond to the shifting environment (Bisbal and McConnaha 1998).

Implications: Human actions can reduce biological variation (Urban and others 1987, Policansky and Magnuson 1998). As we simplify and stabilize environments, biological variation is reduced. This leads to species that are less capable of responding adaptively to environmental change.

If we accept that diversity between species increases ecosystem stability while within species diversity provides the ability of the species to better sustain itself and ultimately adapt to changing environments, then we should manage our activities to allow natural expression of biological diversity. While diversity can be quantified, determination of the “proper” level of biological diversity is likely not possible, partly because it shifts and varies over time in response to natural selection. The challenge is to manage human activities to minimize our impacts on selection and allow diversity to develop accordingly.

Principle 7. Ecological management is adaptive and experimental.

Discussion: Many of the features of ecological systems described in these principles counsel against the notion of command and control of the environment (Holling and Meffe 1996). Instead, the complexity and variability of ecosystems argues for management that is inherently experimental (McConnaha and Paquet 1996) and that admits and accounts for the range of natural dynamics at all levels of biological organization. Our knowledge of ecological systems is incomplete. We can describe the structure and nature of ecosystems in some ways, but important details elude us. More importantly, we have only recently begun to appreciate the Columbia River as an ecosystem. For most of this century we have thought of the Columbia River as a machine that can be adapted to meet our needs (White 1995). Ready solutions to management of a highly developed system like the Columbia River have not been developed. Finally, as has been emphasized in these principles, ecosystems vary over time. What is key to recovery of species today may not be so important in the future as the system shifts in some largely unpredictable fashion.

Adaptive management – the use of management experiments to investigate biological problems and to test the efficacy of management directions -- provides a model for experimental management of ecosystems. However, ecological scale management presents special challenges to adaptive management (Walters 1997). Ecosystem experiments may be impractical, infeasible or pose equity questions (Volkman and McConnaha 1993). We may be unwilling to experiment with beleaguered fish and wildlife populations. Under these circumstances, there may be less opportunity for large-scale management experiments, and more need for directed experimentation and research. Nevertheless, an explicit, directed approach to learning is essential. Experimental management does not mean passive "learning by doing", but, rather a directed program aimed at understanding key ecosystem dynamics and the impacts of human actions by using the rigorous methods of scientific experimentation and inquiry (Platt 1964).

Implications: This principle argues for management that conscientiously experiments and probes to better understand the ecosystem. Ecosystem management is likely to require the development of new measuring tools (Done and Reichelt 1990). To the standard indices of abundance of important fish and wildlife species, ecosystem management calls for new indicators of success such as development of habitat characteristics, normal trophic structure, biological diversity and species conservation status. What is critical to fish and wildlife restoration in one decade may not be critical in the next as the ecosystem shifts in response to internal or external factors and as human values shift. As we learn about ecosystems, new strategies may be indicated. However, in order to provide relevant information regarding these factors, monitoring and evaluation need to be built into management programs from the ground up.

Principle 8. Ecosystem function, habitat structure and biological performance are affected by human actions.

Discussion: Humans are integral parts of ecosystems. Our actions have a pervasive impact on the structure and function of ecosystems, while, at the same time, our health and well being are tied to these conditions (Vitousek and others 1997). Like many other organisms, humans structure and control ecosystems for their own needs. In some ecosystems, human impacts act as major factors controlling the environment. However, unlike other organisms, we can consciously control our actions to allow needed ecological conditions to develop. While our actions may be unique in the scale of impact on ecological systems, the method of interaction is not; ecological principles apply to human interactions with ecosystems as much as they do to the interactions of fish and wildlife species and the ecosystem.

It is a reasonable assumption that for most species, the ecological conditions that are most conducive to their long-term survival and productivity are those under which they evolved. Human actions in the Columbia River have shifted ecosystems away from their pre-development conditions with negative impacts for many native species, especially fish. Some changes are irreversible. New species such as smallmouth bass, walleye and many plant and terrestrial animals have been introduced and permanent changes have been made to the landscape. Even with complete cessation of human activities, these ecosystems would not return to their previous condition. However, human impacts on ecosystems can be managed to move the system to a state that is more compatible with the needs of other species.

Implications: These scientific principles suggest ways to view our role in ecosystems. Humans have significantly altered the natural landscape in the Columbia River Basin for several millennia and have significantly affected the abundance and distribution of plants and animals (Martin and Szuter 1999). In highly developed ecosystems like the Columbia River, human actions and technology will continue to dominate the system. However, those actions can be managed in a manner consistent with the needs of other species. The issue is to what extent are we able to control our impacts so as to balance the various services potentially provided by the Columbia River basin. It is simply a question of the type of environment in which we choose to live and how much we are willing to limit our actions to achieve these objectives.

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Appendix J

Annotated Bibliography List

CAPACITY

Reference List

Lukesh, G. R. 1930. The Columbia river system. Military Engineer 22 (124): 328-335.
Abstract: Author provides an excellent historical, geographical, hydraulic (gradient, navigability, etc.) synopsis of the Columbia river system (and the Snake river basin) from its sources to the mouth. Discusses the potential for power (includes tables illustrating Streams, Condition of Flow, Kilowatts Available, and Installed Capacity, etc.) and irrigation developments in the Columbia river system-pp. 328-335.

Pacific Fisherman. 1903. Columbia River review. Pacific Fisherman I(6): **6**.Seattle, Washington and Vancouver, B.C. complete p.
Abstract: Notes the policy of Fish Commission Kershaw, of the State of Washington, to double the output of the Chinook, Kalama, and Wind River hatcheries; the estimated capacity of these facilities will approximate 50 million fry, at $7,000 per year. Article also mentions the commissioner's (Mr. Kershaw) to open up new and extensive hatchery on the Grays River, near its headwaters.

CHINOOK

Reference List

Gaumer, Tom, Demory, Darrell, and Osis, Laimons. 1973. 1971 Columbia River Estuarine estuary resource use study. Fish Commission of Oregon, Division of Management and Research, Portland, Oregon.
Abstract: Authors provide information regarding fish species (invertebrate and vertebrate) harvested and observed in the recreation harvest from the seaward end of the south jetty upstream to the area adjacent to Jetty Sands parking lot, from 1 March through 31 October 1971. Figures and tables temporally and spatially illustrate the species and catch statistics for this harvest.

Griffin, L. E. 1935. Certainties and risks affecting fisheries connected with damming the Columbia River. Northwest Science IX(1): 25-30 (February, 1935).
Abstract: Author discusses 1) the economic importance of anadromous and resident fish species, and the effects on dam construction on said species; 2) the importance and distribution of salmon harvest in the Columbia basin; 3) the certainties associated with current state of technology of fish passage systems, and risks associated with designs and plans to be incorporated at the Bonneville project; 4) recommended actions to reduce risks associated with current fish passage technology; 5) certainties and risks associated with sedimentation and submergence of fish habitat (sloughs and shallows) in the Bonneville impoundment; 6) the certainties and risks of power plants to migration of young salmon; and 7) turbine designs and devices to reduce the risks associated with hydropower operaton. Author alludes to a hypothesis that the Columbia impoundments (e.g. Bonneville) may present risks to the importance of the sloughs and shallow ponds contiguous to the river, as being very important as a food source to young salmon during their downstream migration.

Oregon State. 1896. 3rd and 4th Annual Reports of the State Fish and Game Protector of the State of Oregon 1895-1896. State of Oregon, Salem, Oregon. W.H. Leeds, State Printer, 1896. 10,53 p.
Abstract: The Protector (Hollister D. McGuire) discusses failure of the last legislature to enact laws for more effectual regulation and protection related to such topics as concurrent regulations with the state of Washington, protection of salmon through construction of fishways, and harvest limitations on the columbia River, page 5. Mentions that oregon ahs an 1878 statute on the books requiring fishway construction at barriers to salmon, but his predecessors showed no willingness to enforce the statute. He lists the fishways that have been put in under his direction. pages 8-9. He discusses Indian fishing (Warm Spring Indians) and the earliest date of chinook salmon spawning in vicinity of the upper Clackamas River at its junction with a warm spring where thousands of salmon naturally spawn; this date is July 20th. page 10. Notes that a dam and operation of fishing in the lower Clackamas River (four miles below the hatchery) prevent salmon from ascending to the hatchery racks in 1893 and 1894; mentions that dam was removed last spring 1895. page 31. Mentions that $10,000 was appropriated by the 1893 Oregon legislature for work to construct a fishway on the Willamette River at the falls at Oregon City, and notes that fishway work is completed bu not adequate (except during high water stage) for the March and April migration of chinook at Oregon City falls, and that another $4000 is necessary to effect this passage. pages 50-52. Recommends that a provision in the law should mandate that fish screeens constructed at mill races, irrigation ditches, or canals, taking or receiving water from any river, creek, stream or lake having food fish; his attention to the need for such law was derived from a letter of Dr. C.H. Gilbert (Stanfor University) who noted that water diverters on the Wallowa River killed thousands of young chinook and bludback salmon by diversion of them into irrigated fields. page 53. Notes that an Oregon law of 1893 and reenacted in 1895 created the office of the Fish & Game Protector. page 83.

Oregon State. 1907. Annual Report of the Department of Fisheries of the State of Oregon for year 1907 to the legislative assembly, twenty-fourth regular session (1907). State of Oregon, Salem, Oregon. W.S. Duniway, State Printer, 1907. 78-79 p.
Abstract: The Master Fish Warden (H.G. Van Dusen) states that "in view of the fear that the salmon of the Columbia River was not being rehabilitated through the medium of the system of artificial propagation, I am very pleased to be able to chronicle...that there has been a considerable increase in salmon produced by the Columbia River this year over last year..." This increase was for Chinook and steelhead in both Washington and Oregon. He mentions that chinook and steelhead over past five years, but decreases in silversides and bluebacks; and says that artificial propgation has been of assistance in the increase of chinook and steelhead. Page 7. Notes that hatcheries select to use large and strong fish (males) for egg fertilization, and do not use small males; attributes this selective practice to maintaining the 25 lb. average weight of chinook ovr the past seasons. Page 8. Notes that egg collection at facilities in Snake and Wallowa Rivers was very unsatisfactory, even though the fish racks were operated early, few fish go upstream this far, and those that did were three males to one female. But the eggtake at federal and state hatcheries (Oregon and Washington) below Celilo Falls the eggtake was good. page 13. Notes an inspection of the Santiam River (Willamette tributary) in regards to sites for artificial propagation activities. pages 17-18. Mentions that the first contract for the construction of the fishway over the falls of the Willamette River at Oregon City was completed and accepted by the state engineer on November 29, 1904. Mentions that as the Willamette Pulp and Paper Company completed a concrete dam at the falls, this dam caused water hydraulic problems in the fishway (upper pools) - the gradient of the upper portion of the fishway was too steep. This situation caused problems for the spring chinook migration over the falls. Surveys were conducted to make recommendations and provide cost estimates to remedy the fishway problem. Pages 20-24. Notes that hatchery station was established and operated on the McKenzie River at a site situated a couple of miles below Gates Creek; mentions that they took spawn of the early variety of chinook from August 15 to October 15th. States that liberated approximately 1.5 million fry of this 1905 brood year into the McKenzie River in the immediate vicinity of the station during the months of

January and February 1906. Pages 75-76. Notes that Wallowa Hatchery station did not secure any sockeye salmon spawn during the 1905 BY - (note: appears that this BY cycle is extinct or some lower river blockage prevented sockeye from upper area). page 78. Notes that by leaving racks of the Wallowa Hatchery in the river late, they discover a late run of silversides that passed the racks in the month of November, but were unable to hold them to spawning due to severe cold weather conditions. page 78. Notes that the Ontario hatchery station (Snake River at Swan Falls) left their rack in river late (until November 23rd) in hopes of collecting late running silversides, but none appeared. Page 84. Mentions the 1901 law passed by the Oregon State legislature that prohibited fishing above tide water and established fishing deadlines on all coast streams. page 129. Notes that fishway for the falls of the Willamette River at Oregon City provides excellent passage for early chinook in 1906, Page 132. Mentions request for two special deputy fish wardens to enfore laws regarding water diversions and dam obstructions that are causing mortality of young migrants going to sea; notes causes due to extensive development of power/mill dams across streams and irrigation projects that are taking water for irrigation puroses. Pages 134-135. Notes the needs for laws that assure better escapement to the spawning ground in the Columbia River; infers that hatcheries alone will not solve the problem of diminishing harvest to fishermen in the Columbia River. page 137. Notes that 1906 BY salmon returns (chinook and sockeye) in northeastern Oregon (Wallowa and Ontario Hatcheries) were poor; and that salmon runs in the lower Columbia River below Celilo Falls appeared to have been successful in running the gauntlet of net fishermen in the lower Columbia, Page 139. Mentions that he must secure eggs in order to assure shortage of Snake River stock (at Ontario Hatchery) four to five years hence, based on "...theory that Salmon return to the stream of their nativity to spawn..." Page 140.

Oregon State. 1951. Biennial report of the Fish Commission of the State of Oregon to the governor and forty-sixth legislative assembly, 1951. Fish Commission of the State of Oregon; Salem, Oregon, State Printing Office, 1951.
Abstract: Notes that (1) Fish commission has particular interest in the study of logging effects on salmon production, page 3. (2) On June 1948, the states of Oregon, Washington, and Idaho, and Federal Government (Fish & Wildlife Service, Department of Interior) consummated agreement of the provision of funds for the rehabilitation of the lower tributaries of the Columbia River, under the Lower Columbia River Salmon Rehabilitation Program, page 10. (3) A fishway is installed at a diversion dam (owned by the Vancouver Plywood Company) on Rock, a tributary of the North Santiam River, this reopened considerable area for steelhead spawning. page 12. (4) A new concrete fishway is constructed at the Powerdale Dam (owned by Pacific Power and Light Company) on the Hood River, page 13. (5) A fish screening and by-pass system is completed in the Marmot Dam Canal (Marmot Dam project, owned by Portland General Electric Company) on the Sandy River, page 13. (6) Columbia River investigations are studying five different problems; (a) extension of reduction in productivity of the Columbia River Basin by the encroachment of man, (b) harvest practices, stock timing/migration/distribution; (c) knowledge of growth and survival and limiting factors of young salmon in freshwater, (d) effect contemplated water development projects on Columbia River salmon, and (e) studies on sturgeon. page 15. (7) A need for the development of cheap and nutritional diets alternative to the liver based diets. page 18.

Pollock, C. R. 1930. Fishery conditions in the state of Washington: Puget Sound appears healthy, but Columbia River shows decline. Pacific Fisherman Annual Statistical Number, Vol. 28, No. 2, January 25, 1930, pages 110-111. Seattle, Washington.
Abstract: Supervisor of Fisheries states that there was a shortage of escapement in the Columbia River district. Mentions that there is little hope of increasing spring chinook run until adequate screening installations have been completed on irrigation ditches. Says that summer and fall chinook runs must be looked to as the source of harvest for the fishing industry in the Columbia River district. Also provides a report on hatchery operations in the Columbia River district during 1929.

Washington State. 1921. 30th and 31st annual reports of the state fish commissioner to the governor of the state of Washington: April 1, 1919 to March 31, 1921. State of Washington Department of Fisheries and Game, Olympia, Washington. Frank M. Lamborn, Public Printer, 1921.
Abstract: The commissioner (L.H. Darwin) discusses: 1) the actions and impacts of the 1921 legislative action to create the State Fish Commission, with respect to Washington fisheries resource management, in the context of state and international (Canada) benefits (p. 8-10); 2) discusses "Wastefulness of Natural production," in the context of justifying increased harvest rates through use of efficient fish artificial propagation. NOTE: this reference may be the premise for Washington state fisheries policy over the next 60 years (p. 18-19); 3) Notes negotiations with Northwestern Electric Company to provide mitigation monies for construction of a new hatchery at Chinook, WA (replacement of the old Chinook Salmon Hatchery) in lieu of upgrading and operating the existing fishway over their hydroelectric dam on the Big White Salmon River. Mentions that dam is 160 ft. in height, and that adult steelhead trout are the only species that transcend this dam upstream (p. 24); 4) extensive discussion of the Indian fishing privileges at Prosser Dam, and the fate of salmon resources in the Yakima River, based on the prognosis of irrigation/water developments in the Yakima basin - states that within the next 10 years salmon will not exist in the Yakima (p. 27-29).

DAMS

Reference List

Andrew, F. J., Kersey, L. R., and Johnson, P. C. 1955. An investigation of the problems of guiding downstream migrant salmon at dams. International Pacific Salmon Fisheries Commission, Bulletin VIII.
Abstract: A comprehensive treatment of criteria and design of electric devices for guiding downstream salmon migrants; notes behavior of migrants in terms of response to electric fields and migration rates observed for sockeye and coho during experiments.

Baxter, R. M. 1977. Environmental effects of dams and impoundments. Annual Review of Ecology and Systematics 8: 255-283.
Abstract: Author provides 1) a general history and background of the impoundments, 2) Morphology and physical and chemical limnology of man-made lakes, 3) biology of reservoir ecosystems, 4) downstream effects of impoundments, 5) other consequences of impoundments, 6) summary and conclusions, and 6) a comprehensive listing of references on the subject.

Bell, M. C. 1954. Salmon fisheries versus power development. World Fishing 3(11): 392-396, 421-422 (November 1954).
Abstract: Author provides a short synopsis of the Columbia River basin and its conflict between water users (dams and irrigation) and salmon fisheries resources; notes data regarding some Columbia River dam projects, number fish screen projects, and sockeye run size.

Bixby, W. H. 1912. Rivers and harbors improvement: Progress and needs in the United States, 1911. Professional Memoirs Vo. IV, No. 13: 114-128.Corps of Engineers, US Army, and Engineer Department at Large,
Abstract: Author notes the General Dam Act of June 23, 1910, which recognized the fact that ownership of power developed by dams constructed wholly at private expense is a matter for control by individual states and not by the federal government. In accordance with this Act, which must be compilied with before riparian owners can build dams in navigable waters, the US is empowered to require the dam owner to furnish the US free of cost such water and such locks, log sluices, fishways, and other auxilary constructions as are necessary in the interest of navigation and the fisheries... p. 125-126.

Bixby, William H. 1912. Rivers and harbors improvement: progress and needs in the United States, 1911. Professional Memoirs Vol IV, No. 13: Corps of Engineers, United States Army, and Engineer Department at Large, 114-128 p.
Abstract: Author notes the General Dam Act of June 23, 1910, which recognized the fact that ownership of power developed by dams constructed wholly at private expense is a matter for control by individual states and not by the federal government. In accordance with this Act, which must be complied with before riparian owners can build dams in navigable waters... the US is empowered to require the dam owner to furnish the U.S free of cost such water and such locks, log sluices, fishways, and other auxiliary constructions as are necessary in the interest of navigation and the fisheries...p. 125-126.

Bristow, M. P., D.H. Bundy, C.M. Edmonds, P.E. Ponto, B.E. Frey, and L.F. Small. 1985. Airborne laser fluorosensor survey of the Columbia and Snake Rivers; simultaneous measurements of chlorophyll, dissolved organics, and optical attenuation. International Journal of Remote Sensing 6: 1707-1734.
Abstract: Author reports on the use and applicability of airborne laser fluorosensor surveys in determination of chlorophyll-a profiles of the lower Columbia and Snake Rivers. Profiles of chlorophyll-a collected during peak discharges suggest the existence of subsurface chlorophyll-a maxima in the reservoirs formed by the eight dams of Columbia-Snake Inland Waterway.

Craig, J. A. 1935. The effects of power and irrigation projects on the migratory fish of the Columbia River. Northwest Science IX(1): 19-24 (February, 1935).
Abstract: Author discusses the effects of human land and water uses (logging, mining, power, and irrigation) on fisheries resources in the Columbia basin. Provides examples of habitat alterations imposed by these human uses. Briefly discusses life history and ecology of all anadromous salmonid species inhabiting the Columbia River basin. Discusses how the use of streams for power and irrigation purposes affect migratory salmon species: 1) obstacles that obstruct or delay migration of adult upstream to natal steams; and 2) injurious or delay impediments to downstream juvenile migration. Presents fishways and screening as mechanisms to protect fish, and the use of artificial propagation in the case of high dams.

Davidson, F. A. 1935. Research projects of the US Bureau of Fisheries in the Northwest. Northwest Science IX(1): 15-18.
Abstract: Author provides a synopsis of the US Bureau of Fisheries research projects that it has undertaken in the Northwest region. These projects are generally categorized as: A. Program for Study of Columbia River Salmon Fisheries, that includes 1) Statistical study of the Columbia River salmon fisheries, 2) Study of the protection of migratory fish at power dams and in irrigation canals in the Columbia River system, & 3) Biological study of the Columbia River salmon fisheries; B. Coho Salmon Investigation; and C. Puget Sound Sockeye Salmon Investigation.

Evergreen. 1993. The mighty Columbia I am life. Evergreen 23 pp. p.
Abstract: Author provides a concise history and chronology of events/activities (early 19 th century to present) in the Columbia basin, with respect to exploration & settlement and development of commerce & exploitation of natural resources in the basin. Many references and comments regarding the fisheries resources of the basin are provided.
Chronology of events/activities:
(1) 1859- the first large scale irrigation project is completed in the Walla Walla river valley; p. 3
(2) 1880- between 1880 and 1910, loggers build more than 100 splash dams in the Columbia river basin, in order to transport logs; p. 3
(3) 1915- the Columbia Gorge Highway is completed on the Oregon side of the Columbia river; p. 3
(4) 1939- the Bonneville Power Administration signs its first industrial sales contract, with the

Aluminum Company of America; ALCOA constructs a smelter on the Columbia, a few miles downstream of Vancouver; p. 3
(5) 1941- September 28 th, Grand Coulee Dam begins operation; p. 4
(6) Congress authorizes construction of Hungry Horse Dam, on the South Fork of the Flathead River in Montana; this dam was the first of many upstream dams to control summer and winter flows for maximum power generation by downstream dams; p. 4
(7) 1945- the US Congress authorizes construction of five dams: McNary, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite; p. 4
(8) 1946- the US Congress authorizes construction of Chief Joseph Dam; p. 4
(9) 1950- the US Congress ratified the River and Harbor Flood Control Act, authorizing four more dams: The Dalles and John Day on the mainstem Columbia; Albeni Falls and Pend Oreille in northeast Washington; and Libby Dam on the Kootenai in northwest Montana; p. 4;
(10) 1955- the Federal Power Commission grants Idaho Power Company a 50 year license to build three dams in Hells Canyon on the middle Shake River; p. 4 and
(11) 1968- construction begins on eight hatcheries to compensate for chinook and steelhead losses from four federal dams on the lower Snake River; p. 4

Foerster, R. E. 1951. Forum: Fish and Power. Transactions of Fourth British Columbia Natural Resources Conference, Victoria BC, pages 128-140.
<ins>Abstract</ins>: Authors discuss and provide references for the following topics associated with Fraser and Columbia rivers, in terms of a historical chronology: 1) Homing tendency of Pacific salmon, 2) catch to escapement ratios, 3) spawning potential 4) natural propagation, 5) treatment of obstructions, 6) effect of power installation, 7) power dams as obstructions, 8) fish ladders over low dams, 9) importance of collecting devices, 10) high dam problems, 11) influnce of the reservoir area on adult migration and spawning, 12) quality of water in reservoir, 13) descent of migrating salmon, 14) alternative or replacement salmon production projects, 15) collection and removal of adult salmon to other streams, 16) artificial propagation, 17) a working policy 18) extension of salmon producing areas, 19) conclusions, and 20) literature cited. NOTE: Excellent synopsis of power and fisheries related interactions.

Fuhrer, Gregory J., Tanner, Dwight Q., Morace, Jennifer L., McKenzie, Stuart W., and Skach, Kenneth A. 1996. Water quality of the lower Columbia River Basin: analysis of current and historical water-quality data. Water-Resources Investigations Report 95-4294. US Department of the Interior, Portland, Oregon.
<ins>Abstract</ins>: The lower Columbia River Basin includes the river basins draining into the Columbia River below Bonneville Dam—the largest of which is the Willamette River. This report presents the results of a study by the U.S, Geological Survey, done in cooperation with the Lower Columbia River Bi-State Water-Quality Program, to describe the water-quality conditions in the lower Columbia River Basin by interpreting historical data collected and data collected in 1994. Historical water-quality data spanning more than 50 years and comprising more than 200 parameters were collated for interpretation in this report. The U.S. Geological Survey, the Oregon Department of Environmental Quality, and the Washington Department of Ecology collected water-quality data at 10 sites in the lower Columbia River Basin from January to December of 1994. Water-quality constituents measured in 1994 were screened against U.S. Environmental Protection (EPA) and State guidelines.

Arsenic, a human carcinogen, was detected in 15 of 16 samples in the lower Columbia River, but was not detected in any of the sampled tributaries. All 15 arsenic detections had concentrations that exceeded both the EPA human-health advisories for drinking water. Chromium was detected at all four Columbia River sites—most frequently in the Columbia River at Hayden Island. None of the chromium concentrations detected, however, exceeded water-quality criteria or guidelines.

Measurements of suspended trace-element concentrations (trace-element concentrations associated with the suspended-sediment fraction) showed that the suspended form is the dominant transport phase for aluminum, iron, and manganese, whereas the dissolved form is the dominant transport phase for arsenic, barium, chromium, and copper. On the basis of tributary loads during summer low-flow months, sources of suspended silver, nickel, aluminum, and antimony exist in the lower Columbia River Basin, whereas the sources of suspended zinc and arsenic exist outside of the lower basin.

Twenty organic compounds were detected of the 47 compounds analyzed for this study. None of the organic compounds measured exceeded EPAs ambient water-quality criteria or drinking-water guidelines. The Willamette River at Portland had the largest number of detections, and all 20 compounds were detected at one time or another at that site. The largest concentrations of the agricultural pesticides, atrazine, metolachlor, and simazine were detected in the Willamette River, where they were detected in 93, 86, 93 percent, respectively, of the samples collected. The highest concentrations of atrazine in the Willamette River were associated with the spring application and fall runoff periods.

Both historical and current data showed that the highest water temperatures in the lower Columbia River Basin are present during August. For water years 1977-81 in the Columbia River at Bradwood (river mile 38.9), 75 percent of the daily mean water temperatures during August exceeded 20 degrees Celsius, a ”special condition“ criterion for the State of Washington. The special condition criterion was exceeded at four sites on the lower Columbia River during July and August. 1994—a period coinciding with season-high air temperatures and low streamflow. Trend tests using data from 1974 to 1994 showed significant ($p<0.05$) upward trends for water temperature at the Columbia River at Warrendale and the Willamette River at Portland.

Concentrations of dissolved oxygen and total dissolved gas were above saturation levels during high stormflows in the lower Columbia River and the Willamette River during 1994. The high concentrations of total dissolved gas in the Columbia River exceeded Oregon and Washington State standards of 110 percent of saturation and were caused by spilling water at the Columbia River dams. Aquatic life in the lower Columbia River Basin was not subjected to low dissolved-oxygen concentrations. Comparison of dissolved-oxygen concentrations in the Willamette River from 1949—58 to 1972—94 showed a significant increase in dissolved-oxygen concentrations during the low-streamflow months of summer.

Trend tests showed significant (p,0.05) downward trends from 1973 to 1994 for three constituents at the Columbia River at Warrendale: phosphorus in unfiltered water, total dissolved solids, and specific conductance. These trends may be a consequence of more conservative agricultural practices in the area upstream from Warrendale.

Gangmark, H. A. 1957. Fluctuations in abundance of Columbia River chinook salmon, 1928-54. Special Scientific Report Fisheries No. 189, 21 pages. US Fish and Wildlife Service, Department of Interior, Washington, DC.
<u>Abstract</u>: Notes general history of fishing seasons in late 1800s through 1940s (eg 1877, weekend closures of fishing were established.) A discussion of the influence of water use projects on chinook salmon in the Columbia River; mentions that dams influence migration routes and habitats of downstream migrants. Briefly discusses relative abundance of chinook juvenile migrants at Bonneville since 1938.

Idaho State. 1921. Eighth biennial report of the Fish & Game Warden of the State of Idaho, 1919-1920. Otto M. Jones, State Game Warden; Boise, Idaho.

Abstract: (1) Note that in 1910 sunbeam Dam (Custer County), owned by the Sunbeam Dam Company, was constructed on the Salmon River, and was an absolute barrier to fish trying to reach the spawning grounds of small tributaries and lakes in the upper Salmon River (Stanley Basin District); and ineffective wooden fish ladder was constructed shortly after dam completion, but the first high water demolished the structure. (2) In 1920, State Game Warden ordered that a permanent fish ladder be constructed at Sunbeam Dam, and ready for operation by mid-summer. pages 45-47. (3) Notes a visit to the Grangeville Power & Light Company Dam on the Clearwater River, and consultations with the dam owners to devise a plan for the fishway over the dam. By November, the fishway had not been fully completed; the dam manager surmised that salmon could ascend the fishway in its current condition during high water, pages 47-48. (4) Notes on fishway and fish screen construction activities at the Deer Flat Reservoir and tributaries thereof (Boise River Basin area) page 49. (5) Notes on visit and observations of diversion dams in the Weiser and Payette Basin; observes the fishway at the Black Canyon Dam on the Payette River, and salmon passage efeectiveness is questioned, but it is stated that considerable numbers of salmon were caught in upper water of the Payette river in 1920, pages 53-56. (6) Notes an estimate of five hundred ditches on the Lemhi River and its tributaries, page 58.

Idaho State. 1923. Ninth biennial report of the Fish & Game Warden of the State of Idaho, 1921-1922. Otto M. Jones, State Game Warden; Boise, Idaho.
Abstract: (1) Photographs of sections of the upper Salmon River below the Middle Fork are illustrated on pages 16 and 17. (2) Notes and describes problem of constructing fishways at dams used for flooding/water release purposes of ponding and flushing logs downstream. State policy appeared to allow the watershed to be logged off using these dams as log transport mechanisms; fishways were not used during this watershed use phase (logging) because continuous stream flow was not available, page 36. (3) Notes on a photograph of the fishway that was installed by the Idaho Power Company at the Swan Falls Dam on the upper Snake River, during the 1921-1922 biennium, pages 36-38. (4) Note that during the 1921-1922 biennium, 58 dams were inspected, 25 fishways were constructed, and 11 dams were removed., page 38. (5) Notes that Idaho Fish & Game laws provide the department an ideal fish screen law, and describes the law, pages 38-39. (6) Photographs of the Sunbeam Dam and fishway project are illustrated on pages 40-41.

Idaho State. 1925. Tenth biennial report of the Fish & Game Warden of the State of Idaho, 1923-1924. R.E. Thomas, State Game Warden; Boise, Idaho.
Abstract: (1) Notes that the year 1924 was marked with extreme drought of water supplies (streams, lakes, reservoirs), page 24. (2) Note that the Black Canyon Dam (US Bureau of Reclamation project) on the south fork of the Payette River is completed, and no facilities for fish passage is provided. Mentions that experiments of other states show that it is not practical to construct fishways at dams over 50 feet in height, page 27. (3) Notes that the policy of states, like California, require that a power company or private enterprise shall operate a fish hatchery, at its own expense, in lieu of building a fish ladder, page 27. (4) Note that desirable fish species were for the first time planted in waters of the Payette, Boise, Challis, Selway, Clearwater, and Nez Perce National Forests - a cooperative effort of the Forest Service and Idaho Fish & Game, page 95. (5) Note that the Middle Fork of the Salmon River is rugged and variable in character, and is a beautiful stream wholly within timbered areas of the National Forests, page 38. (6) Notes/table of fish plantings in the Middle Fork of the Salmon River, page 100. (7) Notes that redfish (kokannee?) were successfully planted in Big Redfish Lake in 1921, page 101. (8) Note on the establishment of a small summer fish hatchery on the North Fork of the Payette River near Cascade, Idaho, page 116. (9) Notes that the Grangeville hatchery is established by the Commercial Clum of Grandeville (per Idaho Fish & Game Department) on Clearwater River near Grangeville, Idaho; eggs will be collected in the Clearwater and Lochsa basin, page 117. (10) Notation that small numbers of chinook salmon fingerlings are handled at Sandpoint and Hayspur Hatchery facilities, page 119. (11) Note of policy that every lake and stream is entirely

different in charcteristics, and must be treated in an individual manner, page 126.

Jaske, R. T. and J.B. Goebel. 1967. Effects of dam construction on temperatures of the Columbia River. Journal of the American Water Works Association 59: 935-942.
Abstract: Author analyzes and correlates water temperature data/measurements (perhistorical records 1933-1965) of Columbia River dam projects (Priest Rapids, Rocky Reach, Rock Island, and Grand Coulee) to determine efffects of dams on water temperature in Columbia River. Concludes that (1) erection of low head reservoirs on the mainstem Columbia has not produced significant change in average temperature of the river, (2) the erection of Grand Coulee Dam on Lake Roosevelt has resulted in a 30 day delay in the transport of water through the reservoir system, and (3) the erection of dams and reservoirs decreases expected variance in water temperature.

Johansen, Dorothy and Gates, Charles. 1967. Empire of the Columbia - a history of the Pacific Northwest. Second Edition; Harper & Row Publishers, New York, Evanston, and London 654 pages.
Abstract: The authors provide a comprehensive history of the Columbia River basin in terms of its native inhabitants, early exploration and settlement, natural resources exploitation, industries/commerce development, politics and socio-economic policies. The following historical notes of historical milestones and fisheries/natural resources information were derived: 1) On 3 December 1805, Lewis and Clark camp in a primitive log shelter on the south side of the Columbia River at the mouth of the Lewis and Clark River, and call the camp site Fort Clatsop after the Indians in the vicinity; p. 78; 2) In 1808, Finan McDonald (North West Company) built a temporary depot at Kootenai Falls; p. 89; 3) In September 1809, David Thompson (North West Company) selected the site for Kullyspel House on the eastern shore of Lake Pend d'Oreille; p. 89; 4) In the fall 1809, David Thompson (North West Company) bult Saleesh House near Thompson Falls on the Clarke Fork River, p. 89; 5) In 1810 or 1811, Finan McDonald and Jacques (Joco) Finlay of the North West Company built Spokane House near the present city of Spokane, WA; p. 89; 6) In 1811, David Stuart (expedition of Astorians-Pacific Fur Company) established Fort Okanogan at the confluence of the Okanogan and Columbia rivers; p. 102; 7) In December 1813, the North West Company takes possession of Fort Astoria, which was sold involuntarily by the Pacific Fur Company (John Jacob Astor) and it is renamed Fort George; p. 105; 8) In 1818, Donald McKenzie (North West Company) built Fort Nez Perce (REVIEWER's NOTE: later operated by the Hudson Bay Company and called Fort Walla Walla) as a trade center for the Nez Perce Indians, and a supply depot to the vast area explored and trapped by the north West Company; p. 107; 9) In 1819, Donald McKenzie (North West Company) ascended the Snake River from the mouth of the Clearwater River to the Burnt River in a boat ("bateau") p. 107; 10) In the summer of 1818, Fort George (Fort Astoria) was restored to possession of the US (per the Treaty of Ghent, 1814),and the North West company remained in charge of the post as a concession of John B Prevost (special agent of the US Government); p. 111; 11) In the fall of 1818, the US and Great Britain agree to the convention of 1818 which established the boundary between the US and Canada at the 49th parallel from the Pacific to the Rockies; p. 112; 12) In 1838, a small water-powered sawmill, located about five miles east of Fort Vancouver (operated by John McLoughlin, Hudson bay company), employed six to ten saws and twent-five men, and produced lumber for rebuilding the Fort; p. 133; 13) In 1828, John McLoughlin and George Simpson (Hudson Bay Company) selected a site at Willamette Falls, where Simpson reported that "whole Forests of Timber can be floated into a very fine Mill Seat...[and] Saws enough could be employed to load the British Navy." Author notes that in 1831 timbers for a mill were cut at the spot, and the project was abandoned; p. 133; 14) Author notes farming activity of the Joh McLoughlin's operation (Hudson Bay company) in the lower Columbia: a) in 1839, the plows broke heavy sod at cowlitz Farsm..., b) farming was taking place in the Tualatin and Willamete valleys, cattle grazing on the Tualatin prairies, and c) in 1833, eight families formed the nucleus of farming community called French Prairie; p. 135; 15) In 1832, Capt. Nathaniel J. Wyeth established Fort Hall on the Snake River at the mouth of the Portneuf above American Falls; p. 146; 16) In 1832,

Capt. Nathaniel J. Wyeth established Fort William at Wappatoo (Sauvies) Island at the mouth of the Willamette River, in order to fish and pack salmon; p. 147; 17) In September 1835, Capt. Nathaniel J. Wyeth's company abandons Fort Hall on the Lewis River (Snake River); p. 147; 18) In spring 1836, Capt. Nathaniel J. Wyeth's company abandons the fishing and packing operation at Wappatoo (Sauvies) Island at the mouth of the Willamette River, due to Hudson Bay Company competition; sails with a half cargo of fish; p. 147; 19) In 1839, Captain Edward Belcher, in command of a British naval squadron, arrived in the columbia River to survey the river's bar, channel, and inner anchorages, in anticipation of increased trade; p. 183; 20) In the summer of 1841, Lieutenant Charles Wilkes, commander of the US Exploring Expedition (1838-42) enters the Columbia River with two vessels; p. 185; 21) In 1848, the US Congress passes the Organic Act that created the Territory of Oreogn; p. 299; 22) Author notes that gold strikes were reported in the Santian and John Day Rivers (circa early 1850s) p. 265; 23) Author notes that herds of cattle and strings of horses move north through the Cowlitz, Yakima, Wenatchee, and Okanogan valleys to supply the mining camps (circa late 1850s) p. 265; 24) In 1860, the oregon Steam navigation Company (OSN) was organized (through a merger of small boat companies) to transport freight between portland (OR) and the mining region of Idaho; p. 279; 25) In 1862, the Oregon Steam Navigation Company (OSN) built a six-mile railroad at the Cascades on the Washington side of the Columbia River and a fourteen-mile road running from The Dalles to beyond Celilo falls; p. 279; 26) Author notes land allocations to Land Grant Railroads (Northern Pacific, Central Pacific, and Union Pacific) in the Northwest, where they were subsidized with lands from the public domain; each was to receive a 200 foot right-of-way and sections of land to help finance construction (p. 305-315). Examples of these grants are: a) Northern pacific had a grant of lands of alternate sections through the columbia River and Cowlitz River Valley of 2,000,000 acres of timber (estimated at $100 million) to build the Kalama to Tacoma railway(p.308), and b) Oregon Central Railraod (later part of the Northern Pacific, eventually merged with the Great Northern Railroad) was granted 5,000,000 acres in the Willamette, Umpqua, and Rogue River Valleys (p. 309) to connect Portland to California; 27) In 1902, the US Congress passes the Newlands Act, under which the US Reclamation Service is created; the purposes of the Newlands Act was threefold: a) plan and construct major improvements by a federal agency, b) design and carry out each project so as to provide maximum benefits for the entire area in which it is located, and c) make federally financed projects self-liquidating; p. 392; 28) In 1923, the US Reclamation Service is renamed the US Reclamation Bureau; p. 392; 29) Author notes that private ownership of pacific Northwest forest lands in 1913 as follows: a) Weyerhaeuser Timber company 26.1% of timberland in Washington, b) Weyerhaeuser Timber Company and Northern Pacific Railraod - 45.7% in Washington, c) Weyerhaeuser Timber company and Southern Pacific Railroad - 22.4% in Oreogn; p. 402; 30) Author notes that before 1911 skid logging (by oxen, horses, mechanical donkey) was done on the ground, p. 403; 31) Author describes in 1918 two plans for development of water in the Columbia Basin for irrigation were proposed: a) gravity system bringingwater for Lake Pend d'Oreille (Idaho) to the Columbia Basin (series of canals, pumps, siphons), and b) dam and storage reservoir in the Grand Coulee area: politics, multiple purpose benefits, and economic costs dictated the final decision for the Grand Coulee plan; p. 514-4517; 320 In 1907, President Theodore Roosevelt appointed the Inland Waterways Commission to study the whole question of river development; and in 1908, the Inland Waterways Commission submitted its report that emphasized the need for federal policy to emphasize multiple use projects instead of single pupose projects; p. 516; 33) In 1925, the US congress authorized House Document Number 308 for the Corps of Engineers to conduct river surveys covering matters such as flood control, power development, irrigation, navigation, and domestic water suppliesp; p. 516; 34) In 1932, the Corps of Engineers submitted their report on the Columbia River, referred to as the "308 Report ," to the US Congress; this report essentially recommended proceeding with the Grand Coulee project; and development of system of 10 multiple purpose dams on the Columbia River between the Canadian border and tidewater (Grande Coulee, Foster Creek, Chelan, Rocky Reach, Rock Island, Priest Rapids, Umatilla Rapids, John Day Rapids, The Dalles, and Bonneville); p. 516-517; 35) In 1932(?), the Washington

State Legislature set up the Columbia Basin commission to promote the Grand Coulee project and state, under this authorizatio state relief funds were used to do sme prelilminary work at the project site; p. 517;   36) In March 1933, federal monies in the amount of $60 million were channelled through the Public Works Administration, created by President Franklin Roosevelt, to build a low head dam at Grand Coulee; p. 517;   37) In 1935, the US Congress passed the Rivers and Harbors Act, which included the formal approval of work on the Grand coulee Dam project, that thus far had been carried out under presidential order of funds under the FERA and WPA programs; p. 519;   38) In 1930, the Washington State Legislature passed the Public Utility District Law, that allowed an otherwise unincorporated area to organize as a utility district (PUD) to build dams and to generate, purchase, and distribute power; p. 521;   39) In 1920, the US Congress passed the Federal Power Act, under which the Federal Power Commission was created to license companies constructing facilities on navigable waters (which by definition came under federal jurisdiction); p. 521;   40) In 1937, the US Congress passed the Bonneville Administration Act that a) the Bonneville Dam facilities be operated by the Corps of Engineers, b) the Grand Coulee Dam be managed by the Bureau of Reclamation, and c) a civilian administration, appointed by the Secretary of Interior, be charged with the marketing of energy produced at both Bonneville and Grand Coulee dams; p. 527;   41) Author notes that in 1902 a raging fire devastated 700,000 acres of timber in Lewis County, Washington (known as the Yacolt burn); p. 544;   42) In 1949, the Washington State legislature declared the lower Columbia River watershed a sanctuary for the special purpose of building up native fish stocks; p. 557;   43) In 1955, the City of Tacoma started construction of the Mayfield Dam project on the Cowlitz River, under authorization of the US Federal Power Commission; and the State of Washington instituted court action on behalf of the Washington State fisheries agencies, p. 57;   44) In 1958, the US Supreme Court rules against the instituted court action of the State of Washington on behalf of the Washington State fisheries agencies regarding the Mayfield Dam project on the Cowlitz River, p. 557;   45) In 1965, the City of Tacoma started construction of the Mossy Rock Dam project on the Cowlitz River, under authorization of the US Federal Power commission; p. 557;   46) In 1948, the US Fish & Wildlife Service, the Washington Department of Fisheries, and the Oregon Fish Commission enter a 20 year cooperative agreement, the Lower Columbia Fisheries Compensation Program, of fisheries research and development in the lower Columbia River watershed, p. 558.

Lelbhardt, Barbara. 1990. Law, environment, and social change in the Columbia basin: the Yakima Indian Nation as a case study, 1840-1933. Dissertation for Doctor of Philosophy in Jurisprudence and Social Policy, University of California at Berkeley, 1990, 488 pages.
<u>Abstract</u>: A. Author provides a comprehensive history and legal premise of water rights and fishing issues of the Yakima Indian Nation within the Yakima and Columbia rivers basin; includes an extensive bibliography. Documents the social and economic dependence of the Yakima Indians on fisheries resources; provides some insight of salmon, water, and habitat of the Yakima Basin prior to and during development of fisheries and agricultural industries in the Yakima basin. The following historical notes of historical milestones and fisheries resources information were derived: 1) In 1850, the US Congress passes the Land Donation Act which provided for the appropriation of lands from the public domain in the terriitories (e.g. Oregon Territory); p. 104;   2) In 1873, the Washington Territorial legislature passed an act that allowed Yakima County farmers, miners, manufacturers- or anyone that could use water for "beneficial purposes" to construct diversion works necessary to convey water onto their non-riparian lands (An Act Regulating Irrigation and Water Rights in the County of Yakima, Washington Territory, 13 November 1873, Washington Laws 520-522), p. 245;   3) In 1890, the Washington State Legislature passed a statute that provided for the appropriation of any unclaimed waters 'from any natural streams or lakes in the state" for irrigation and permitted the condemnation of rights of ways for ditches to carry water 91890 Washington laws 706, paragraph 1), p. 246;   4) In 1917, Washington State Legislature passed a law adopting an administrative water code that recognized prior appropriation as the only means by which an individual could acquire water rights (Riparian and Appropriation Rights, Washington laws 447-68), p. 247;   5) Around 1867, the

Meninick/Shumit Ditch on Simcoe Creek (tributary to the yakima River) was constructed on the Yakima Indian Reservation; p. 250; 6) In 1906, the US Congress passed the Jones Act, that provided for funding the on-reservation portion of the US Reclamation Service's larger yakima irrigation project by allowing each Indian allottee to sell 60 acres of his or her allotment for bring water to the remaining twenty acres under the project; p. 254-255; 7) In 1891, the Northern Pacific, Yakima, Kittitas Irrigation Company, who filed on 1000 cfs of Yakima River water (in 1890) began construction of the Sunnyside irrigation project, and in that year built an adjustable dam (at the old Yakima dance house site) that was believed to have the capability to appropriate virutally the entire low flow when the river was at its lowest point; p. 258; 8) In 1892, the first 25 miles of the Sunnyside irrigation project is dedicated; p. 259; 9) In 1893, the Northern Pacific Railroad (owner of the Northern Pacific, Yakima, Kittitas Irrigation Company) declares bankruptcy during the Panic of 1893; p. 259; 10) In 1894, the US Congress passed the Carey Act which allowed states to choose up to one million acres of arid land for irrigation development; p. 260; 11) In 1895, the Washington State legislature set up the Arid Lands Commission to investigate the possibility of developing lands between the Yakima and Columbia Rivers, above the Sunnyside irrigation project; p. 260; 12) Up to and through the 1890s individuals, farmers cooperatives, and ditch companies invested in their own small scale irrigation systems; p. 260; 13) In 1902, the US Congress passed the Newlands Act which created the Reclamation Service with the US Department of Interior; the Reclamation Service was empowered to provide planning, engineering, and financial assistance for irrigation projects; p. 261; 14) In 1906, the US Reclamation Service purchases the Sunnyside irrigation project from the Northern Pacific, Yakima, Kittitas Irrigation company, p. 241; 15) In 1908, the US Supreme Court issued its decision on the Winters vs US, where the court held that Indians reserve water rights even when their treaties made no express mention of water; p. 270; 16) In 1905, the Washington irrigation Company, on their attorneys' advice blew up the dam of Union Gap irrigation Company at Lake Cle Elum when insufficient water thretened to destroy the crops on the Sunnyside Project; . p. 272; 17) In 1889, the Ahtaneum Creek (tributary of the Yakima River) was virtually drained of water by irrigators on the north side of stream where it bordered the Yakima Indian Reservation; p. 275; 18) In 1891, the Ahtaneum Creek (tributary of the Yakima River) was virtually drained of water by irrigators on the north side of stream where it bordered the Yakima Indian Reservation; . p. 275; 19) In 1892, (a dry summer), the US Bureau of Reclamation attempted to re divert water of Ahtaneum Creek, virtually drained of water by irrigators on the north side of stream where it bordered the Yakima Indian Reservation, but the north-side irrugation users brought suit against the Bureau's action; . p. 276; 20) In 1905 the US Secretary of Interior allocated 2065 cfs and 147 cfs of yakima River water respectively to the white water users and Yakima Indian water users; p. 292; 21) J.H. Lynch (in 1901) noted that the more water flowed in the Ahtaneum Creek (tributary of the Yakima River) in the early days than at present, and the runoff was also later, coming mostly after July 1st; he said " the watershed had not been burned off nor grazed excessively by sheep, hence more water". ; p. 310; 22) In 1908, the Washington State Fish Commissioner asked the Reclamation Service to include fish ladders at Yakima project dams, but was told that fish ladders were not feasible, nor was the Reclamation Service responsible for meeting state fishery laws; p. 310-311; 23) The Washington State Fish commissioner (Mr. Darwin) closed the Klickitat River to food fishing (white commercial and Indian fishing) - not sport fishing - between 1915 and 1917, p. 373.

Moore, M., K. McLeod, and D. Reed. 1960. Conservation of fisheries resources in the Columbia River Basin. Fisheries, Volume III, Washington Department of Fisheries, 344 pages.
Abstract: Volume III is comprised of revised editions of Volumes I and II, plus additional material. A general synopsis of water developments in the Columbia River basin, and the resulting salmon declines are noted; illustrates scope of water developments and their impacts on access to upstream areas, using a schematic for dams completed, under-construction, and planned (p. 122-123). discusses contribution of Columbia River stocks to coastal and inshore fishing areas. A historical review of hatcheries in the State of Washington is presented (pages 331-344); major phases of salmon

hatcheries in Washington are noted as: Phase One 1890-1905: Period of concentration on the taking of large numbers of eggs with frey releases and very limited or no rearing and feeding. Phase Two: 1906-1936: Period of large egg taking and short-term rearing. Phase Three: 1937-1945: Period of smaller egg takes, intensive rearing in ponds, migratory and disease studies. Phase Four: 1945-1949: Expansion and modernization of hatchery system with new stations, rebuilding of old stations and institution of the Columbia River Fisheries Devlopment Program. Phase Five: 1957-to date(1960): Period of initiation and development of fish farms in conjunction with hatcheries with goal of maximum use of all available fresh and saltwater areas possible for salmon production at reduced cost. Page 333.

Needham, P. R. 1939. Migratory fishes and dam construction in west coast rivers. Transactions of the 4th North American Wildlife Conference 1939: pages 300-304.
Abstract: Author provides synopsis of man-induced activities (railroad construction, hydraulic mining, irrigation, domestic use) and their impacts on migratory salmonids in West coast rivers. Dam construction (Bonneville and Grand Coulee Dams) is used as a particular of current activities that threaten anadromous salmonids; mentions that the Grand Coulee salvage operation at Rock Island Dam, and provides fish counts at Rock Island (1934-1937). Short discussion is given regarding dam construction activities and the purposes of the Sacramento-San Joaquin water plan. Recommends that mandatory fish investigations should be conducted for at least 5 years prior to actual start of construction of dams in waters affecting runs of migratory fish.

Netboy, Anthony. 1958. Salmon of the Pacific Northwest: fish versus dams. Binfords & Mort, Publishers, Portland, Oregon. 122 pages.
Abstract: Author discusses: (1) Life history and migrations of Pacific species in the Columbia River; (2) Indian fisheries and methods prior to and after the settlement of white men in the Columbia basin; (3) Historical and contemporary alterations of the Columbia River (e.g. land use, pollution, and dams); (4) Fish passage, management, and propagation methods to overcome the human alterations in the Columbia River.

Netboy, Anthony. 1980. The Columbia River salmon and trout; their fight for survival. University of Washington Press, Seattle and London. 180 pages.
Abstract: Author documents and describes (1) the pristine Columbia River; (2) The Columbia River Indian fishery; (3) life history of Columbia River salmon and steelhead trout species; (4) Intrusive alterations (e.g. irrigation, pollution, dams) of the watershed and consequences (e.g. decline of Pacific salmon species); (5) Fishery compensation programs in the Columbia River; and (6) Endanger species. Contains a comprehensive bibliography of Columbia River related historical and contemporary references.

O'Malley, H. 1935. Some problems which confront the fishery experts in the construction of dams in the Inland Empire. Northwest Science IX(1): 23-24 (February, 1935).
Abstract: Author presents the problems of dam construction in the Columbia River as 1)successful passing of adults over dams, 2) getting small fish and steelhead kelts back to the sea, and 3) the complex problem of changed conditions brought about by the dams and artificial lakes. Mentions the four commissions that control the destiny of commercial and game fishes in the States of Washington and Oregon; the annual value and employment associated with the fishing industry; the budget and employment figure projected for construction of the Bonneville dam; fishways associated with the Rock Island dam; and the impassability of Grand Coulee dam. Discussion of the biological effects on native fish species, based on experiences in New England and other parts of the US; generalizes and predicts the ecological changes of the habitat and species resulting from water impoundments on the Columbia River. Briefly mentions the requirement for proper screening of power intakes and immediate steps to combat pollution, due to industrialization of the Inland Empire.

Oregon Master Fish Warden. 1909. Report of Oregon Master Fish Warden. Pacific Fisherman Annual Review, February 1909, pages 32-37. Seattle, Washington.
Abstract: Author provides an extensive report on the status of the Oregon fish resource. Highlights of this article are: 1) irrigation ditches present a serious problem to young salmon due to the lack of prevention in diversion to fields; mentions that most of the diversion dams have fishways that provide passage for adult salmon. 2) Passage of laws banning fishing above the Sandy River, and restriction of lower Columbia River commercial fishing; extensive discussion of needed legislation, and closed areas/seasons. 3) Boundary problems between Oregon and Washington, in terms of fishing activities and enforcement of regulations. 4) Hatchery activities in the Columbia River (District No. 6).

Oregon State. 1907. Annual Report of the Department of Fisheries of the State of Oregon for year 1907 to the legislative assembly, twenty-fourth regular session (1907). State of Oregon, Salem, Oregon. W.S. Duniway, State Printer, 1907. 78-79 p.
Abstract: The Master Fish Warden (H.G. Van Dusen) states that "in view of the fear that the salmon of the Columbia River was not being rehabilitated through the medium of the system of artificial propagation, I am very pleased to be able to chronicle...that there has been a considerable increase in salmon produced by the Columbia River this year over last year..." This increase was for Chinook and steelhead in both Washington and Oregon. He mentions that chinook and steelhead over past five years, but decreases in silversides and bluebacks; and says that artificial propgation has been of assistance in the increase of chinook and steelhead. Page 7. Notes that hatcheries select to use large and strong fish (males) for egg fertilization, and do not use small males; attributes this selective practice to maintaining the 25 lb. average weight of chinook ovr the past seasons. Page 8. Notes that egg collection at facilities in Snake and Wallowa Rivers was very unsatisfactory, even though the fish racks were operated early, few fish go upstream this far, and those that did were three males to one female. But the eggtake at federal and state hatcheries (Oregon and Washington) below Celilo Falls the eggtake was good. page 13. Notes an inspection of the Santiam River (Willamette tributary) in regards to sites for artificial propagation activities. pages 17-18. Mentions that the first contract for the construction of the fishway over the falls of the Willamette River at Oregon City was completed and accepted by the state engineer on November 29, 1904. Mentions that as the Willamette Pulp and Paper Company completed a concrete dam at the falls, this dam caused water hydraulic problems in the fishway (upper pools) - the gradient of the upper portion of the fishway was too steep. This situation caused problems for the spring chinook migration over the falls. Surveys were conducted to make recommendations and provide cost estimates to remedy the fishway problem. Pages 20-24. Notes that hatchery station was established and operated on the McKenzie River at a site situated a couple of miles below Gates Creek; mentions that they took spawn of the early variety of chinook from August 15 to October 15th. States that liberated approximately 1.5 million fry of this 1905 brood year into the McKenzie River in the immediate vicinity of the station during the months of January and February 1906. Pages 75-76. Notes that Wallowa Hatchery station did not secure any sockeye salmon spawn during the 1905 BY - (note: appears that this BY cycle is extinct or some lower river blockage prevented sockeye from upper area). page 78. Notes that by leaving racks of the Wallowa Hatchery in the river late, they discover a late run of silversides that passed the racks in the month of November, but were unable to hold them to spawning due to severe cold weather conditions. page 78. Notes that the Ontario hatchery station (Snake River at Swan Falls) left their rack in river late (until November 23rd) in hopes of collecting late running silversides, but none appeared. Page 84. Mentions the 1901 law passed by the Oregon State legislature that prohibited fishing above tide water and established fishing deadlines on all coast streams. page 129. Notes that fishway for the falls of the Willamette River at Oregon City provides excellent passage for early chinook in 1906, Page 132. Mentions request for two special deputy fish wardens to enfore laws regarding water diversions and dam obstructions that are causing mortality of young migrants going to sea; notes causes due to extensive development of power/mill dams across streams and irrigation projects that are taking water for irrigation puroses. Pages 134-135. Notes the needs for laws that

assure better escapement to the spawning ground in the Columbia River; infers that hatcheries alone will not solve the problem of diminishing harvest to fishermen in the Columbia River. page 137. Notes that 1906 BY salmon returns (chinook and sockeye) in northeastern Oregon (Wallowa and Ontario Hatcheries) were poor; and that salmon runs in the lower Columbia River below Celilo Falls appeared to have been successful in running the gauntlet of net fishermen in the lower Columbia, Page 139. Mentions that he must secure eggs in order to assure shortage of Snake River stock (at Ontario Hatchery) four to five years hence, based on "...theory that Salmon return to the stream of their nativity to spawn..." Page 140.

Oregon State. 1913. Biennial report of the Department of Fisheries of the State of Oregon to the legislative assembly, twenty-seventh regular session, 1913. State of Oregon, Salem, Oregon. Willis S. Duniway, State Printer, 1913.
Abstract: Master Fish Warden (R.E. Clanton) describes the enactment of a policy of feeding fry in retaining ponds, at Oregon state hatchery facilities, until they are a sufficient age and size to protect themselves against predators. pages 13-16. Mentions that the policy of retaining and feeding fish to a larger size necessitates the need for investigations and research for some other food, other than liver, that is equal in nutritive value and less expensive. page 16. Notes the acceptance by the Bonneville Hatchery of 1.5 million sockeye salmon eggs from the US Bureau of Fisheries that were source from Yes Bay in southeastern Alaska. page 18. Mentions that the construction of dams associated with irrigation projects on the streams east of the Cascade Mountains have practically destroyed all of the spring chinook spawning grounds, and forced the state to secure the spawn of this species from the Willamette River and its tributaries. page 63. Note that the operations of the Salmon River hatchery in the Sandy River basin was abandoned in the fall of 1910 due to lack of chinook spawned, but was operated in the spring of 1912 to secure steelhead spawn. page 71. Mentions that chinook and silverside spawn were taken at the Wallowa hatchery station in 1912, page 72. Mentions improvements to the fishway (south-side) at Spray Dam (irrigation dam operated by farmers) on the John Day River is in good conditon, and recommends the construction of an additional fishway (north side). page 93-95. Notes the concept of constructing auxiliary retaining ponds on small streams near the Bonneville Central hatchery in order to rear salmon fry for release. Page 97-98. Notes on dietary/fish nutrition investigations for feeding fish different dietary mixture. pages 98-100. Discusses marking techniques and marking experiments to determine movements of salmon released from artificial propagation facilities. page 100-103. Mentions that the 1909 Oregon legislature appropriated $1000 for the purpose of destroying seals and sea lions at the mouth of the Columbia River.

Oregon State. 1939. Biennial report of the Fish Commission of the State of Oregon to the governor and the fortieth legislative assembly, 1939 . Fish Commission of the State of Oregon, 1939.
Abstract: Reports that an authentic effort has been made to record all barriers, such as dams and other barriers to salmonid fisheries resources, in the state of Oregon. Information includes the number, type, location, height, length, etc. of barrier. Records will be analyzed and obstructions classified as to types, purposes, and possible effects on spawning areas; and finally analyzed as to whether or not adequate passage ways for fish are provided at each. page 29. A report of the Department of Research for the biennium ending 1938 is provided by Willis H. Rich, the temporary director. The Fish Commission of Oregon formed this department in 1938, page 35. Notes the policy of transferring fish by truck from a station on one stream to another is undesirable since it disturbs the homing instinct of salmon; in the future, pending available funds, the policy will be to establish and operate small stations on such streams of the state as are suitable for salmon runs. page 41. Note that the Bonneville station has been developed further as an experimental station for the development of methods for improvement of hatchery practices. page 42. Tables are provided that illustrate no., size at release (length in inches), and age of salmon liberated from Oregon facilities in 1937 and 1938, page 49.

Oregon State. 1941. Biennial report of the Fish Commission of the State of Oregon to the governor and forty-first legislative assembly, 1941. Fish Commission of the State of Oregon; Salem, Oregon, State Printing Office, 1941.
Abstract: Notes the plans for a series of dams on the tributaries of the Willamette River, which poses a serious threat to the maintenance of some very important Columbia River salmon runs. At present (1940) projects have started on the Row, Coast Fork and Long Tom Rivers. page 38.

Oregon State. 1945. Biennial report of the Fish Commission of the State of Oregon to the governor and forty-third legislative assembly, 1945. Fish Commission of the State of Oregon; Salem, Oregon, State Printing Office, 1945.
Abstract: Notes (1) that Mr. Livingston Stone of the US Fish Commission employs the practice of artificial propagation of salmon on the Clackamas River near the mouth of Clear Creek in 1876, page 41. (2) Due to the construction of past and future dams on the Columbia River and its tributaries it generally agreed by scientists and others that the hope of maintaining and supporting the salmon runs in the Columbia Basin will rest largely upon artificial means of production. page 41. (3) That based on recent feeding experiments and observations of migratory habits of silver chinook and blueback salmon it has been determined necessary to feed these species for a period of 14 months at stations located onstreams in which the spawning areas are limited or destroyed. page 41. (4) The construction (proposed) of the Umatilla Dam on the Columbia will be much higher than Bonneville dam, and will constitute an insurmountable barrier for migration of salmon and salmon producing areas above the project will be lost for all time; thus is was decided to develop salmon production to the fullest extent in tributaries of Columbia below the proposed dam site. page 42.

Oregon State. 1949. Biennial report of the Fish Commission of the State of Oregon to the governor and forty-fifth legislative assembly, 1949. Fish Commission of the State of Oregon; Salem, Oregon, State Printing Office, 1949.
Abstract: Notes that (1) of the Engineering Division has added hundreds of miles of spawning area for natural production through removal of impassable barriers and emplacement of fish ladders at falls and dams; and removal of logging debris from streams. page 5. (2) The Hatchery Division has restocked areas, rehabilitated by the Engineering Division, with young fingerling salmon, page 5. (3) More factual information of fisheries resources have been obtained by the Research Division, page 5. (4) A new fishway was installed at the Bear Creek Lumber Company Dam on Bear Creek (tributary of the Salmon River in Lincoln County). page 13. (5) The fishway at Sherar Falls on the Deschutes River, which was started in 1945, is completed. Spring chinook, blueback salmon, and steelhead frequenting this stream are now able to readily pass this natural falls at all water levels. page 14. (7) A new concrete fishway is completed at the Mountain States Power Company diversion dam on the South Santiam River, near Lebanon, Oregon; a cooperative project of the Oregon Game and the Oregon Fish Commission. (8) Hatchery biology and various factors (fish diseases, diets, and best time of liberation) are currently being studied. page 17. (9) Fish Commission started a new series of publications titled "Fish Commission Research Briefs," on April 1948, page 18.

Pacific Fisherman. 1903. Dams jeopardize fish industry. Pacific Fisherman I(3): 5.Seattle, Washington and Vancouver, B.C.
Abstract: Notes the development of dams for power, irrigation and milling purposes are a jeopardy to the fishing industry due to their increasing number, and barrier to migration. Mentions that present law requires the construction of fishways at dams for salmon to ascend to areas above barriers; states immediate steps should be taken to remedy the matter.

Richardson, L. R. 1934. Observations on the effects of dams on lakes and streams. Transactions of the American Fisheries Society 64: 457-460.
Abstract: Notes that impoundments prevent migration of desirable species, and some physiographic

factors/alterations resulting from impounding waters.

Scheufele, Roy W. 1970. History of the Columbia Basin Inter-Agency Committee. Prepared under sponsorship of the Pacific Northwest River Basins Committee.
Abstract: A. Author presents a comprehensive details regarding the genesis, policy & objectives, actions, and chronology of meeting/events for the Columbia Basin Inter-Agency Committee, during the period of 1946-1967. Provides information regarding governmental legislation (laws) and policy framework, institutional relationships with other state and federal agencies in the Columbia basin, and accomplishments of the agency. NOTE: Reference is very important in terms of its description of policy and philosophy governing water and fisheries policy in the Columbia River basin during the period of 1946-1967. B. Genesis of Agency and Federal Action (pages 3-9): 1) In 1902, the US Congress passes the Reclamation Act; 2) In 1905, the US Congress establishes the US Forest Service; 3) In 1920, the US Congress passes the Federal Power Act; 4) In 1925, the US Congress passes a statute that directed the inventory of those streams in the US where power development appeared feasible and practical in coombination with navigation, flood control, and irrigation; 5) In 1927, the US Congress passes the River and Harbor Act, which commenced the survey of Pacific Northwest streams, that were inventoried under the 1925 congressional statute; 6) In 1936, the US Congress passes the Flood Control Act; 7) In 1936 (?) the US Congress establishes the US Soils Conservation Service; 8) In 1943, the Pacific Northwest Regional Planning Commission, an arm of the National Resources Planning Board, is abolished by the US Congress; 9) In July 1943, the governors of the Pacific Northwest States establish the Northwest States' Development Association to coordinate and correlate plans of member states as they relate to unified development of all the resources of the Pacific Northwest; 10) In December 1943, the Northwest States' Development Association prepares a program and governing principles of emergency and immediate post-war projects for the development of the Columbia Drainage Basin; 11) In summer 1939, the US Departments of Interior, Agriculture, and War (Corps of Engineers) enter a tripartitie agreement to coordinate their work, both in Washington DC and field regions; 12) In December 1943, the US Federal Power Commission joins the tripartite of the US Departments of Interior, Agriculture, and War (Corps of Engineers), and execute a quadpartite agreement that provided monthly meetings of these agencies to discuss restuls of studies/investigations, to adjust differences of opinions, and to promote ways/means for implementing other provisions of the agreement-representatives of these four Departments constituted the Federal Inter-Agency River Basin Commission (FIABRC); 13) In February 1946, the Columbia Basin Inter-Agency Committee, the second field committee of Federal Inter-Agency River Basin Commission, is established to facilitate progress on the multipurpose development projects presetnly authorized by congress (p. 7-9 provides details of conditions of the agreement.); 14) In 1965, the US Congress passes the Water Resources Planning Act; 15) In June 1967, the Pacific River Basins Commission takes over the functions of the Columbia Basin Inter-Agency Committee. C. A chonicle of agency meetings and general outcomes from these meetings is presented (pages 10-123) 1) In March 1947, the Assistant Secretary of Interior (Warner W. Gardner) sends a memorandum/recommendations to the Federal Inter-Agency River Basin Commission (FIABRC) that propose the construction of mainstem dams on the Columbia below Okanogan R. and on the Snake below the Salmon R., with the exception of the proposed McNary Dam, be postponed until 1958 (for 10 years) provided that alternate sources of power could be devloped to meet Bonneville Power Administration load demands; this moratorium period would allow the US Fish & Wildlife Service and state fisheries agencies to determine remedial measures (per research, studies, and planning) that could be taken to preserve the Columbia River fishery; p. 22-23); 2) On 2 April 1947, the Assistant Secretary of Interior (Warner W. Gardner) memorandum was forwarded by the Federal Inter-Agency River Basin Commission (FIABRC) to the Columbia Basin Inter-Agency Committee for study, discussion, and recommendations; 3) On 23 July 1947 at the 11th meeting of the columbia Basin Inter-Agency Committee, (a) Fred Foster (US Fish & Wildlife Service) outlined the Lower Columbia River Fishery Program, consisting of obstruction

removal, pollution abatement, diversion screening, fishway construction, hatchery construciton and fish sanctuaries - a program estimated at a cost of $20 million, and (b) a Fish & Wildlife subcommittee was established to coordinate and integrate fish and wildlife programs with water esource program; p. 25; 4) On 22 September 1947, the Fish & Wildlife Subcommittee (Columbia Basin Inter-Agency Committee) filed a report that summarized factual data relating to navigation, power, fish, irrigation, Indians, and National Defense, p. 26; 5) On 8 October 1947, at its 12 meeting, the columbia Basin Inter-Agency Committee unanimously approved and forwarded a letter to the Federal Inter-Agency river basin Commission (FIABRC) recommending that a) Grand Coulee power installations proceed, construction of Hungry Horse, Foster Creek, Detroit, and McNary Dam proceed, etc. b) authorized dams on the columbia River system not to be rescheduled, approval of the Lower Columbia River Fishery Program, and compensaiton of Treaty Indians, and c) upstream dams be authorized promptly and if authorized before 1958 they be constructed ahead of planned/unauthorized The Dalles, John Day and Arlington Dams unless the fish problem has been solved in the interim, etc., p. 26; 6) In 1950, the columbia Basin Inter-Agency Committee establishes the Fisheries Steering Committee, and this subcommittee prepares a comprehensive program of research and construction (to cost 25-50 million dollars) and proposed to finance it by a tax of fifty cents per kilowatt year (note proposal failed and caused an outcry from power interests) p. 27; 7) On 17 September 1948, at its 21st meeting, the Columbia Basin Inter-Agency Committee authorized a Technical Subcommittee for Operating Plan to prepare an integrated and coordinated operating plan for the release and control of waters in connection with Columbia River development program (note plan was never consummated) p. 32; 8) On 10 November 1948 at its 22nd meeting of the columbia Basin Inter-Agency Committee, the Corps of Engineers presented an eight volume "Review of the Columbia River and its Tributaries,: a report costing $5 million; p. 33; 9) On 28 June 1950 at its 40th meeting, the Columbia Basin Inter-Agency committee approved an interim fishery research program (prepared by the Fish & Wildlife Subcommittee) that called for studies of fish passage at river obstructions, impoundment studies, artificial propagation, and studies of life history, trends and abundance, trout habitat and pollution, at an estimated $600,000 per year - another $500,000 was included for stream development and improvement; p. 46; 10) On 19 January 1955, the Columbia Basin Inter-Agency Committee directed the Fisheries Steering Committee to a) prepare an Upper Columbia River fishery program comparable to that in effect on the Lower Columbia River, b) a program of needed fishery research for the whole area, and c) explore ways and means of implementing/financing both programs; p. 83; 1) On 13 March 1957, the Columbia Basin Inter-Agency Committee accepted the Fisheries Steering Committee report with respect to a) prepare an Upper Columbia River fishery program comparable to that in effect on the Lower Columbia River, and b) a program of needed fishery research for the whole area - established resarch priorities and recommendaitons as to what agency would carry out specific studies recommended; p. 91; 12) On 13-14 November 1963, the Columbia Basin Inter-Agency Committee heard a panel of University of Washington academicians (James Crutchfield, W.F. Royce, D. Bevan, Robert Fletcher, R.C. Van Cleave, and R.W. Johnson) carry on extensive dialogues on "Fisheries in the Pacific Northwest - the academicians view this controversial issue," Don Bevan was very critical of fishery regulation; p. 114; 13) On 14 December 1965 at the 132 meeting of the Columbia Basin Inter-Agency Committee, the Executive Subcommittee presented its recommendations on seven fishery proposals (previously submitted by the Fisheries Steering Committee on 6 October 1965) summarized as follows: Proposal 1 - Greater Committee representation for salmon and steelhead, Proposal 2 - Reduction of the use of the Columbia River water for nuclear production to reduce heat pollution of the river, Proposal 3 - Establishment of working contract with Canada on Fishery problem, Proposal 4 - Development of small watersheds for power production should be discontinued, Proposal 5 - Assure proper attention to fish requirements in any inter-basin water transfer studies, Proposal 6 - Fishery research should be continued, the Proposal 7 - The Columbia River Fishery Development program should be retained; 14) On 29 September 1966 at its second Columbia-North Pacific study review, the Columbia Basin Inter-Agency Committee accepted the report of the Water Supply and Pollution Subcommittee

entitled "Columbia River - Water Temperature Conditions and Research Requirements" report stemmed from one of the seven fishery proposals (previously submitted by the Fisheries Steering committee on 6 October 1965; p. 21); (15) On 9 June 1967, the Columbia Basin Inter-Agency committee held its last meeting, and handed over its responsiblities, function and records to the new River Basins Commission, p. 122.

Smith, H. M. 1895. Notes on reconnaissance of the fisheries of the Pacific coast of the US in 1894. US Fish Commission Bulletin, vol. XIV, 1894 (1895), pp. 223-288. Washington, D.C.
Abstract: Author notes his observations of the lower Columbia River commercial fishery and cannery operation during spring 1893. Note regarding Oregon legislation to construct a fishway at Willamette Falls. Author mentions the necessity for law to mandate emplacement of fishways at existing dams, a prohibition of the construction of additional dams, and a limitation on salmon at dams. Provides a report on the causes of salmon destruction in the headwaters, and suggested actions to stop the destruction.

Taft, A. C. 1940. A summary of the present status of dams versus migratory fishes on the Pacific coast with special reference to problems in California. Stanford Ichthyological Bulletin 1(6): 205-208.
Abstract: The author states that few of the governmental and public agencies involved in the construction of dams in western US had any knowledge of the value or importance of fish as a natural resource; mentions that fisheries representation on boards was minimal. Use California laws and statutes as an example for the eleven western states to illustrate the legal machinery with which the fisheries administration has available in his dealings with water developers.

US Bureau of Fisheries. 1924. Report of the Commissioner of Fisheries for the fiscal year 1923 with appendices. Department of Commerce , Washington, DC: Government Printing Office.
Abstract: Note about important former spawning grounds of blueback salmon of the Columbia River basin being made inaccessible by construction of power and irrigation works, and in 1922 an investigation was made to locate spawning places remaining; mentions spawning run to Sunbeam Dam (Salmon River), and an improvement to the fishway to make better access for fish bound for the Redfish Lakes, Page 17. Appendix VII: Progress in biological inquiries, 1923. Report of hte Division of Scientific Inquiry for the fiscal year 1923 (Document Nol. 956 issued February 2, 1924) by Willis H. Rich. Notes about sockeye mark, release, and adult returns of sockeye released at Herman Creek Hatchery (Oregon Fish Commission facility). Notes on Harlan B. Holmes; investigations of blueback spawning grounds in Columbia Basin, with mention to the large lakes of the upper Yakima, Wallowa, and Payette being rendered inaccessible by construction of dams and irrigation ditches, Pages 10-12. Appendix XIII: Propagation and Distribution of Food Fishes, fiscal year 1923 (Document No. 964 issued September 3, 1924) by Glen C. Leach notes operational activities of Clackamas, Upper Clackamas, Little White Salmon, Big White Salmon, Washougal, Sandy, and Salmon (Idaho) fish culture facilities, Pages 33-37. Note that salmon pack was lightest inhistory, that egg take at all facilities (state and federal) with exception of the Kalma facility was proportionately low, that the number of spawners reaching the vicinity of hte stations was larger than expected, Page 33.

US Bureau of Fisheries. 1926. Report of the Commissioner of Fisheries for the fiscal year 1925 with appendices. Department of Commerce , Washington, DC: Government Printing Office.
Abstract: Note of policy for providing passage at dams, and screening of irrigation ditches to protect anadromous fishes, Page II. Mention of marking experiments from 1916 through 1924. Note of discovery of blueback salmon spawning ground in Okanogan River, Page XIX. Appendix III: Progress in Biological Inquiries, July 1 to December 31, 1924 (Document No. 990 issued October 24, 1925) by Willis H. Rich. Notes on marking experiments; mentions recapture of 14 five year old chinook (Little White Salmon Hatchery origin) in commercial fishery, Page 51. Note about discovery of blueback salmon spawning grounds in Okanogan River, Pages 51-52. Appendix IX: Propagation

and Distribution of Food Fishes, fiscal year 1925 (Document No. 999 issued March 29, 1926) by Glen C. Leach notes operational activities of Clackamas, Upper Clackamas, Little White Salmon, Big White Salmon, Washougal, Sandy, and Salmon (Idaho) fish culture facilities, Pages 464-466.

US Bureau of Fisheries. 1932. Report of the Commissioner of Fisheries for the fiscal year 1931 with appendices. Department of Commerce , Washington, DC: Government Printing Office.
Abstract: Notes on Fish Screen and Fish Ladder Investigations; mentions fish ladders at Wapato and Sunnyside Dams on the Yakima River, Page XXIV. Apppendix III: Progress in Biological Inquiries, 1930 (issued December 4, 1931) by Elmer Higgins. Notes on Columbia River marking experiments, Page 591. Appendix IV: Propagation and Distribution of Food Fishes, fiscal year 1931 (issued April 28, 1932) by Glen C. Leach notes operational activities of Clackamas, Upper Clackamas, Little White Salmon, Big White Salmon, and Salmon (Idaho) fish culture facilities, Pages 658-660.

US Bureau of Fisheries. 1936. Report of the US Commissioner of Fisheries for the fiscal year 1934 with appendices. Department of Commerce , Washington, DC: Government Printing Office.
Abstract: Appendix III: Progress in Biological Inquiries, 1933 (issued September 26, 1934) by Elmer Higgins. Notes on investigations concerning the protection of migratory fish at power dams on the Columbia River; J.A. Craig and Harlan B. Holmes were detailed to conduct studies of the effects of Grand Coulee Dam. Mention of spawning survey of spawning streams between Rock Island and Grand Coulee, and recommendations from Fish Commissions of Oregon and Washington, Pages 347-348. Appendix IV: Propagation and Distribution of Food Fishes, fiscal year 1934 (issued June 7, 1935) by Glen C. Leach notes operational activities of Clackamas, Upper Clackamas, Little White Salmon, Big White Salmon fish culture facilities, Page 403.

US Department of Commerce. 1923. Spawning grounds of blueback salmon in the Columbia Basin. Fisheries Service Bulletin No. 92, Bureau of Fisheries, US Department of Commerce, Washington DC, January 2, 1923.
Abstract: Notes the report of Harlan B. Holmes on his investigations of the spawning grounds of blueback salmon in the Columbia River during 1922. Mentions the following: 1) all of the well known areas formerly used by blueback have been rendered inaccessible by construction of dams and irrigation ditches, 2) the blueback spawning grounds in the Yakima Basin (Washington), Payette Lakes (Idaho), and Wallowa Lake (Oregon) are closed, 3) the investigation shows that a run of blueback pass up the Salmon River in Idaho at least as far as Sunbeam Dam, bound for the Red Fish lakes, and 4) evidence of blueback into Red Fish lakes justifies providing an efficient passage over Sunbeam Dam, p. 4-5.

US Department of Commerce. 1929. Improvements in fish screens for reducing losses in irrigation ditches. Fisheries Service Bulletin No. 164, Bureau of Fisheries, US Department of Commerce, Washington DC, January 2, 1929.
Abstract: Notes: 1) Millions of salmon are lost to irrigation canals and ditches during their seaward migration; 2) The US Bureau of Fisheries secured Shirley Baker, an engineer of San Francisco, CA, to study devices in overcoming fish losses to irrigation canals/diversion; 3) Over 30 projects in Montana, Oregon, Idaho and Washington were visited; 4) Investigations disclosed that the mechanical screen type developed by the Oregon State Game Commission worked satisfactorily for smaller installations; 5) Much information for principles of screening designed resulted from studies of Professor F.O. Mullen, department of electrical engineering, Oregon Agricultural College; 6) T.H. Burkey of Pasadena, CA asked for the opportunity to demonstrate his screen design, and it worked well during a test on a 30 foot wide canal; 7) Investigators studied fish ladders for carrying fish over dams, and concluded that for dams over 100 feet or more no fish ladders or mechanical lifting devices were found in successful operation, p. 1-2.

US Department of Commerce. 1934. Bureau receives appropriation for Columbia River salmon work. Fisheries Service Bulletin No. 230, pages 1-2, Bureau of Fisheries, US Department of Commerce, Washington DC, July 1, 1934.
Abstract: Notes that the Emergency Appropriation Act for 1935 included a provision for further work by the US Bureau of Fisheries on the propagation of salmon in the Columbia River district - $24,140 to conduct practical and scientific investigations and research relative to salmon fisheries, and $9,650 for repairs and alterations of the Bureau's present hatcheries in the district. Three research projects are proposed for fiscal year 1935: 1) A statistical study of the Columbia River fishery to determine whether or not the fish populations are decreasing in abundance at such a rate that additional protective measures are needed and analysis of the component parts of the salmon runs; 2) A study of migratory fish at power dams and irrgation canals in the Columbia River system to determine the success of the various devices employed for passing the migratory species over these obstructions; and 3) A biological study of the Columbia River fishery that includes a biological survey of all tributaries of the Columbia River, which form the present and past spawning grounds for migratory species, to determine the total spawning areas in each tributary, the extent to which unavailable areas can be recovered, and the effect of pollution and other unfavorable factors reducing the success of natural production; it will also include observation of life histories of various species, and studies of methods of artifical propagation and transplanting of migratory species to determine the possiblity of restoring depleted runs, of restocking tributaries that are now unproductive, and of improving the quality/ charactereof various runs of fish. p.1.

US Department of Commerce. 1934. Bureau receives appropriations for Columbia River salmon work. Fisheries Service Bulletin No. 230, p. 1-2. US Department of Commerce, Washington, DC.
Abstract: Describes the Emergency Appropriation Act for 1935 to further the work of the US Bureau of Fisheries on the propagation of salmon in the Columbia River district; provides the description of research work to be conducted during 1935 in the Columbia River: 1) statistical and relative abundance studies, 2) protection of migratory fish at Columbia River power dams and irrigation projects, and 3) biological survey of the Columbia River tributaries.

US Department of Commerce. 1935. Bureau participates in northwest scientific meeting. Fisheries Service Bulletin No. 237, p. 5. US Department of Commerce, Washington, DC.
Abstract: Note of attendance and presentations by F.A. Davidson, J.A. Craig, and H.B. Holmes at the Northwest Scientific Association at Spokane, Washington, on 28 and 29 December. Craig presented paper on influence of dams and irrigation on migratory fish species; H.B. Holmes presented paper on proposed methods and devices to pass fish over Bonneville Dam.

US Department of Commerce and Labor. 1917. The question of fishways. Economic Circular No. 24, Bureau of Fisheries, issued May 8, 1917.
Abstract: Author (R.E. Coker, assistant in charge of scientific inquire) provides a paper regarding 1) the function of a fishway, 2) conditions governing the necessity for a fishway, 3) species of fish to be considered in connetion with fishways, and 4) summary and general conclusion. Notes that Bureau of fisheries knows of no fishways in US "that sucessfully pass salmon over dams more than 20 feet in height, and doubtless there are few fishways successful for dams over 12 feet in height, even for salmon." p.4

US Fish and Wildlife Service. 1947. A program of rehabilitation of the Columbia River fisheries. Prepared jointly by State of Washington Department of Fisheries and State of Oregon Fish Commission, in cooperation with US Fish & Wildlife Service. 23 pages.
Abstract: An informational pamphlet that provides an historical synopsis of federal dam construction (Bureau of Reclamation dams) in the Columbia basin; includes a 3-page table that gives vital statistics of Bureau of Reclamation dams in the Columbia watershed (facility operation, date of fish screeen

operation, and geographic location). Outlines a six-year work program (type of work and estimated costs) for salmon fisheries rehabilitation.

Ward, H. B. 1927. The influence of a power dam in modifying conditions affecting the migration of salmon. Proceedings of the National Academy of Sciences, Vol. 13, No. 12, December 15, 1927, pages 827-833.
Abstract: Author describes characteristics of Pacific Northwest streams that are inhabited by Pacific salmon species, and where water power/ dams projects are built. Discusses factors (biological and environmental) that affect migratory movement of salmon in streams- particularly water velocity and temperature; and the effects of dams on this migratory behavior, with respect to movement to and from the natal areas of salmon. Reports on efectiveness and associated problems of fish passage/handling devices to transport salmon to natal areas above a power project. Information and conclusions derived from author's investigations in the Baker River/ Lake Shannon (tributary to the Skagit River in Washington State); some conclusions based on Alaska sockeye investigations.

Ward, H. B. 1929. Further studies on the influence of a power dam in modifying conditions affecting the migration of salmon. Proceedings of National Academy of Science, Vol. 15, No. 1, January 15, 1929, pages 56-62.
Abstract: Author describes characteristics of Pacific Northwest streams, that are inhabited by Pacific salmon species, and where water power/dams projects are built. Discusses factors (biological and environmental) that affect migratory movement of salmon in streams - particularly water velocity and temperature; and the effects of dams on this migratory behavior, with respect to movement to and from the natal areas of salmon. Reports on effectiveness and associated problems of fish passage/handling devices to transport salmon to natal areas above a power project. Information and conclusions derived from author's current and previous investigations in the Baker River/Lake Shannon (tributary to the Skagit River in Washington State); some conclusions based on Alaska sockeye investigations.

Washington State. 1907. 16th and 17th annual reports of the state fish commissioner and game warden: 1905-1906. State of Washington Department of Fisheries and Game, Seattle, Washington. C.W. Corham, Public Printer, 1907.
Abstract: The commissioner (John L. Riseland) discusses the situation of fishing, fishing seasons, and disjointed regulations of Oregon and Washington in the lower Columbia River; expresses concern that if the early season is not shortened, the Royal chinook will further decline and lead to situation where packers will have to depend on fall season rather than early and mid seasons. Provides newspaper quotes from the Portland Oregonian that support his statements. pages 10-14. Provides a report on Washington salmon hatcheries in the Columbia basin; notes that the Wenatchee Hatchery is the only hatchery tributary to the Columbia that propagates Silverside salmon (coho). Also mentions that manager of the Colville Hatchery could only acquire 90,000 silverside salmon eggs in the stream (Colville River); and that the facility was deemed not to operate. Notes that the Klickitat hatchery was never completed, and was abandoned in 1902, pages 24-25. Notes that the Wind River Logging company, on the Wind River, flooded the Wind River, carrying all their logs into the Columbia River; this citation documents the use of crib dams to contain logs and flush logs down the Wind River, page 30. Notes that the Methow hatchery is the only remaining salmon hatchery (Colville, Little Spokane and Klickitat hatcheries are closed) on the east side of the Cascades to propagate silverside salmon; infers that Colville, Little Spokane and Klickitat Rivers have or had runs of coho salmon, pages 30-131. Provides letters that note run and habitat conditons on the Klicktat, Colville, Wenatchee, and Lewis Rivers, Page 39-42.

Washington State. 1911. 20th and 21st annual reports of the state fish commissioner and ex-officio game warden: 1909-1910. State of Washington Department of Fisheries and Game, Olympia, Washington.

E.L. Boardman, Public Printer, 1911.
Abstract: The commissioner (J.L. Riseland) reports: 1) State legislature appropriated $1000 for the extermination of seals and sea lions in the Columbia River district; letter of 1910 number of seals and sea lions exterminated. page 4; (2) Legislature passed a bill appropriating $5000 for repairing the Kalama hatchery buildings and building of rearing ponds, page 10; (3) The Walla Walla Trout hatchery was turned over to the state in early 1909, page 21; (4) The Lewis River Trout hatchery was constructed in early summer of 1909, located on Basket Creek in Clark County (about 20 miles from the city of Vancouver), page 21; (5) A review of activities at Columbia Basin Salmon hatcheries; a) mentions a logging crew putting logs into the Kalama River above the salmon hatchery, and causing damage to the hatchery racks; b) notes that logging and timber companies and state hatcheries operations (e.g. splash dams and log flushing) can coexist if arrangements similar to those of the state and the Wind River Logging Company can be agreed to page 26; and c) mentions that silverside salmon are the main species propagated at the Methow hatchery, and that irrigation ditches have always been a hardship to salmon from this facility.; (6) Note on experiments by columbia River cannery men: One at Hamilton Slough on the lower columbia River - captured 35 adult blueback and attempted to hold them, but they died; one at The Dalles, Oregon - adult chinook were capture with fish wheel, and held in lake-like impoundment, but fish died from fungus, and on pages 39-40 (7) Notes on investigation of chinook and silverside salmon in the Wenatchee River at Lamb-Davis Dam, at leavenworth, where salmon were counted in the fishway (978 counted, and another 60 taken by Indians at dam) and some were retained for eggtake; took about 30,000 eggs (shipped to Kalama Hatchery) until accident from pile driver sunk the fishway, and salmon ahd to be released to continue their way upstream to spawn. page 41.

Washington State. 1916. 24th and 25th annual reports of the state fish commissioner to the governor of the state of Washington: April 1, 1913 to March 31, 1915. State of Washington Department of Fisheries and Game, Olympia, Washington. Frank M. Lamborn, Public Printer, 1916.
Abstract: The commissioner (L.H. Darwin) discusses: 1) fishway construction, and negotiations in regards to hydro-electric dams, both in western and eastern Washington (p.27-29); 2) appropriations and agreements on construction and operation of a new salmon and trout hatchery on the Wenatchee River near Leavenworth, WA (p. 30-31); 3) conflict in Oregon, Washington, and Idaho laws along the Columbia River (p. 34-35); 4) eyeing stations at several trout hatcheries in the Columbia Basin - Lake Chelan, Walla Walla, Lewis River, etc. (p. 45); 5) status of Columbia River district salmon hatcheries - questions the continued operation of the Methow hatchery (near Twisp) due to lack of spawn, improper location, and impact of irrigation on fry releases, etc. (p. 58-59); 6) acquisition of steelhead spawn in the upper Twisp River, instead of the lower river where fish are green (p. 58).

Washington State. 1924. 32nd and 33rd annual reports of the state supervisor of fisheries for the period: April 1, 1921 to March 31, 1923. State of Washington Department of Fisheries and Game, Olympia, Washington. Frank M. Lamborn, Public Printer.
Abstract: The State Supervisor (Ernest Seaborg) notes irrigation dams as a menace to anadromous fish in the Columbia River Basin (p. 11).

Washington State. 1925. 34th and 35th annual reports of the state supervisor of fisheries for the period: April 1, 1923 to March 31, 1925. State of Washington Department of Fisheries and Game, Olympia, Washington. Jay Thomas, Public Printer, 1925.
Abstract: The State Supervisor (Ernest Seaborg): 1) notes the activities and actions related to the application submitted by the Washington Irrigation and Development Company to construct a dam at Priest Rapids on the Columbia River (p. 11-12); 2) Notes that steelhead and silver salmon in the Methow River are doomed respectively because of 110% egg transfers from the Methow hatchery, and because of irrigation ditches and power dams (p. 27); 3) notes Wenatchee Hatchery efforts are failing due to irrigation and power dams being installed (p. 27); 4) notes that Klickitat, Spokane and

Colville hatcheries failed to secure salmon spawn in their respective stream systems (p. 28); 5) notes that nine of the thirty-five state hatcheries have proven unsuccessful as a direct result of irrigation ditches and dams, and one was unsuccessful due to depletion by the commercial fishery (p. 29).

Washington State. 1932. 40th and 41st annual reports of the state department of fisheries and game, division of fisheries, for the period April 1, 1929 to March 31, 1931, fiscal years 1929 and 1930. State of Washington Department of Fisheries and Game, Olympia, Washington. Jay Thomas, Public Printer, 1932.
Abstract: The Director of Fish and Game (Charles R. Maybury); 1) The Washington state legislature passes an act that abolishes the fisheries board, and transfers the duties to a Director of Fisheries and Game (p. 3-4); 2) Notes regarding activities and mitigation recommendations associated with water developments at Rock Island on the Columbia River and Ariel on the Lewis River (Inland Power and Light company of Portland, Oregon) p. 28-31; 3) Notes on fish ladder construction projects and facilities completions at Sunnyside, Wapato, and prosser dams (p. 32).

DEGRADATION

Reference List

US Department of Commerce. 1932. Doctor Ellis demonstrates serious effects of mine pollution. Fisheries Service Bulletin No. 211, Bureau of Fisheries, US Department of Commerce, Washington DC, December 1, 1932.
Abstract: Notes the history and results of Dr. M.M. Ellis (US Bureau of Fisheries) who studied the pollution problem of Couer d'Alene River in Idaho, regarding wastes from silver, lead, and zinc mines. Survey extended from Montana to Spokane River in Washington. Provids extensive information on extent and type of habitat degradation to streams and lakes caused from mining wastes. Mentions that aquatic production of Couer d'Alene Lake was showing decline in the southern end from 1911, and species of trout were scarce, p. 3-4.

HABITAT

Reference List

Attwell, J. 1974. Columbia River gorge history, Volume One. Fourth Printing, Talkie Books, 34 Landing Road, Skamania, WA 98648, p. 151.
Abstract: A history of the Columbia River in its early days is provided with respect to early inhabitants (Indians, explorers, white settlers), industry/commerce activities. References regarding fisheries and habitat characteristics of this area in this era are lacking in this reference. The following notes are related to milestones/events; 1) 1825 Fort Vancouver was the first settlement in what is now the state of Washington; p. 41; 2) 1837 John McLoughlin had farms at Fort Vancouver on the Cowlitz River; p. 45; 3) In 1846, Joel Palmer established the Columbia River Pack Trail, down the south side of the river from The Dalles to the Sandy River, for cattle; p. 50; 4) In 1851, Frances A. Chenowith established the Cascades Portage Railroad, the first railroad in the northwest, at the Cascades to portage cargo around the rapids on the Columbia River.

Bayha, Keith. 1974. Anatomy of a river Pacific Northwest River Basins Commission, 1 Columbia River, P.O. Box 908, Vancouver, Washington 98660, Vancouver, Washington.
Abstract: Authors present a comprehensive evaluation of water requirements for the Hell's Canyon reach of the Snake river, based on field surveys of March 1973. Surveys included collection of information regarding the time of travel of the stage wave and water mass, water quality, biological resources, etc. Includes photographs that illustrate the habitat (terrestrial and water) of this area.

Blanchard, R. E. 1977. Columbia River estuary physical alterations. Columbia River estuary, inventory of physical, biological and cultural characteristics 209-1 to-209-22.Columbia River Estuary Taskforce, Astoria, Oregon.
Abstract: The author discusses the man-induced physical alterations river bed, and adjacent riparian/upland areas of the Columbia river estuary, caused by following projects/activities (1) dredging & disposal for improvement and maintenance of river navigation (2) dikes & levees for flood control/protection, and (3) jetties/pile dikes for protection the river mouth entrance. Description of project histories, types, methods, and locations are discussed and supporting illustrations (tables and figures) are presented. Land disposal of dredging spoils are given with respect site, location (approximate river mile), habitat type, wildlife affected, and area size (in acres).
Note: Excellent reference for generally determining the location of projects by typed and general impacts.

Bottom, D. and Jones, K. K. 1990. Species composition, distribution, and invertebrate prey of fish assemblages in the Columbia River estuary. Prog. Oceanogr. 25: 243-270 .
Abstract: Authors note that seasonality of abundance and species in an estuary reflect the timing of migration and the reproductive cycles of marine and anadromous species. Composition of the fish community and dominant species in the Columbia river estuary are similar to many smaller estuaries in the Pacific Northwest; these similarities reflect the influence of the nearshore marine environment on the fish community structure, and considerable physiological tolerance of many euryhaline species. The distribution of fish assemblages in the Columbia river estuary is influenced by large seasonal variation in river discharge and salinity; and within large areas and salinity zones, species assemblages use different habitat and prey. The distribution of abundance and the stomach fullness of fishes vary directly with the density of potential prey; it is hypothesized that fish production may be limited by dynamic physical processes that control prey availability or the feeding efficiencies of predators in the highly turbid water.

Bryant, F. G. 1949. A survey of the Columbia River and its tributaries with special reference to the management of its fishery resources. 2. Washington streams from the mouth of the Columbia River to and including the Klickitat River (Area I). Special Scientific Report No. 62, US Fish and Wildlife Service, Department of Interior, Washington DC.
Abstract: Provides a comprehensive description and perspective of tributaries at period in time, in terms of habitat and water flow/temperature. 103 pages.

Bryant, F. G. and Parkhurst, Z. E. 1950. Survey of the Columbia and its tributaries 4. Area III Washington streams from the Klickitat and Snake Rivers to Grand Coulee Dam, with notes on the Columbia and its tributaries above Grand Coulee Dam. Special Scientific Report Fisheries No. 37, US Fish and Wildlife Service, Department of Interior, Washington, DC.
Abstract: Provides a comprehensive description and perspective of Columbia tributaries (within Washington State), above the Klickitat River (excluding the Snake River) at period in time, in terms of habitat and water flow/temperature.

Burner, C. J. 1951. Characteristics of spawning nests of Columbia River salmon. Fisheries Bulletin 52(61): 97-110.US Fish and Wildlife Service, Department of Interior, Washington, DC.
Abstract: Author describes spawning habitat and characteristics of chinook (spring, summer, fall) coho, chum, and sockeye, based on observations in Columbia tributaries (lower and upper).

Cobb, J. N. 1922. Protecting migrating Pacific salmon. Transactions of the American Fisheries Society 52: 146-153.
Abstract: Author gives extensive information on the Yakima Basin regarding habitat, fish, and water development projects (Kennewick, Wapato, Sunnyside, Prosser) Provides general design and adult

fish behavior (steelhead) at Sunnyside, Kennewick, and Prosser.

Columbia Basin Interagency Committee. 1957. Columbia River basin fishery program, part II: Inventory of streams and proposed improvements for the development of the fisheries resources. Fishery Steering Committee, Columbia Basin Interagency Committee, January 1957; 100 pages.
Abstract: Provide a comprehensive inventory and listing of proposed improvements of habitat/rehabilitation projects and considerations for major tributaries of the Columbia basin above McNary Dam. Notes basin descriptions for each tributary, in terms of flow, temperature (air and water). Includes maps of tributary/basins showing geographical orientation of streams and proposed improvements.

Craig, J. A. 1935. The effects of power and irrigation projects on the migratory fish of the Columbia River. Northwest Science IX(1): 19-24 (February, 1935).
Abstract: Author discusses the effects of human land and water uses (logging, mining, power, and irrigation) on fisheries resources in the Columbia basin. Provides examples of habitat alterations imposed by these human uses. Briefly discusses life history and ecology of all anadromous salmonid species inhabiting the Columbia River basin. Discusses how the use of streams for power and irrigation purposes affect migratory salmon species: 1) obstacles that obstruct or delay migration of adult upstream to natal steams; and 2) injurious or delay impediments to downstream juvenile migration. Presents fishways and screening as mechanisms to protect fish, and the use of artificial propagation in the case of high dams.

Davison, M. A. and Spencer, R. D. 1979. *Columbia river islands land status survey, Columbian White-Tailed Deer Study.* Project E-I, Study 2, Job 4, Section 4. Washington Department of Game, Olympia, Washington.
Abstract: Author provides information regarding the status of habitat and ownership for 28 islands, located within 107 mile section of the lower Columbia river between Bonneville Dam and Cathlamet, Washington. Provides information for each island, with respect to geographic location/acreage, ownership (deed abstract), floral communities/habitat, historical, present, future uses of island. Includes information regarding alterations in terms of dredging, fill, and forest removal, etc. **Note: Excellent Reference**

Downing, Alfred. 1980. The region of the upper Columbia River and how I saw it Ye Galleon Press, Fairfield, Washington.
Abstract: Author provide a general accounting of his adventures and trip with Lt. T. Symons (U.S. Army) during the expedition down the upper Columbia river. No substantive information regarding fisheries-related habitat and stock was derived from a review of this monograph. A listing of books and periods was derived as a source for additional reference candidates.

Downs, J. L., Tiller, B. L., Witter, M., and Mazaika, R. 1996. Monitoring and mapping selected riparian habitat along the lower Snake River. PNNL-10953/UC-702: Pacific Northwest National Laboratory, Richland, Washington.

Dunn, J., Hockman, G., Howerton, J., and Tabor, J. 1984. Key mammals of the Columbia River estuary. Columbia River Estuary Data Development Program, Astoria, Oregon. 116 p. p.
Abstract: Authors provide extensive information about key mammalian species occurring the Columbia river estuary, with respect to 1) habitat use, 2) period of birth, 3) relationship to other trophic levels, and 4) critical habitat. Extensive tables and graphics are provide to illustrate spatial and temporal occurrence and inhabitation of key mammals within the Columbia river estuarine zone.

Franchere, Gabriel. 1969. Journal of a voyage on the north west coast of North America during the years 1811, 1812, 1813, and 1814 The Champlain Society, Toronto. 78,82-83, 96-97, 100-101, 110-111, 142-143, 148-149, 152-157 p.
Abstract: Author provides an account of his observations and experiences during his travels in the Columbia river basin during the early 19th century. Briefly notes habitat, flora, and fauna at various points of travel up and down the Columbia river and its tributaries. General description of attributes for the Snake river mouth.

Glenn, John G. n.d. Diary of John G. Glenn, 1852 14-15 p.
Abstract: Author provides a brief description of the scenery and habitat of the Grand Ronde sub-basin.

Good, James W. 1977. Columbia river tidal marshes. Columbia River estuary, inventory of physical, biological and cultural characteristics, Sect. 302-1 to 302-19. Columbia River Estuary Data Development Program.
Abstract: The author identifies, describes, and enumerates the marsh habitat and communities of the Columbia river estuary. Provides illustrations (figures and tables) describing the location and area of tidal marsh habitat; and discusses each tidal marsh area with respect to community structure and alterations/impacts induced by human interventions (dredging, diking, etc.).
Note: Excellent reference for deriving a perspective of the estuarine habitat and associated communities prior to and after human intervention.

Good, James W. and Potter, George D. 1977. Columbia river estuary shoreline habitat and wildlife resources. Columbia River estuary, inventory of physical, biological and cultural characteristics, Sect. 303-1 to 303-33. Columbia River Estuary Data Development Program,
Abstract: The authors identify, describe, and enumerate the shoreline/riparian habitat and wildlife communities (waterfowl, birds, big game, furbearers, small mammals, reptiles, amphibians, and marine mammals) of the Columbia river estuary. Provide illustrations (figures and tables) describing the kinds, location and area of various wildlife and their associated habitat that presently occur within the estuarine zone of the Columbia river.
Note: Excellent reference for deriving a perspective of the estuarine habitat and associated wildlife communities occurring in the shoreline/riparian zone of the Columbia river estuary.

Griffin, L. E. 1935. Certainties and risks affecting fisheries connected with damming the Columbia River. Northwest Science IX(1): 25-30 (February, 1935).
Abstract: Author discusses 1) the economic importance of anadromous and resident fish species, and the effects on dam construction on said species; 2) the importance and distribution of salmon harvest in the Columbia basin; 3) the certainties associated with current state of technology of fish passage systems, and risks associated with designs and plans to be incorporated at the Bonneville project; 4) recommended actions to reduce risks associated with current fish passage technology; 5) certainties and risks associated with sedimentation and submergence of fish habitat (sloughs and shallows) in the Bonneville impoundment; 6) the certainties and risks of power plants to migration of young salmon; and 7) turbine designs and devices to reduce the risks associated with hydropower operaton. Author alludes to a hypothesis that the Columbia impoundments (e.g. Bonneville) may present risks to the importance of the sloughs and shallow ponds contiguous to the river, as being very important as a food source to young salmon during their downstream migration.

Harden, Absolom B. 1847. Diary of Absolom B. Harden 1, 14-30 (incomplete) p.
Abstract: Author provides descriptions of his activities and the habitat in various sub-basins (e.g. Grand Ronde) of the Snake and Columbia river.

Hardesty, W. P. 1923. Drainage project on the Columbia adjoining Portland, Ore.: levees and pumping plant with three types of motor-driven pumps --new sluice gate --design --assessment system. Engineering News-Record 90(9): 395, 398.
Abstract: Reference discusses a drainage project on the Columbia river that encompasses the use of levees and a pumping plant for reclamation of 8,478 acres of low land in Multnomah County Drainage District No. 1 (near Portland, Oregon). The project affects the habitat characteristics of Columbia Slough and adjacent lands. An eleven mile levee borders and is set back 50-100 ft from the river; a fringe of willows and cottonwoods lies between the river and levee. The enlargement of the slough is considered for use as a dilution vehicle for municipal sewage. Includes a map illustrating the Columbia Slough/project area and its orientation with the Columbia river reach adjacent to the Vancouver/Portland area.

Hazel, C. R. 1984. Avifauna of the Columbia River estuary. Columbia River Estuary Data Development, Astoria, Oregon. 85 p. p.
Abstract: Author presents and describes information regarding key avian species and their associated habitat, key avian habitats and their avian species composition, and food habits of key avian species within the Columbia river estuary. Tables and graphics are used to illustrate the spatial and temporal distribution of key avian species, and their associated habitats and food habits.

Hines, H. K. 1893. An illustrated history of the State of Washington. The Lewis Publishing Company, Chicago. 933 pages.
Abstract: Author provides a very comprehensive history of the Washington and Oregon areas, during the pre-and post-Oregon Territory period (late 1770s to late 1880s); provides biographical sketches of principals of Washington state history. Limited notes regarding fisheries resources and habitat alternations are provided. NOTE: excellent reference for Washington and Oregon territorial history.

Idaho State. 1927. Eleventh biennial report of the Fish & Game Warden of the State of Idaho, 1925-1926. R.E. Thomas, State Game Warden; Boise, Idaho.
Abstract: (1) Photograph of the riparian zone of a section of the Selway River; near the junction with the Clearwater River, is illustrated on page 6. (2) The topography and status of lands of Idaho is generally described in terms of its habitat zones and types of development, page 7. (3) Photograph of the riparian zone of a section of the Middle Fork of the Salmon River is illustrated on page 18. (4) Photograph of the riparian zone near the junction of Camas Creek and the Middle Fork of the Salmon River is illustrated on page 28. (5) Description of the resident fish planting program in the Redfish Lake section of Idaho in 1925; this program illustrates the emphasis of the resident fishes management in lieu of anadromous species (e.g. Blueback salmon), page 47-48. (6) Photograph of the riparian zone of a section of the upper inlet to Redfish lake is illustrated on page 55. (7) Photograph of the Vernon and Edna Lakes area in the headwaters of the south fork of the Payette River is illustrated on page 58. (8) Note that a landlocked salmon, weighing slightly over six pounds was taken in the Salmon River a short distance below the outlet of Redfish Lake. NOTE: This fish may have been anadromous variety of blueback salmon? page 59. (9) Photograph of the riparian zone of a section (with a road along stream-side) of the Lochsa River, near Kooskia, Idaho County is illustrated on page 66.

Johnson, Overton and Winter, W. H. 1906. Route across the Rocky Mountains with a description of Oregon and California, their geographical features, their resources, soil, climate, productions, etc., 1843. Chapters I & II. The Quarterly of the Oregon Historical Society VII(1): 62-63, 88-103 p.
Abstract: Authors provide descriptive information regarding the habitat, geology, and flora/fauna of Oregon Territory between the Blue Mountains and the coast. Provides general descriptions of riparian habitat in terms of flora. NOTE: Excellent reference to derive habitat status/description prior to significant alteration due to settlement and resources development.

Johnson, Overton and Winter, W. H. 1906. Route across the Rocky Mountains with a description of Oregon and California, their geographical features, their resources, soil, climate, productions, etc., 1843. Chapters III & IV. The Quarterly of the Oregon Historical Society VII(2): 163-165, 174-179 p.
Abstract: Authors provide descriptive information regarding the habitat, geology, and flora/fauna of Oregon Territory in the Willamette River valley region and the Columbia River estuarine area (p. 175-76). Provides general descriptions of riparian habitat in terms of flora. NOTE: Excellent reference to derive habitat status/description prior to significant alteration due to settlement and resources development.

Lancaster, Samuel C. 1915. The Columbia America's great highway. Press of Kilham Stationary and Printing Company, Portland, Oregon.
Abstract: Author provides a general history of the Columbia basin, in terms of the human activities along the Columbia river. Excellent color photographs of the various locations along the Columbia river, viewed from the old Columbia highway route, are presented; illustrates various morphological attributes, habitat structure, etc. of these locations, situated on the lower Columbia river (Cascades area to Astoria).

Lelbhardt, Barbara. 1990. Law, environment, and social change in the Columbia basin: the Yakima Indian Nation as a case study, 1840-1933. Dissertation for Doctor of Philosophy in Jurisprudence and Social Policy, University of California at Berkeley, 1990, 488 pages.
Abstract: A. Author provides a comprehensive history and legal premise of water rights and fishing issues of the Yakima Indian Nation within the Yakima and Columbia rivers basin; includes an extensive bibliography. Documents the social and economic dependence of the Yakima Indians on fisheries resources; provides some insight of salmon, water, and habitat of the Yakima Basin prior to and during development of fisheries and agricultural industries in the Yakima basin. The following historical notes of historical milestones and fisheries resources information were derived: 1) In 1850, the US Congress passes the Land Donation Act which provided for the appropriation of lands from the public domain in the terriitories (e.g. Oregon Territory); p. 104; 2) In 1873, the Washington Territorial legislature passed an act that allowed Yakima County farmers, miners, manufacturers- or anyone that could use water for "beneficial purposes" to construct diversion works necessary to convey water onto their non-riparian lands (An Act Regulating Irrigation and Water Rights in the County of Yakima, Washington Territory, 13 November 1873, Washington Laws 520-522), p. 245; 3) In 1890, the Washington State Legislature passed a statute that provided for the appropriation of any unclaimed waters 'from any natural streams or lakes in the state" for irrigation and permitted the condemnation of rights of ways for ditches to carry water 91890 Washington laws 706, paragraph 1), p. 246; 4) In 1917, Washington State Legislature passed a law adopting an administrative water code that recognized prior appropriation as the only means by which an individual could acquire water rights (Riparian and Appropriation Rights, Washington laws 447-68), p. 247; 5) Around 1867, the Meninick/Shumit Ditch on Simcoe Creek (tributary to the yakima River) was constructed on the Yakima Indian Reservation; p. 250; 6) In 1906, the US Congress passed the Jones Act, that provided for funding the on-reservation portion of the US Reclamation Service's larger yakima irrigation project by allowing each Indian allottee to sell 60 acres of his or her allotment for bring water to the remaining twenty acres under the project; p. 254-255; 7) In 1891, the Northern Pacific, Yakima, Kittitas Irrigation Company, who filed on 1000 cfs of Yakima River water (in 1890) began construction of the Sunnyside irrigation project, and in that year built an adjustable dam (at the old Yakima dance house site) that was believed to have the capability to appropriate virutally the entire low flow when the river was at its lowest point; p. 258; 8) In 1892, the first 25 miles of the Sunnyside irrigation project is dedicated; p. 259; 9) In 1893, the Northern Pacific Railroad (owner of the Northern Pacific, Yakima, Kittitas Irrigation Company) declares bankruptcy during the Panic of 1893; p. 259; 10) In 1894, the US Congress passed the Carey Act which allowed states to choose up

to one million acres of arid land for irrigation development; p. 260;   11) In 1895, the Washington State legislature set up the Arid Lands Commission to investigate the possibility of developing lands between the Yakima and Columbia Rivers, above the Sunnyside irrigation project; p. 260;   12) Up to and through the 1890s individuals, farmers cooperatives, and ditch companies invested in their own small scale irrigation systems; p. 260;   13) In 1902, the US Congress passed the Newlands Act which created the Reclamation Service with the US Department of Interior; the Reclamation Service was empowered to provide planning, engineering, and financial assistance for irrigation projects; p. 261; 14) In 1906, the US Reclamation Service purchases the Sunnyside irrigation project from the Northern Pacific, Yakima, Kittitas Irrigation company, p. 241;   15) In 1908, the US Supreme Court issued its decision on the Winters vs US, where the court held that Indians reserve water rights even when their treaties made no express mention of water; p. 270;   16) In 1905, the Washington irrigation Company, on their attorneys' advice blew up the dam of Union Gap irrigation Company at Lake Cle Elum when insufficient water thretened to destroy the crops on the Sunnyside Project; . p. 272;   17) In 1889, the Ahtaneum Creek (tributary of the Yakima River) was virtually drained of water by irrigators on the north side of stream where it bordered the Yakima Indian Reservation; p. 275;   18) In 1891, the Ahtaneum Creek (tributary of the Yakima River) was virtually drained of water by irrigators on the north side of stream where it bordered the Yakima Indian Reservation; . p. 275;   19) In 1892, (a dry summer), the US Bureau of Reclamation attempted to re divert water of Ahtaneum Creek, virtually drained of water by irrigators on the north side of stream where it bordered the Yakima Indian Reservation, but the north-side irrugation users brought suit against the Bureau's action; . p. 276;   20) In 1905 the US Secretary of Interior allocated 2065 cfs and 147 cfs of yakima River water respectively to the white water users and Yakima Indian water users; p. 292;   21) J.H. Lynch (in 1901) noted that the more water flowed in the Ahtaneum Creek (tributary of the Yakima River) in the early days than at present, and the runoff was also later, coming mostly after July 1st; he said " the watershed had not been burned off nor grazed excessively by sheep, hence more water". ; p. 310;   22) In 1908, the Washington State Fish Commissioner asked the Reclamation Service to include fish ladders at Yakima project dams, but was told that fish ladders were not feasible, nor was the Reclamation Service responsible for meeting state fishery laws; p. 310-311;   23) The Washington State Fish commissioner (Mr. Darwin) closed the Klickitat River to food fishing (white commercial and Indian fishing) - not sport fishing - between 1915 and 1917, p. 373.

Mattson, C. R. 1948. Spawning ground studies of Willamette River spring chinook salmon. Oregon Fish Commission, Research Briefs 1(2): 21-32.
Abstract: Provides extensive and comprehensive environment/habitat/distribution information for chinook salmon in the Willamette River and its tributaries.

May, Dean L. 1994. Three frontiers - family, land, and society in the American west, 1850-1900. Cambridge University Press, 313 pages.
Abstract: Author provides the history of settlement and development of the Willamette Valley region (Oregon), the Utah Valley region (Utah), and the Boise Valley region (Idaho) from the 1840-1900. He documents and illustrates agrarian development in these regions (during and after the mining era); provides a perspective of milestones/events affecting settlement and expansion of population in these regions. Note: an excellent documentation of mining and agriculture development in terms of habitat alteration of the Boise River basin/upper Snake river region of Idaho during the 1850-1900 era. The following notes are related to this development in Boise and Willamette basins: 1) An excellent description of the habitat surrounding the Boise River is provided by early explorers/settlers such as John C. Fremont (1843) and Basil Nelson Longsworth (18 August 1853)p. 20-21;   2) Short description of the habitat in the region of the Santiam and Pudding Rivers region in the 1840s..."largely open prairie land begins to break into rolling hills...scattered thickets of Douglas fir, hemlock, spruce, incense cedar in the 1840s", p. 26;   3) Short description of the habitat in the Middleton region of the lower Boise River in 1863..."bottoms were wooded, covered with brush, and

often cut through with sloughs...and subirrigated by the low water table throughout the season." p. 37 (Map of Middleton area, and rivers, p. 36).

McClung, James S. 1862. Journal to Oregon, April 22nd 1862 1, 71-80 (incomplete) p.
Abstract: Author provides descriptions of habitat (e.g. forest/timber) and water resources (e.g. springs) in various sub-basins (e.g. Powder and Grande Ronde) to the Snake and Columbia Rivers.

McIntosh, B. A., J.R. Sedell, J.E. Smith, R.C. Wissmar, S.E. Clarke, G.H. Reeves, and L.A. Brown. 1994. Historical changes in fish habitat for select river basins of eastern Oregon and Washington. Northwest Science 68, Special Issue: 36-53.
Abstract: Authors compare the changes in and condition of fisheries habitat in a subset of historical surveyed streams (Tucannon, Asotin, Grande Ronde, yakima, Wenatchee and Methow basins) by comparing the US Bureau of Fisheries surveys (1934-1942) with resurveys of 1990-1992. Habitat information and analyses regarding pool habitat, substrate composition, and riparian zone are provided.

McIntosh, Bruce A. 1992. Historical changes in anadromous fish habitat in the Upper Grande Ronde River, Oregon, 1941-1990. Masters Thesis. Oregon State University, Corvallis, Oregon. 1-88 (complete) p.

McIntosh, Bruce A., Sedell, James R., Smith, Jeanette E., Wissmar, R. C., Clarke, S. E., Reeves, G. H., Brown, L. A., Hessburg, Paul F., and Everett, Richard L. Management history of eastside ecosystems: changes in fish habitat over 50 years, 1935 to 1992. General Technical Report PNW-GTR-321. US Department of Agriculture, Forest Service, Pacific Northwest Research Station in cooperation with Pacific Northwest Region, 8-25 p.

Merrel, T. R. 1951. Stream improvement as conducted in Oregon on the Clatskanie River and tributaries. Oregon Fish Commission, Research Briefs 3(2): 41-47.
Abstract: Provides information regarding the habitat of this river system, and associated recommendations for habitat improvements in tributaries/areas negatively impacted by logging activities 15 years previous.

Moore, Cecil R. 1939. The Willamette river project. Military Engineer 31(177): 208-211.
Abstract: Author provides a brief history, and geophysical, hydrologic, climatologic description of the Willamette river basin. Discusses and describes the Willamette basin plan that will includes 1) navigation improvement from the mouth to upstream of Willamette Falls, 2) irrigation (seven storage projects of 335,000 acre ft) and stream purification projects. Mentions loss and mitigation of fish habitat and mitigating factors for this loss in terms of improved water flows and quality. Provides illustrative tables for reservoir projects and project costs- pp. 208-211.

Mudd, D., Boe, L., and Bugert, R. 1980. Evaluation of wildlife habitat developed on government project lands along Snake river in Washington. Washingtn Department of Game, Habitat Management Division, 62, maps p.
Abstract: Report provides a baseline of wildlife resources and habitat in areas of the lower Snake river affected by the Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dam projects.

Nielson, R. S. 1950. Survey of the Columbia and its tributaries, Part 5. Special Scientific Report Fisheries No. 38, US Fish and Wildlife Service, Department of Interior, Washington, DC.
Abstract: Provides a comprehensive description and perspective of the Deschutes, John Day, Umatilla and Walla Walla River systems at period in time, in terms of habitat and water flow/temperature.

O'Malley, H. 1935. Some problems which confront the fishery experts in the construction of dams in the Inland Empire. Northwest Science IX(1): 23-24 (February, 1935).
Abstract: Author presents the problems of dam construction in the Columbia River as 1)successful passing of adults over dams, 2) getting small fish and steelhead kelts back to the sea, and 3) the complex problem of changed conditions brought about by the dams and artificial lakes. Mentions the four commissions that control the destiny of commercial and game fishes in the States of Washington and Oregon; the annual value and employment associated with the fishing industry; the budget and employment figure projected for construction of the Bonneville dam; fishways associated with the Rock Island dam; and the impassability of Grand Coulee dam. Discussion of the biological effects on native fish species, based on experiences in New England and other parts of the US; generalizes and predicts the ecological changes of the habitat and species resulting from water impoundments on the Columbia River. Briefly mentions the requirement for proper screening of power intakes and immediate steps to combat pollution, due to industrialization of the Inland Empire.

Oregon State. 1903. Annual Reports of the Department of Fisheries of the State of Oregon to the legislative assembly, Twenty-second regular session, 1903. State of Oregon, Salem, Oregon. W.H. Leeds, State Printer, 1903. 14-21, 34-37, 64-79, 116-119 p.
Abstract: The Master Fish Warden (H.G. Van Dusen) provides detailed accounts for investigations of various waters/streams, such as the Salmon River (tributary to the Sandy River), Clackamas River, the McKenzie River (tributary to the Willamette River), Gate Creek and Blue River (tributary to the McKenzie River), Santiam River (tributary to the Willamette River), Molalla River (tributary to the Willamette River), Tanner and Eagle Creek (tributary to the Columbia River near Bonneville), Deschutes River (tributary to the Columbia River), Crooked River (tributary to the Deschutes River), John Day River (tributary to the Columbia River), Grande Ronde River and its tributaries including Wallowa lake (tributary to the Columbia River), Imnaha River (tributary to the Snake River), Powder River (tributary to the Snake River), Malheur River (tributary to the Snake River), Owyhee River (tributary to the Snake River), and Snake River. Includes notations of salmon species presence and timing, utilization, habitat/habitat alteration, etc. pages 10-21. Notes fish investigative/propagation activities at the Grande Ronde River Experimental Station at the mouth of the Wenaha River (tributary to Grande Ronde River at approximately RM 50); provides information on fish species passage to a fish rack across the Wenaha River; blueback pass this point between June 20th and July 20th, silversides begin showing on September 14th (silverside eggtake conducted mid-October into early December, summary table, Page 36. Notes during investigations/field work at the Swan Falls Experimental Station on the Snake River, that chinook salmon began to arrive at this point on September 1st, and fish were spawned from October 12th to November 13th. page 37. Notes that Oregon State passed a law in 1899 that required the licensing of the salmon and sturgeon industry (fishing and processing) some of funds derived from this licensing law were to be used for artificial propagation of fishes. page 88. Notes on the Grande Ronde River Hatchery Station: chinook salmon begin arriving immediately after rakc is emplaced in the Wenaha River completed on July 4th. Holding rack enclosre is full by September 1st, and first eggs are taken on September 13th and completed October 31. First sockeye eggs were taken october 21st. Pages 116-118. Notes on the Ontario hatchery Station on the Snake River (lies on the left bank of the Snake River directly opposite Morton's Island, near Ontario Oregon); rack barrier is emplaced on August 25th, and next day 300 chinook salmon were already in the racks; run continued at this rate per day until last of September; eggtake was conducted from October 13th through November 8th. pages 119-121.

Oregon State. 1947. Biennial report of the Fish Commission of the State of Oregon to the governor and forty-fourth legislative assembly, 1947. Fish Commission of the State of Oregon; Salem, Oregon, State Printing Office, 1947.
Abstract: Notes that (1) the State of Oregon is entering a period of expansion and industrialization, and population increase where development of rivers will deplete fisheries resources; the early history

of the state saw the destruction of salmon spawning habitat. (2) the policy of the Oregon Fish Commission is (a) to study the causes and effects of decline of varios fisheries, (b) to study methods of rehabilitation of species involved, and (c) to evaluate and increase efficiency of artificial propagation and to use hatcheries to supplant and rehabilitate, but not replace, natural spawning. (3) A new fishway is constructed by the Oregon Iron and Steel Company at their dam in the Tualatin River, tributary of the Willamette River, under the supervision of the Division of Engineering (Oregon Fish Commission) page 13. (4) A fishway at Eagle Creek Falls on Eagle Creek (tributary to the Clackamas River) is removed under the supervision of the Division of Engineering (Oregon Fish Commission), page 13. (6) A new dam is constructed by the Hines Lumber Company on the North Fork of the Willamette River, at Westfir (Oregon) construction of an adequate fishway will be completed by early summer 1947. page 14.

Parkhurst, Z. E. 1950. Survey of the Columbia and its tributaries, Part 6 Area V - Snake River system from mouth through Grande Ronde River. Special Scientific Report Fisheries No. 39, US Fish and Wildlife Service, Department of Interior, Washington, DC.
Abstract: Provides a comprehensive description and perspective of the Snake and Grande Ronde River systems at period in time, in terms of habitat and water flow/temperature.

Parkhurst, Z. E. 1950. Survey of the Columbia and its tributaries, Part 7 - Snake River from above the Grande Ronde River through the Payette River. Special Scientific Report Fisheries No. 40, US Fish and Wildlife Service, Department of Interior, Washington, DC.
Abstract: Provides a comprehensive description and perspective of the Snake above the Grande Ronde, Salmon, Weiser, and Payette Systems at period in time, in terms of habitat and water flow/temperature.

Parkhurst, Z. E. 1950. Survey of the Columbia and its tributaries, Part 8 Area VII - Snake River from above the Payette River to Upper Salmon Falls. Special Scientific Report Fisheries No. 57, US Fish and Wildlife Service, Department of Interior, Washington, DC.
Abstract: Provides a comprehensive description and perspective of the main Snake and its tributaries above the Payette River at period in time, in terms of habitat and water flow/temperature.

Parkhurst, Z. E., Bryant, F. G., and Nelson, R. S. 1950. Survey of the Columbia River and its tributaries - Part III. Special Scientific Report Fisheries No. 36, US Fish and Wildlife Service, Department of Interior, Washington, DC.
Abstract: Provides a comprehensive description and perspective of Columbia River tributaries in Oregon and the Willamette system at period in time, in terms of habitat and water flow/temperature.

Porter, Elizabeth Lee. 1864. Crossing the plains, a diary by Elizabeth Lee Porter 1864 1, 6-7 (incomplete) p.
Abstract: Author gives abbreviated diary of her activities and observations from Iowa to Oregon; some brief notes of climate and habitat of various sub-basins (e.g. Burnt, Powder and Grand Ronde) to the Snake and Columbia river.

Renshaw, Robert Harvey. 1851. Diary of Robert Harvey Renshaw 1, 24-35 (incomplete) p.
Abstract: Author notes his activities and habitat of various sub-basins (e.g. upper Snake tributaries, Burnt, Powder, and Grand Ronde)to the Snake and Columbia rivers. Gives brief mention to the timber and water of the Grand Ronde area.

Rich, E. E. 1950. Peter Skene Ogden's Snake country journals, 1824-25 abd 1825-26 The Hudson's Bay Record Society, London. 92-93, 126-135, 166-171, 190-193 p.
Abstract: Author provides an account of his observations and experiences during his travels in the

Columbia river basin during the early 19th century. Briefly notes habitat, flora, and fauna at various points of travel in the various sub-basins (e.g. Bruneau, Payette, Malheur, Owyhee, etc.)of the Upper Snake river, and the Umatilla, John Day, Deschutes, Hood, and Willamette sub-basins of the Columbia river.
General description of attributes for the upper Snake river in the vicinity of the Payette river to the Burnt river (River Brule). - observation of dead salmon (carcasses) along the river.
General description of attributes for the upper Snake river in the vicinity of Burnt river (River Brule) to the Malheur River.
General description of attributes for the upper Snake river in the vicinity of Burnt river (River Brule) to the King Hill creek.- note of sturgeon present in this area during spring.
General description of attributes for the upper Snake river in the vicinity of the Payette river mouth.
General description of attributes for the upper Snake river in the vicinity of the Owyhee river mouth.
General description of attributes for the upper Snake river in the vicinity of the Owyhee river mouth to the Malheur river mouth-notes water flow (spring freshet condition).
General description of attributes for the upper Snake river in the vicinity above the Owyhee river mouth to the Bruneau river mouth.
General description of attributes for the upper Snake river in the vicinity of the Bruneau river mouth.
General description of attributes for the upper Snake river in the vicinity above the Owyhee river mouth to the Bruneau river mouth - notes seeing salmon ascending the stream.
General description of attributes for the upper Snake river in the vicinity above the Owyhee river mouth to the Bruneau river mouth - notes regarding Indian fishing success/salmon presence in the vicinity.
General description of attributes for the upper Snake river in the vicinity above the Bruneau river mouth to Alkali creek mouth.
General description of attributes for the upper Snake river in the vicinity of the Bruneau and Snake river confluence.
General description of attributes for the upper Snake river in the vicinity below Big Wood river to the Bruneau river.
General description of attributes for the upper Snake river in the vicinity of King Hill Creek.

Scheufele, Roy W. 1970. History of the Columbia Basin Inter-Agency Committee. Prepared under sponsorship of the Pacific Northwest River Basins Committee.
Abstract: A. Author presents a comprehensive details regarding the genesis, policy & objectives, actions, and chronology of meeting/events for the Columbia Basin Inter-Agency Committee, during the period of 1946-1967. Provides information regarding governmental legislation (laws) and policy framework, institutional relationships with other state and federal agencies in the Columbia basin, and accomplishments of the agency. NOTE: Reference is very important in terms of its description of policy and philosophy governing water and fisheries policy in the Columbia River basin during the period of 1946-1967. B. Genesis of Agency and Federal Action (pages 3-9): 1) In 1902, the US Congress passes the Reclamation Act; 2) In 1905, the US Congress establishes the US Forest Service; 3) In 1920, the US Congress passes the Federal Power Act; 4) In 1925, the US Congress passes a statute that directed the inventory of those streams in the US where power development appeared feasible and practical in coombination with navigation, flood control, and irrigation; 5) In 1927, the US Congress passes the River and Harbor Act, which commenced the survey of Pacific Northwest streams, that were inventoried under the 1925 congressional statute; 6) In 1936, the US Congress passes the Flood Control Act; 7) In 1936 (?) the US Congress establishes the US Soils Conservation Service; 8) In 1943, the Pacific Northwest Regional Planning Commission, an arm of the National Resources Planning Board, is abolished by the US Congress; 9) In July 1943, the governors of the Pacific Northwest States establish the Northwest States' Development Association to coordinate and correlate plans of member states as they relate to unified development of all the

resources of the Pacific Northwest; 10) In December 1943, the Northwest States' Development Association prepares a program and governing principles of emergency and immediate post-war projects for the development of the Columbia Drainage Basin; 11) In summer 1939, the US Departments of Interior, Agriculture, and War (Corps of Engineers) enter a tripartitie agreement to coordinate their work, both in Washington DC and field regions; 12) In December 1943, the US Federal Power Commission joins the tripartite of the US Departments of Interior, Agriculture, and War (Corps of Engineers), and execute a quadpartite agreement that provided monthly meetings of these agencies to discuss restuls of studies/investigations, to adjust differences of opinions, and to promote ways/means for implementing other provisions of the agreement-representatives of these four Departments constituted the Federal Inter-Agency River Basin Commission (FIABRC); 13) In February 1946, the Columbia Basin Inter-Agency Committee, the second field committee of Federal Inter-Agency River Basin Commission, is established to facilitate progress on the multipurpose development projects presetnly authorized by congress (p. 7-9 provides details of conditions of the agreement.); 14) In 1965, the US Congress passes the Water Resources Planning Act; 15) In June 1967, the Pacific River Basins Commission takes over the functions of the Columbia Basin Inter-Agency Committee. C. A chonicle of agency meetings and general outcomes from these meetings is presented (pages 10-123) 1) In March 1947, the Assistant Secretary of Interior (Warner W. Gardner) sends a memorandum/recommendations to the Federal Inter-Agency River Basin Commission (FIABRC) that propose the construction of mainstem dams on the Columbia below Okanogan R. and on the Snake below the Salmon R., with the exception of the proposed McNary Dam, be postponed until 1958 (for 10 years) provided that alternate sources of power could be devloped to meet Bonneville Power Administration load demands; this moratorium period would allow the US Fish & Wildlife Service and state fisheries agencies to determine remedial measures (per research, studies, and planning) that could be taken to preserve the Columbia River fishery; p. 22-23); 2) On 2 April 1947, the Assistant Secretary of Interior (Warner W. Gardner) memorandum was forwarded by the Federal Inter-Agency River Basin Commission (FIABRC) to the Columbia Basin Inter-Agency Committee for study, discussion, and recommendations; 3) On 23 July 1947 at the 11th meeting of the columbia Basin Inter-Agency Committee, (a) Fred Foster (US Fish & Wildlife Service) outlined the Lower Columbia River Fishery Program, consisting of obstruction removal, pollution abatement, diversion screening, fishway construction, hatchery construciton and fish sanctuaries - a program estimated at a cost of $20 million, and (b) a Fish & Wildlife subcommittee was established to coordinate and integrate fish and wildlife programs with water esource program; p. 25; 4) On 22 September 1947, the Fish & Wildlife Subcommittee (Columbia Basin Inter-Agency Committee) file d a report that summarized factual data relating to navigation, power, fish, irrigation, Indians, and National Defense, p. 26; 5) On 8 October 1947, at its 12 meeting, the columbia Basin Inter-Agency Committee unanimously approved and forwarded a letter to the Federal Inter-Agency river basin Commission (FIABRC) recommending that a) Grand Coulee power installations proceed, construction of Hungry Horse, Foster Creek, Detroit, and McNary Dam proceed, etc. b) authorized dams on the columbia River system not to be rescheduled, approval of the Lower Columbia River Fishery Program, and compensaiton of Treaty Indians, and c) upstream dams be authorized promptly and if authorized before 1958 they be constructed ahead of planned/unauthorized The Dalles, John Day and Arlington Dams unless the fish problem has been solved in the interim, etc., p. 26; 6) In 1950, the columbia Basin Inter-Agency Committee establishes the Fisheries Steering Committee, and this subcommittee prepares a comprehensive program of research and construction (to cost 25-50 million dollars) and proposed to finance it by a tax of fifty cents per kilowatt year (note proposal failed and caused an outcry from power interests) p. 27; 7) On 17 September 1948, at its 21st meeting, the Columbia Basin Inter-Agency Committee authorized a Technical Subcommittee for Operating Plan to prepare an integrated and coordinated operating plan for the release and control of waters in connection with Columbia River development program (note plan was never consummated) p. 32; 8) On 10 November 1948 at its 22nd meeting of the columbia Basin Inter-Agency Committee, the Corps of Engineers presented an eight volume "Review of the

Columbia River and its Tributaries,: a report costing $5 million; p. 33; 9) On 28 June 1950 at its 40th meeting, the Columbia Basin Inter-Agency committee approved an interim fishery research program (prepared by the Fish & Wildlife Subcommittee) that called for studies of fish passage at river obstructions, impoundment studies, artificial propagation, and studies of life history, trends and abundance, trout habitat and pollution, at an estimated $600,000 per year - another $500,000 was included for stream development and improvement; p. 46; 10) On 19 January 1955, the Columbia Basin Inter-Agency Committee directed the Fisheries Steering Committee to a) prepare an Upper Columbia River fishery program comparable to that in effect on the Lower Columbia River, b) a program of needed fishery research for the whole area, and c) explore ways and means of implementing/financing both programs; p. 83; 1) On 13 March 1957, the Columbia Basin Inter-Agency Committee accepted the Fisheries Steering Committee report with respect to a) prepare an Upper Columbia River fishery program comparable to that in effect on the Lower Columbia River, and b) a program of needed fishery research for the whole area - established resarch priorities and recommendaitons as to what agency would carry out specific studies recommended; p. 91; 12) On 13-14 November 1963, the Columbia Basin Inter-Agency Committee heard a panel of University of Washington academicians (James Crutchfield, W.F. Royce, D. Bevan, Robert Fletcher, R.C. Van Cleave, and R.W. Johnson) carry on extensive dialogues on "Fisheries in the Pacific Northwest - the academicians view this controversial issue," Don Bevan was very critical of fishery regulation; p. 114; 13) On 14 December 1965 at the 132 meeting of the Columbia Basin Inter-Agency Committee, the Executive Subcommittee presented its recommendations on seven fishery proposals (previously submitted by the Fisheries Steering Committee on 6 October 1965) summarized as follows: Proposal 1 - Greater Committee representation for salmon and steelhead, Proposal 2 - Reduction of the use of the Columbia River water for nuclear production to reduce heat pollution of the river, Proposal 3 - Establishment of working contract with Canada on Fishery problem, Proposal 4 - Development of small watersheds for power production should be discontinued, Proposal 5 - Assure proper attention to fish requirements in any inter-basin water transfer studies, Proposal 6 - Fishery research should be continued, the Proposal 7 - The Columbia River Fishery Development program should be retained; 14) On 29 September 1966 at its second Columbia-North Pacific study review, the Columbia Basin Inter-Agency Committee accepted the report of the Water Supply and Pollution Subcommittee entitled "Columbia River - Water Temperature Conditions and Research Requirements" report stemmed from one of the seven fishery proposals (previously submitted by the Fisheries Steering committee on 6 October 1965; p. 21); (15) On 9 June 1967, the Columbia Basin Inter-Agency committee held its last meeting, and handed over its responsiblities, function and records to the new River Basins Commission, p. 122.

Seaman, Margaret H. 1977. Columbia River estuary inventory of physical, biological and cultural characteristics. Columbia River Estuary Study Taskforce,
Abstract: Author provides a document containing a compilation of work contributions by various experts for the Columbia river basin, with respect to physical characteristics (e.g. climate, freshwater, estuarine tides, etc.); biological characteristics (e.g. tidal marshes, shoreline habitat, plankton, fishes, etc.); and cultural characteristics (e.g. land & water uses, recreation, etc.).

Shippen, H. 1954. Columbia River survey, ecological section. (Final report to the US Fish Wildl. Serv.). contract 14-19-008-2220. 178 p. p.
Abstract: Author provides a listing of fish species reported in the Columbia river drainage, based on various published and unpublished references; associates fish species with reference sources contained in listing of abstracts/annotations. These references within the abstracts/annotations section of this report contain information regarding species description, distribution, habitat, food habits, reproduction, and predation. Some but limited information for fishes species inhabiting the estuarine zones of the Columbia rive. **Note: Excellent Source For Old References Regarding the Fish Species and Habitat (including anadromous salmonids) within the Columbia River Basin.**

Simenstad, C. A., Jay, D., McIntire, C. D., Nehlsen, W., Sherwood, C., and Small, L. 1984 . The dynamics of the Columbia River estuarine ecosystem, Vol. I and II. Columbia River Estuary Data Development Program, Astoria, Oregon. 695 p. p.
Abstract: Authors present a synthesis of ecological information & data, derived the physical and biological studies carried out in the Columbia river estuary by CREDDP.The general sections of this reference are:
1. Regional setting and previous studies;
2. Circulatory processes;
3. Sedimentary geology;
4. Historical changes in Columbia river estuarine physical processes;
5. Conceptual framework for physical-biological integration;
6. Ecosystem processes; and
7. Ecosystem analyses by regions and habitat types.

Simenstad, C. A., Jay, D. A., and Sherwood, C. R. 1992. Impacts of watershed management on land-margin ecosystems: the Columbia River estuary. 266-306. Watershed Management: balancing sustainability and environmental change. Springer-Verlag, New York, NY. 543 p.
Abstract: Authors describe the pattern of land use development, changes in estuarine dynamics/process, and habitat alterations of the Columbia river estuary, with respect to river flow, physical properties, and discharge of sediments. State a reduction in 1) mean river flow by ~20%, 2) spring freshet discharge by ~50% of natural flow, 3) sediment inflow by ~25%, and 4) tidal prism by ~15% since the 19 th century. Modifications of the estuary have had significant effects on the estuarine processes that occur in the estuarine turbidity maximum (ETM). Subject of headings of reference are: 1) Watershed impacts on land-margin ecosystems, 2) Land margin ecosystems of illustrative of watershed impacts, 3) River characteristics and the influence of watershed alterations, 4) River flow dynamics, 5) Water characteristics and constituents, 6) Historic alterations to the Columbia river from the watershed to the land margin (includes subsections specifying/describing alterations to (a) watershed, (b) river flow frequency spectrum, & (c) sediment transport), 7) Effects of modifications to watershed on land-margin ecosystem processes (ETM, estuarine heat budget, organic input and food web, consumer populations & ecology). Reference contains excellent descriptive tables and figures that illustrate estuarine alterations, historical trends of specific physical/hydrologic factors in the estuary, and historical trends in anadromous salmon landings in the Columbia river.

Simenstad, C. A., Small, L. F., McIntire, C. D., Jay, D. A., and Sherwood, C. 1990. Columbia River estuary studies: An introduction to the estuary, a brief history, and prior studies. Prog. Ocean. 25: 1-13.
Abstract: Authors provide a short synopsis on: 1) a description of the Columbia river estuary, 2) previous investigations and the Columbia River Estuary Data Development Program (CREDDP), and Definitions and Conventions in CREDDP. Figures illustrate the various regions & zones and bathymetry of the Columbia estuary. A table illustrates and quantifies the area of habitat types within each region of the Columbia estuary. Extensive reference list included.

Smith, C. 1979. Salmon fishers of the Columbia. Oregon State University Press, Corvallis.
Abstract: Author describes a history of the Columbia River fishing industry, from the early Indian fishing activities through the modern day, using numerous reference sources. Provides fish landing and pack statistics over this period. Discusses the habitat alterations/ losses, due to water development, and artificial propagation activites in the Columbia River. Also discusses management history of the Columbia River, and regulatory actions of the States of Oregon and Washington since the late 1800s.

Stanley, G. F. 1970. Mapping the frontier - Charles Wilson's diary of the survey of the 49th parallel, 1858-1862, while secretary of the British Boundary Commission. University of Washington Press, Seattle, 182 pages.
Abstract: Charles William Wilson, a British Army officer, documents his travels, activities during his assignment in the survey and mapping of the region around the British Columbia and US boundary. Lieutenant Wilson provides excellent notes and observations of fisheries resources, Indian fishing, and habitat in the upper Columbia basin (e.g. Columbia, Okanogan, Ketttle, Pend d'Oreille rivers basins); ;and also documents fisheries/habitat in the Fraser River basin and Skagit River basin. (NOTE: an excellent reference to fish stocks and habitat that have not been documented in other references/publications related to the Columbia River fisheries resources). The following historical notes of historical milestones and fisheries/natural resources information were derived: 1) Mentions the survey (late 1850s) of the DD.G.F. Macdonald (civil engineer) in the region between the Chilliwack Lake and the Skagit river; p. 13; 2) An illustration of a map of the area (Chilliwack, Skagit, Pasayten, Ashnola (Rosalia), Similkameen, and Okanogan Rivers basin) surveyed in 1858-1860, p. 34-35; 3) Indian fishing and processing for winter use noted on the Fraser River opposite Fort langley on 16 October 1858, p. 37; 4) Description of habitat surrounding the Chillawack River (tributary to the Fraser R.) at Chilukweyuk Prairie Headquarters camp on 16 June 1859; also mentions that salmon abound in this area; p. 49; 5) On 30 July 1859, Lt. Wilson mentions that a "fearful fire was raging" in the Skagit Valley beyond the Cascades that originated from an American camp fire, which the Americans were too lazy to put out properly; p. 65; 6) On 9 October 1859, Lt. wilson mentions, in respect to the Chillawack river and tributaries that "at this season of the year is the quantity of dead salmon on the banks of the river; in some of the smaller streams the quantities are so numerous that it produces a most intolerable smell and renders the water anything but pleasant for drinking purposes...who has been dissecting several of them, thinks this arises from the want of insects to feed enormous numbers of salmon that run up the rivers." p. 73; 7) On 22 May 1860, Lt. Wilson describes Indian fishing activities at The Dalles (Celilo Falls) and notes that the fish "average 25 to 40 lbs. weight..." p. 95; 8) An illustration (map) of the region survey in the upper Columbia River basin (e.g. Kettle, Colville, Spokane, Pend d'Oreille Rivers) in 1860-1861; p. 104-5; 9) On 29 June 1860, lt. Wilson briefly describes the habitat of the Spokane River basin in the area between Willow Springs and Deep Creek; p. 108-9; 10) On 30 June 1860, Lt. Wilson briefly describes the habitat of the Colville River; p. 109; 11) On 2 July 1860, Lt. Wilson reported that the American Commission has been brought to a standstill at Pend d'Oreille Lake dur to extensive flooding..."I hear a tract of nearly 60 miles of land is flooded there." p. 112; 12) On 1 August 1860, Lt. Wilson extensively describes Indian fishing activities at Kettle Falls on the Columbia River, and notes that the Indians catch 700 to 1000 fish per day; p. 113-114; 13) On 12 August 1860, Lt. Wilson briefly describes the habitat surrounding the Okanogan River in the vicinity of Lake Osoyoos; and mentions the salmon fishing methods of the Indians "catching the salmon running at this time in great numbers...: p. 118; 14) On 26 August 1860, Lt. Wilson mentions gold miners at work on the Similkameen River near the forks of the Similkameen and Ashnolon (Rosalia) rivers, and notes that there were about 150 miners in the lower Similkameen basin; p. 124; 15) On 29 August 1860 Lt. Wilson briefly describes the habitat of Rock Creek (tributary to Kettle River); p. 125; 16) On 30 August 1860, lt. Wilson briefly describes the habitat of the Kettle River (Nehoialpitku") in the vicinity of the town of Rock Creek and also describes the gold mining activity and methods on Rock Creek; p. 126-6; 17) On 31 August 1860, Lt. Wilson briefly again describes the habitat of the Kettle River ("Nehoialpitku"); p. 128; 18) On 2 September 1860, Lt. Wilson notes that "salmon are running in great numbers up the river (the Kettle River "Nehoialpitku"); p. 129; 19) Lt. Wilson describes the habitat in the Little Spokane River basin; p. 146. General description of attributes in the vicinity of the confluence of the Snake and Columbia Rivers. General description of attributes in the vicinity of the Palouse river mouth.

Stone, L. 1885. Explorations on the Columbia River from the head of the Clarks Fork to the Pacific

Ocean, made in the summer 1883, with reference to the selection of suitable place for establishing a salmon breeding station. US Bureau of Fisheries Report, 1883 (1885), p. 237-258. Doc. 97 issued 1886; F11-241. US Bureau of Fisheries, Washington, DC.
Abstract: Derived reference from Appendix V: An analytical subject bibliography of the publications of the Bureau of Fisheries, 1871-1920, by Rose M.E. MacDonald. Document review: Author generally describes his investigation of the various Columbia tributaries in terms as potential fish hatchery sites; provides some habitat characteristics of the tributaries.

Sutton, Sarah. 1854. Diary of Sarah Sutton 1, 69-86 (incomplete) p.
Abstract: Author provides some detailed descriptions of activities, habitat and surroundings of various sub-basins (e.g. Burnt, Powder, and Grande Ronde) during her journey to Oregon; diary abruptly ends since the author died at an unknown place in transit of the Grande Ronde valley.

Symons, Thomas W. 1882. Report of an examination of the upper Columbia River and the territory in its vicinity in September and October 1881. 47th congress, 1st Session, Senate, Ex. Doc. No. 186, Washington; Government Printing Office, 1882. 1-135, maps (complete) p.
Abstract: Author presents a comprehensive account of observations (geologic, botanical, hydraulic/topographic characteristics) and surveys of the upper Columbia River and its tributaries (e.g. Pend d'Oreille, Kootenay, Colville, Spokane, San Poil, Methow River, etc.) Note: Excellent reference to derive habitat information and inferences of the upper Columbia River.

Thomas, D. W. 1983. Changes in the Columbia River estuary habitat types over the past century. Columbia River Estuary Data Development Program, Astoria, Oregon. 51 p. (complete) p.
Abstract: The author provides and compares information for habitat of the Columbia river from the period predating most human interventions (circa 1870) to the present day (1980). Qualitative and quantitative changes in various estuarine habitat are described and illustrated (figures & tables) according to:
(1) Area- river mouth, mixing zone,Youngs Bay, Baker Bay, Grays Bay, Cathlamet Bay, Upper Estuary, and Estuary;
(2) Habitat type- deep water, medium depth, shallows/ flats, tidal marshes, tidal swamps, developed floodplain, uplands (natural & filled), non-estuarine swamp, and non-estuarine water;
(3) Acreage by period- 1870 and present;
(4) Change- acreage (plus or minus) and percentage;
(5) 1870 acreage, Present estuarine acreage, estuarine area removed, and non-estuarine wetlands added.
Includes appendices providing information regarding:
(1) Excerpts from Annual Reports of Superintendent of the US Coast Survey concerning the Columbia river survey for 1868-1873;
(2) Verification of the US Coast Survey charts;
(3) An explanation of the boundaries of the historical subarea map;
(4) Subarea reports for the River Mouth, Mixing Zone, Youngs Bay, Baker Bay, Grays Bay, Cathlamet Bay, and Upper Estuary;
(5) The nineteen intertidal vegetation communities of the Columbia river, with tables showing their present acreage per subarea and their former acreage and importance (Thomas, 1980).
Note: Excellent reference.

United States. Army Corps of Engineers. 1974. Draft environmental statement of Lower Monumental lock and dam, Snake river, Washington U.S. Army Engineer District, Walla Walla, Washington.
Abstract: This draft environmental impact statement addresses the proposed Lower Monumental dam project. Includes information that describes the Lower Monumental project and the existing

environment (terrestrial and water habitat/resources) in the area of the project; and describes the impacts of proposed project alternatives.

United States. Army Corps of Engineers. 1975. Draft environmental statement of Lower Granite project, Snake river, Washington U.S. Army Engineer District, Walla Walla, Washington.
Abstract: This draft environmental impact statement addresses the proposed Lower Granite dam project. Includes information that describes the Lower Granite project and the existing environment (terrestrial and water habitat/resources) in the area of the project; and describes the impacts of proposed project alternatives.

United States. Army Corps of Engineers. 1975. Draft environmental statement of lower Snake river fish and wildlife compensation U.S. Army Engineer District, Walla Walla, Washington. 1, I-4, 46-47, 70-106, maps p.
Abstract: This draft environmental impact statement addresses proposed actions to compensate fish and wildlife losses resulting from four multi-purpose water resources development projects on the lower Snake river. Includes information that describes the existing environment (terrestrial and water habitat/resources) in the area of the project; and describes the impacts of proposed project alternatives.

United States. Army Corps of Engineers. 1979. Final environmental statement of Ice Harbor lock and dam, Snake river, Washington U.S. Army Engineer District, Walla Walla, Washington. 1,11, 2(1)-2(19), 2(33)-2(36) p.
Abstract: This draft environmental impact statement addresses the proposed Ice Harbor dam project. Includes information that describes the Ice Harbor project and the existing environment (terrestrial and water habitat/resources) in the area of the project; and describes the impacts of proposed project alternatives.

United States. Army Corps of Engineers and Department of Commerce. 1994. (Draft environmental statement.). Lower Snake river biological drawdown test.
Abstract: This draft environmental impact statement addresses a proposed biological drawdown test to be conducted a Lower Granite Reservoir, possibly as early as 1995. Include information describing the Lower Granite project and the existing environment (terrestrial and water habitat/resources) in the area of the project.

US Army. 1897. Report of the chief of engineers 1897 in six parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1897. (Annual report).Government Printing Office, Washington. 3456-3463 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 502-503, Part 4, p. 3404-3406;
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 503, Part 4, p. 3407-3414;
(3) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 504, Part 4, p. 3414-3416.
(4) Cowlitz river- Part 1, p. 520, Part 4, p. 3463-3465;
(5) Young's and Klasskuine rivers-Part 1, p. 466, Part 5, p.3595-3596 (removal of snags and

overhanging trees);
(6) Clatskanie river, from mouth to town of Clatskanie-Part 1, p. 467, Part 4, p. 3596-3598;
(7) Lewis river (survey)-Part 1, p. 523, Part 4, p. 3469-3478; and
(8) South channel of Columbia river (in front of Astoria, OR-Part 1, p. 468, Part 4, p. 3406-3407. General description of attributes for the Snake river in the vicinity of Wild Goose Island (~74 miles above the Snake river mouth)- human alterations. General description of attributes for the Snake river in the vicinity of Log Island (~38 miles below Lewiston, ID)- human alterations.

US Army. 1898. Report of the chief of engineers 1898 in six parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1898. (Annual report). Government Printing Office, Washington. 3014-3025 (incomplete) p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 507-508, Part 4, p. 3040;
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 505-506, Part 4, p. 3031-3038;
(3) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 499, Part 4, p. 3414-3416.
(4) Cowlitz river- Part 1, p. 508-509, Part 4, p. 3041-3042;
(5) Willamette Slough (Scappoose Creek/ Bay)- Part 4, p. 3043-3044;
(6) Clatskanie river, from mouth to town of Clatskanie-Part 1, p. 510, Part 4, p. 3049-3050; and
(7) South channel of Columbia river (in front of Astoria, OR-Part 1, p. 507, Part 4, p. 3039. Detailed description of attributes for the Snake river from mouth to Riparia- derived from House Document No. 411, Fifty-Fifth Congress, Second Session: Survey of the Snake River, Washington, From Its Mouth to Riparia (with maps in four sheets). General description of attributes for the Snake river in the vicinity of Wild Goose Island (~74 miles above the Snake river mouth)- human alteration. General description of attributes for the Snake river in the vicinity of Log Island (~38 miles below Lewiston, ID)- human alterations.

US Army. 1899. Report of the chief of engineers 1899 in six parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1899. (Annual report).Government Printing Office, Washington.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 595 Part 4, p. 3246-3247 (includes bathymetry map, dated June 1899, of mouth);
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 592-593, Part 4, p. 3239-3245;;
(3) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 586-588, Part 4, p. 3229-3231 (includes map of Hayden Slough characteristics & 6 pages of photographs);
(4) Cowlitz river- Part 1, p. 597-598, Part 4, p. 3249-3250;
(5) Lewis river-Part 1, p. 596-597, Part 4, p. 3248-3249;

(6) Clatskanie river-Part 1, p. 595-596, Part 4, p. 3247-3248; and
(7) Columbia river below Tongue Point-Part 1, p. 594, Part 4, p. 3245-3246.

US Army. 1900. Report of the chief of engineers 1900 in nine parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1900. (Annual report).Government Printing Office, Washington. 4338-4343 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 671-672 & p. 676,-Part 6, p. 4361-4362 & p. 4434-4455 (includes bathymetry map, dated June 1900, of mouth);
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 669-670 & p. 676, Part 6, p. 4352-4360 & p. 4416-4433 (includes bar above Tongue Pt, Dobelbower Bar, Walker Is. Bar, Martin Is., Hunters Bar, Martin Is.-Upper Bar, & Pillar Rock Bar);
(3) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 661-663, Part 6, p. 4334-4337 (includes map of Hayden Slough characteristics;
(4) Cowlitz river- Part 1, p. 674-675, Part 6, p. 4366-4367;
(5) Lewis river-Part 1, p. 673-674, Part 6, p. 4364-4365;
(6) Clatskanie river-Part 1, p. 672-673, Part 6, p. 4363-4364; and
(7) Columbia river below Tongue Point-Part 1, p. 670-671, Part 6, p. 4360-4361.
General description of attributes for the Snake river in the vicinity of Wild Goose Island (~74 miles above the Snake river mouth)- human alteration. General description of attributes for the Snake river in the vicinity of Log Island (~38 miles below Lewiston, ID)- human alterations. General description of attributes for Steptoe Rapids, located ~20 miles below Lewiston, ID. Detailed description of attributes for the Snake R. from Asotin to Wolf Cr. vicinity- derived from House Document No. 75, Fifty-Sixth Congress, 1st Session: Preliminary examination of Snake River from Asotin, WA to Pittsburg, OR (photos and maps included).

US Army. 1901. Report of the chief of engineers 1901 in five parts plus supplement. Annual Reports, War Department, Fiscal Year Ended June 30, 1901. (Annual report).Government Printing Office, Washington. 3528-3544 (incomplete) p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 635-637,-Part 5, p. 3567-3570;
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 633-634, Part 5, p. 3557-3565;
(3) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 627-628, Part 5, p. 3499-3501;
(4) Cowlitz river- Part 1, p. 639-640, Part 5, p. 3573-3575;
(5) Lewis river-Part 1, p. 638-639, Part 5, p. 3572-3573;

(6) Clatskanie river-Part 1, p. 637-638, Part 5, p. 3571-3572; and
(7) Columbia river below Tongue Point-Part 1, p. 634-635, Part 5, p. 3565-3567.
Detailed description of attributes for the Snake river from the mouth to Lewiston, ID. Vicinity-derived from House Document No. 127, Fifty-Sixth Congress, 2nd Session: Preliminary examination of Snake River from Lewiston, ID to Riparia, WA.

US Army. 1902. Report of the chief of engineers 1902 in four parts plus supplement. Annual Reports, War Department, Fiscal Year Ended June 30, 1902. (Annual report).Government Printing Office, Washington.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 556-558,-Part 3, p. 2400-2402;
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 554-555, Part 3, p. 2393--2398;
(3) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 549-550, Part 3, p. 2383-2384;
(4) Cowlitz river- Part 1, p. 559-560, Part 3, p. 2404-2405;
(5) Lewis river-Part 1, p. 560-561, Part 3, p. 2406-2407;
(6) Clatskanie river-Part 1, p. 558-559, Part 3, p. 2403-2404; and
(7) Columbia river below Tongue Point-Part 1, p. 556-558, Part 3, p. 2398-2400.

US Army. 1903. Report of the chief of engineers 1903-Volume 9, Part 1, Volume 10, Part 2, Volume 11, Part 3, Volume 12, Part 4, & Volume 13, Supplement.. Annual Reports, War Department, Fiscal Year Ended June 30, 1903. (Annual report).Government Printing Office, Washington. 2246-2255, 2270-2319 and maps p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 614-616,-Part 3, p. 2271-2318 (includes a comprehensive synopsis for the Columbia river entrance, with respect to description, history, physical data, sand movements, projects such as jetties, dredging, etc, and appendices with historical surveys & bathymetric maps);
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 612-614, Part 3, p. 2263-2270 (includes an index map of the lower Columbia and Willamette rivers, opposite p. 2266);
(3) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 608-609, Part 3, p. 2228-2229;
(4) Cowlitz river- Part 1, p. 616-618, Part 3, p. 2319;
(5) Lewis river-Part 1, p. 618-619, Part 3, p. 2320-2321 (includes index map of Lewis river);
(6) Clatskanie river-Part 1, p. 616-617, Part 3, p. 2318; and
(7) Columbia river below Tongue Point-Part 1, p. 614, Part 3, p. 2398-2400.

Note: Excellent reference that provides the history of the Columbia entrance from late 1700's to present.
Detailed description of attributes for the Snake R. from Lewiston (ID) to Imnaha river mouth- 14 maps included. Detailed description of attributes for the Snake R. from Lewiston (ID) to Imnaha river mouth- 13 maps to scale of 1:5000 with an index sheet and profile of the river (not printed in report?)

US Army. 1904. Report of the chief of engineers 1904- Volume 5, Part 1, Volume 6, Part 2, Volume 7, Part 3, Volume 8, Part 4, & Volume 9, Supplement. Annual Reports, War Department, Fiscal Year Ended June 30, 1904. (Annual report).Government Printing Office, Washington . 3468-3471, maps p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 678-681,-Part 3, p. 3543-3553 (includes a bathymetric map of the Columbia river entrance for June 1904, opposite p. 3548);
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 675--677, Part 3, p. 3534-3542 (includes an index map of the lower Columbia and Willamette rivers, opposite p. 3538);
(3) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 670-671, Part 3, p. 3496-3506;
(4) Cowlitz river- Part 1, p. 682-683, Part 3, p. 3555-3557;
(5) Lewis river-Part 1, p. 683-685, Part 3, p. 3557-3558 (includes index map of Lewis river);
(6) Clatskanie river-Part 1, p. 681-682, Part 3, p. 3554-3555; and
(7) Columbia river below Tongue Point-Part 1, p. 678, Part 3, p. 3543.

US Army. 1905. Report of the chief of engineers 1905- Volume 5, Part 1, Volume 6, Part 2, Volume 7, Part 3, Volume 8, Supplement.. Annual Reports, War Department, Fiscal Year Ended June 30, 1905. (Annual report). Government Printing Office, Washington. 2454-2469, 2482-2495 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 685-687,-Part 3, p. 2484-2492 (includes a bathymetric map of the Columbia river entrance for June 1905, opposite p. 2488);
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 681-684, Part 3, p. 2475-2483 (includes an index map of the lower Columbia and Willamette rivers, opposite p. 2478);
(3) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 676-678, Part 3, p. 2467-2468;
(4) Cowlitz river- Part 1, p. 688-689, Part 3, p. 2493-2494;
(5) Lewis river-Part 1, p. 689-691, Part 3, p. 2495-2496;
(6) Clatskanie river-Part 1, p. 687-688, Part 3, p. 2492-2493; and
(7) Columbia river below Tongue Point-Part 1, p. 684, Part 3, p. 2483-2484.

US Army. 1906. Report of the chief of engineers US Army 1906 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1906. (Annual report).Government Printing Office, Washington . 1984-1999, 2004-2019, 2044-2047 p.

Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 757-760,-Part 2, p. 2012-2017-(includes a bathymetric map of the Columbia river entrance for May-June 1906, opposite p. 2016);
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 754-756, Part 2, p. 2006-2012 - (includes an index map of the lower Columbia and Willamette rivers, opposite p. 2010);
(3) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 750-751, Part 2, p. 1998-2000;
(4) Cowlitz river- Part 1, p. 761-763, Part 2, p. 2018-2019;
(5) Lewis river-Part 1, p. 763-765, Part 2, p. 2019; and
(6) Clatskanie river-Part 1, p. 760-761, Part 2, p. 2017-2018.
Detailed description of the attributes for the Snake R. from Imnaha river mouth to Wolf creek vicinity (Pittsburg, OR)- seven map sheets not included. Detailed description of the attributes for the Snake R. from Imnaha river mouth to Wolf creek vicinity (Pittsburg, OR)- index map of upper Columbia and Snake rivers from Ceilo to Pittsburg Landing.

US Army. 1907. Report of the chief of engineers US Army 1907 in three parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1907. (Annual report).Government Printing Office, Washington. 2168-2179, 2188-2205, 2226-2227 p.

Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Columbia river- mouth to mouth of Willamette river-Part 1, p. 767-768;
2) Columbia and lower Willamette rivers below Portland- Part 1, p.771-772;
3) Mouth of Columbia river- Part 1, p. 773-774, Part 3, p. 2196-2203;
5) Dredge for improving lower Willamette and Columbia rivers- Part 2, p. 1105-1106, Part 3, p. 2190-2196;
6) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 775-776, Part 3, p. 2203-2204;
7) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 777-778, Part 3, p. 2204-2207;
8) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 776-777, Part 3, p. 2204-2207; and
9) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 779, Part 3, p. 2207.

US Army. 1908. Report of the chief of engineers US Army 1908 in three parts. Annual Reports, War

Department, Fiscal Year Ended June 30, 1908. (Annual report).Government Printing Office, Washington. 2244-2257, 2264-2279, 2305-2307 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Columbia and lower Willamette rivers below Portland- Part 1, p.820-822, Part 3, p.2264-2270;
2) Mouth of the Columbia river- Part 1, p. 822-825, Part 3, p. 2270-2274 (**Note**: opposite page 2272 is survey map of Columbia river entrance for the year 1908);
3) Dredge for improving lower Willamette and Columbia rivers- Part 1, p. 1143-1144;
4) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 825-826, Part 3, p. 2274-2275;
5) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 827-829, Part 3, p. 2277-2278;
6) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 826-8277, Part 3, p. 2275-2277; and
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 829-830, Part 3, p. 2278-2279.

US Army. 1909. Report of the chief of engineers US Army 1909 in three parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1909. (Annual report).Government Printing Office, Washington. 2210-2217, 2222-2223, 2230-2238, 2240-2243, 2260-2263 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Columbia and lower Willamette rivers below Portland- Part 1, p. 859-982, Part 3, p. 2230-2236;
2) Mouth of the Columbia river- Part 1, p.862-864, Part 3, p. 2236-2239;
3) Dredge for improving lower Willamette and Columbia rivers- Part 1, p.1153 (**Note**: opposite page 2238 is survey map of Columbia river entrance for the year 1909);
4) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 865-866, Part 3, p. 2239-2240;
5) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 867-869, Part 3, p. 2241-2242;
6) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 866-867, Part 3, p. 2240-2241; and
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 869-870, Part 3, p. 2242-2243.

US Army. 1913. Report of the chief of engineers US Army 1913 in three parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1913. (Annual report).Government Printing Office, Washington. 3068-3085, 3092-3095, 3100-3105,3108-3115, 3140-3143 p.

Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Oregon Slough (part of the former channel of the Columbia river which separates Hayden Island from the Oregon mainland)- Part 1, p. 1338-1340 (**Note:** Includes table of references to examination or survey reports or maps not in the project documents for years 1892, 1896, 1904, & 1912), Part 3, p. 3083-3084;
2) Columbia and lower Willamette rivers below Portland- Part 1, p. 13501354 (**Note:** Includes table of references to examination or survey reports or maps including the project documents for years 1877, 1891, 1892, & 1900), Part 3, p. 3092-3100;
3) Mouth of the Columbia river- Part 1, p. 1354-1359, Part 3, p. 3100-3108 (**Note**: opposite page 3104 is survey map of Columbia river entrance for the year 1913);
4) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1359-1361 & p. 1367-1368 (Note: Snag removal projects), Part 3, p. 3108-3109 & p. 3115 (Note: Snag removal projects);
5) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1364-1367 & p. 1367-1368 (Note: Snag removal projects), Part 3, p. 3113-3114 & p. 3115 (Note: Snag removal projects);
6) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1362-1364 & p. 1367-1368 (Note: Snag removal projects), Part 3, p. 3110-3112 & p. 3115 (Note: Snag removal projects); and
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1368-1369, Part 3, p. 3115-3116.

US Army. 1914. Report of the chief of engineers US Army 1914 in three parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1914. (Annual report).Government Printing Office, Washington. 3197-3215, 3222-3245, 3266-3267 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Oregon Slough (part of the former channel of the Columbia river which separates Hayden Island from the Oregon mainland)- Part 1, p.1387-1389 (**Note:** Includes table of references to examination or survey reports or maps not in the project documents for years 1892, 1896, 1904, & 1912),
2) Columbia and lower Willamette rivers below Portland- Part 1, p. 1400-1403 (**Note:** Includes table of references to examination or survey reports or maps including the project documents for years 1877, 1891, 1892, & 1900),
3) Mouth of the Columbia river- Part 1, p. 1403-1409 (**Note:** Includes (1) Table of references to examination or survey reports or maps including the project documents for years 1879, 1880, 1883, 1886,1890, 1893, 1895,1900 & 1903, and (2) Information on the amount of stone used for the 1884 and 1903 jetty projects);

4) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1409-1411 & p. 1417-1418 (Note: Dredge & snag removal projects), Part 3, p. 3239-3240 & p. 3245 (Note: Dredge & snag removal projects);
5) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1414-1417 & p. 1417-1418 (Note: Dredge & snag removal projects), Part 3, p. 3243-3444 & p. 3455 (Note: Dredge & snag removal projects);
6) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1411-1414 & p. 1417-1418 (Note: Dredge & snag removal projects), Part 3, p. 3240-3243 & p. 3455 (Note: Dredge & snag removal projects); and
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1418-1419, Part 3, p. 3245-3246.

US Army. 1915. Report of the chief of engineers US Army 1915 in three parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1915. (Annual report).Government Printing Office, Washington. 3370-3375, 3388-3389, 3396-3419, 3442-3443 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) The Columbia river between Vancouver, WA and the mouth of the Willamette river- Part 1, p. 1513-115;
2) Oregon Slough (part of the former channel of the Columbia river which separates Hayden Island from the Oregon mainland)- Part 1, p. 1515-1518, Part 3, p. 3389-3390;
3) Columbia and lower Willamette rivers below Portland- Part 1, p. 1527-1532, Part 2, p. 1998-1999, Part 3, p. 3397-3404;
4) Mouth of the Columbia river- Part 1, p.1533-1538, Part 2, p. 1999-2000, Part 3, p. 3404-3414 (**Note**: opposite page 3408 are survey maps of Columbia river entrance for the September and December 1914, and March and June 1915);
5) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1538-1540 & p. 1546-1547 (Note: Dredge & snag removal projects), Part 2, p. 2000, Part 3, p. 3414-3415 & p. 3418-3419 (Note: Dredge & snag removal projects);
6) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1543-1546 & p. 1546-1547 (Note: Dredge & snag removal projects), Part 2, 2001, Part 3, p. 3417--3418 & p. 3418-3419 (Note: Dredge & snag removal projects);
7) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1540-1542 & p. 1546-1547 (Note: Dredge & snag removal projects), Part 2, p. 2000, Part 3, p. 3415-3417 & p. 3418-3419 (Note: Dredge & snag removal projects); and
8) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1547-1549, Part 3, p. 3245-3246.

US Army. 1916. Report of the chief of engineers US Army 1916 in three parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1916. (Annual report).Government Printing Office, Washington. 3207-3219, 3226-3227, 3232-3245, 3270-3273 p.
Abstract: The reference contains comprehensive information regarding projects and activities related

to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Columbia and lower Willamette rivers below Portland- Part 1, p. 1649-1655, Part 3, p.3227-3233;
2) Mouth of the Columbia river- Part 1, p. 1655-1658, Part 3, p. 3233-3238 (**Note**: opposite page 3408 is survey map of Columbia river entrance for the June 1916).
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1658-1661 & p. 1668 (Note: Dredge & snag removal projects), Part 3, p. 3239-3240 & p. 3244-3245 (Note: Dredge & snag removal projects);
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1663-1667 & p. 1668 (Note: Dredge & snag removal projects), Part 3, p. 3242--3244 & p. 3244-3245 (Note: Dredge & snag removal projects);
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1661-1663 & p. 1668 (Note: Dredge & snag removal projects), Part 3, p. 3240-3242 & p. 3244-3245 (**Note**: Dredge & snag removal projects); and
6) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1668-1670, Part 3, p. 3245-3246.

US Army. 1917. Report of the chief of engineers US Army 1917 in three parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1917. (Annual report).Government Printing Office, Washington. 3322-3323, 3328-3335, 3344-3349, 3376-3377 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1716-1719, Part 2, p. 3329-3333;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1719-1726, Part 2, p. 3333-3340;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1726-1729, Part 2, p. 3340-3342;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1735-1739, Part 2, p. 3345--3347;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1739-1741, Part 2, p. 3347-3349; and
6) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1742-1744, Part 2, p. 3349-3350.

US Army. 1918. Report of the chief of engineers US Army 1918 in three parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1918. (Annual report).Government Printing Office, Washington. 3370-3371, 3377-3385, 3394-3397 p.
Abstract: The reference contains comprehensive information regarding projects and activities related

to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p. 1763-1766, Part 3, p. 3377-3380 (**Note**: opposite page 3378 is survey map of Columbia river entrance for the June 1918).;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p.1766-1772, Part 3, p. 3381-3388;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1773-1775, Part 3, p. 3389-3390;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1782-1786, Part 3, p. 3394--3395;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1786-1789, Part 3, p. 3395-3397; and
6) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1789-1791, Part 3, p. 3397-3398.

US Army. 1919. Report of the chief of engineers US Army 1919 in three parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1919. (Annual report).Government Printing Office, Washington . 3424-3441 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p. 1857-1861, Part 3, p. 3433-3437 (**Note**: opposite page 3434 is survey map of Columbia river entrance for the June 1919).;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p.1861-1867, Part 3, p. 3437-3445.
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1867-1870, Part 3, p.3445-3446 ;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1877-1880, Part 2, p. 3450-3451;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1881-1883, Part 3, p. 3452-3453;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1883-1885, Part 3, p. 3453-3454; and
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1885-1888, Part 3, p. 3454-3455.

US Army. 1920. (Annual report).Government Printing Office, Washington. 2926-2945 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis,

Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1851-1854, Part 2, p. 2935-2937 (**Note**: opposite page 2936 is survey map of Columbia river entrance for the June 1920);
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1854-1861, Part 2, p. 2937-2940;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1861-1863, Part 2, p.2941 ;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1870-1873, Part 2, p. 2943-2944;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1874-1876, Part 2, p. 2944;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1876-1878, Part 2, p. 2945; and
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1878-1881, Part 2, p. 2945.

US Army. 1921. Report of the chief of engineers US Army 1921 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1921. (Annual report).Government Printing Office, Washington . 1850-1877, 1886-1895, 1944-1947 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1867-1870 (**Note**: opposite page 1868 is survey map of Columbia river entrance for the June 1921);
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1870-1877;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1877-1880;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1886-1889;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1889-1892;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1892-1894; and
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1894-1897.

US Army. 1922. Report of the chief of engineers US Army 1922 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1922. (Annual report).Government Printing Office, Washington . 1868-1899, 1909-1921, 1964-1967 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones

of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1887-1889;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1890-1897;
3) Willamette Slough (also known as Multnomah Channel- 21 miles in length, flowing in northerly direction, connecting the Willamette and Columbia rivers at St. Helens, OR)- Part 1, p. 1897-1899 (**Note**: a new project in the fiscal year 1922);
4) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1900-1902;
5) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1909-1912;
6) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1912-1914;
7) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1915-1916; and
8) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1916-1919.

US Army. 1923. Report of the chief of engineers US Army 1923 in three parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1923. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1743-11746;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1746-1754;
3) Willamette Slough (also known as Multnomah Channel- 21 miles in length, flowing in northerly direction, connecting the Willamette and Columbia rivers at St. Helens, OR)- Part 1, p. 1754-1756;
4) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1756-1759;
5) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1764-1767;
6) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1767-1769;
7) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1769-1771; and
8) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1772-1774.

US Army. 1924. Report of the chief of engineers US Army 1924 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1924. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis,

Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1748-1751;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1751-1759;
3) Willamette Slough (also known as Multnomah Channel- 21 miles in length, flowing in northerly direction, connecting the Willamette and Columbia rivers at St. Helens, OR)- Part 1, p. 1760-1762;
4) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1762-1764;
5) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1769-1772;
6) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1772-1774;
7) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1775-1776; and
8) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1777-1779.

US Army. 1925. Report of the chief of engineers US Army 1925 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1925. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1676-1679;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1679-1686;
3) Willamette Slough (also known as Multnomah Channel- 21 miles in length, flowing in northerly direction, connecting the Willamette and Columbia rivers at St. Helens, OR)- Part 1, p. 1686-1688;
4) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1688-1691;
5) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1699-1701;
6) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1702-1704;
7) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1704-1705;
8) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1706-1707; and
9) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1708-1709.

US Army. 1926. Report of the chief of engineers US Army 1926 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1926. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding proje cts and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the

river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1665-1668;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1668-1677;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1677-1680;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1688-1691;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1691-1694;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1694-1696;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1696-1698; and
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1698-1701.

US Army. 1927. Report of the chief of engineers US Army 1927 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1927. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidalriver zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1664-1667;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1667-1675;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1675-1678;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1700-1702;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1702-1705;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1705-1707;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1707-1709; and
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1709-1711.

US Army. 1928. Report of the chief of engineers US Army 1928 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1928. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results,

etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1725-1728;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1728-1736;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1736-1739;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1761-1763;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1764-1766;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1766-1768;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1769-1770; and
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1771-1773.

US Army. 1929. Report of the chief of engineers US Army 1929 in two parts. nnual Reports, War Department, Fiscal Year Ended June 30, 1929. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1753-1756;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1756-1764;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1764-1767;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1790-1793;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1793-1796;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1796-1798;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1798-1800; and
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1800-1802.

US Army. 1930. Report of the chief of engineers US Army 1930 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1930. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1844-1847;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1849-1856;

3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1856-1859;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1886-1889;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1889-1892;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1893-1895;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1895-1897;
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1897-1900;
9) Skipanon Channel (located at Warrenton, OR; originally called Skipanon river, a narrow crooked stream with ~1.8 mi tidal)- Part 1, p. 1847-1849 (**Note**: reference provides a short history of the stream & condition);
10) Lake river (enters Columbia river near the mouth of the Lewis river)- Part 1, p. 1885-1886 (**Note**: a short history of the stream and associated activities/description is provided); and
11) Steamboat Slough (also known as Skamokama Slough)- Part 1, p. 1892-1893.

US Army. 1931. Report of the chief of engineers US Army 1931 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1931. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1854-1857;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1861-1869;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1869-1872;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1899-1901;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1901-1905;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1906-1910;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1895-1897;
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1911-1913;
9) Skipanon Channel (located at Warrenton, OR; originally called Skipanon river, a narrow crooked stream with ~1.8 mi tidal)- Part 1, p. 1857-1860 (**Note**: reference provides a short history of the stream & condition);
10) Lake river (enters Columbia river near the mouth of the Lewis river)- Part 1, p. 1896-1899 (**Note**: a short history of the stream and associated activities/description is provided); and
11) Steamboat Slough (also known as Skamokama Slough)- Part 1, p. 1905-1906.

US Army. 1932. Report of the chief of engineers US Army 1932 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1932. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related

to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1756-1760;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1762-1771;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1771-1773;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1794-1796;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1796-1799;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1800-1802;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1802-1803;
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1803-1805;
9) Lake river (enters Columbia river near the mouth of the Lewis river)- Part 1, p. 1792-1794 (**Note**: a short history of the stream and associated activities/description is provided); and
10) Steamboat Slough (also known as Skamokama Slough)- Part 1, p. 1799-1800.

US Army. 1933. Report of the chief of engineers US Army 1933 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1933. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1140-1143;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 11145-1150;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1150-1152;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1164-1165;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1166-1168;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1168-1169;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1802-1803;
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1169-1170; and
9) Skipanon Channel (located at Warrenton, OR; originally called Skipanon river, a narrow crooked stream with ~1.8 mi tidal)- Part 1, p. 1143-1145 (**Note**: reference provides a short history of the stream & condition).

US Army. 1934. Report of the chief of engineers US Army 1934 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1934. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1313-1316;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1318-1325;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1325-1326;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1343-1344;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1344-1347;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1347-1348;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1348-1350;
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1350-1351;
9) Lake river (enters Columbia river near the mouth of the Lewis river)- Part 1, p. 1341-1343 (**Note**: a short history of the stream and associated activities/description is provided);
10) Columbia river at Bakers Bay- Part 1, p. 1351-1352;
11) Columbia river at Bonneville-Part 1, p. 1334-1337; and
12) Skipanon Channel (located at Warrenton, OR; originally called Skipanon river, a narrow crooked stream with ~1.8 mi tidal)- Part 1, - Part 1, p. 1316-1318 (**Note**: reference provides a short history of the stream & condition).

US Army. 1935. Report of the chief of engineers US Army 1935 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1935. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1475-1477;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1479-1487;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1487-1488;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1499-1501;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1501-1503;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1503-1504;

7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1504-1505;
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1505-1507;
9) Lake river (enters Columbia river near the mouth of the Lewis river)- Part 1, p. 1498-1499 (**Note**: a short history of the stream and associated activities/description is provided);
10) Columbia river at Bakers Bay- Part 1, p. 1507-1508;
11) Columbia river at Bonneville-Part 1, p. 1513-1516;
12) Skipanon Channel (located at Warrenton, OR; originally called Skipanon river, a narrow crooked stream with ~1.8 mi tidal)- Part 1, - Part 1, p. 1477-1478 (**Note**: reference provides a short history of the stream & condition);
13) Youngs Bay and Youngs river (lower 8 mi. tidal)-Part 1, p. 1478-1479; and
14) Multnomah Channel (also known as Willamette Slough)-Part 1, p. 1489-1490.

US Army. 1936. Report of the chief of engineers US Army 1936 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1936. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1476-1478;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1481-1487;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1487-1489;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1500-1502;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1502-1504;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1504-1505;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1505-1506;
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1506-1507;
9) Lake river (enters Columbia river near the mouth of the Lewis river)- Part 1, p. 1499-1500 (**Note**: a short history of the stream and associated activities/description is provided);
10) Columbia river at Bakers Bay- Part 1, p. 1507-1508;
11) Columbia river at Bonneville-Part 1, p. 1517-1524;
12) Skipanon Channel (located at Warrenton, OR; originally called Skipanon river, a narrow crooked stream with ~1.8 mi tidal)- Part 1, - Part 1, p. 1479-1480 (**Note**: reference provides a short history of the stream & condition);
13) Youngs Bay and Youngs river (lower 8 mi. tidal)-Part 1, p. 1480;
14) Multnomah Channel (also known as Willamette Slough)-Part 1, p. 1489-1490; and
15) Oregon Slough (also known as North Portland Harbor)-Part 1, p. 1498-1499.

US Army. 1937. Report of the chief of engineers US Army 1937 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1937. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones

of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1487-1489;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1492-1498;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1499-1500;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1509-1510;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1510-1512;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1513-1514;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1514-1515;
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1515-1516;
9) Lake river (enters Columbia river near the mouth of the Lewis river)- Part 1, p. 1508-1509 (**Note**: a short history of the stream and associated activities/description is provided);
10) Columbia river at Bakers Bay- Part 1, p. 1516-1517;
11) Columbia river at Bonneville-Part 1, p. 1529-1536;
12) Skipanon Channel (located at Warrenton, OR; originally called Skipanon river, a narrow crooked stream with ~1.8 mi tidal)-Part 1, p. 1489-1491 (**Note**: reference provides a short history of the stream & condition);
13) Youngs Bay and Youngs river (lower 8 mi. tidal)-Part 1, p. 1491-1492;
14) Multnomah Channel (also known as Willamette Slough)-Part 1, p. 1500-1501;
15) Oregon Slough (also known as North Portland Harbor)-Part 1, p. 1498-1499;
16) Westport Slough (side channel of the Columbia river located 70 mi. below Portland, OR)-Part 1, p. 1498-1499;
17) Elockomin Slough (3.5 mi. in length, located 75 mi. below Portland)-Part 1, p. 1512-1513; and
18) Columbia river between Vancouver and Bonneville-Part 1, p. 1528-1529.

US Army. 1938. Report of the chief of engineers US Army 1938 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1938. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1740-1742;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1746-1750;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1751-1753;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1762-1763;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)-

Part 1, p. 1763-1765;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1766-1767;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1767-1768;
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1768-1769;
9) Lake river (enters Columbia river near the mouth of the Lewis river)- Part 1, p. 1761-1762 (**Note**: a short history of the stream and associated activities/description is provided);
10) Columbia river at Bakers Bay- Part 1, p. 1769-1770;
11) Columbia river at Bonneville-Part 1, p. 1829-1838;
12) Skipanon Channel (located at Warrenton, OR; originally called Skipanon river, a narrow crooked stream with ~1.8 mi tidal)-Part 1, p. 1742-1744 (**Note**: reference provides a short history of the stream & condition);
13) Youngs Bay and Youngs river (lower 8 mi. tidal)-Part 1, p. 1745-1746;
14) Multnomah Channel (also known as Willamette Slough)-Part 1, p. 1753-1754;
15) Oregon Slough (also known as North Portland Harbor)-Part 1, p. 1498-1499;
16) Westport Slough (side channel of the Columbia river located 70 mi. below Portland, OR)-Part 1, p. 1751;
17) Elockomin Slough (3.5 mi. in length, located 75 mi. below Portland)-Part 1, p. 1765-1766;
18) Columbia river between Vancouver and Bonneville-Part 1, p. 1828-1829;
19) Columbia river between Chinook, WA and head of Sand Island-Part 1, p. 1770-1771; and
20) Information regarding diking & Improving Districts along lower Columbia-Part 1, p. 1774-1808.

US Army. 1939. Report of the chief of engineers US Army 1939 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1939. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1890-1893;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1897-1903;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1903-1904;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1914-1915;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1915-1917;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1918-1919;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1919-1920;
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1920-1922;
9) Lake river (enters Columbia river near the mouth of the Lewis river)- Part 1, p. 1913-1914 (**Note**: a short history of the stream and associated activities/description is provided);
10) Columbia river at Bakers Bay- Part 1, p. 1922-1923;
11) Columbia river at Bonneville-Part 1, p. 2002-2011;
12) Skipanon Channel (located at Warrenton, OR; originally called Skipanon river, a narrow crooked

stream with ~1.8 mi tidal)-Part 1, p. 1893-1895 (**Note**: reference provides a short history of the stream & condition);
13) Youngs Bay and Youngs river (lower 8 mi. tidal)-Part 1, p. 1895-1897;
14) Multnomah Channel (also known as Willamette Slough)-Part 1, p. 1904-1905;
15) Oregon Slough (also known as North Portland Harbor)-Part 1, p. 1498-1499;
16) Westport Slough (side channel of the Columbia river located 70 mi. below Portland, OR)-Part 1, p. 1751;
17) Elockomin Slough (3.5 mi. in length, located 75 mi. below Portland)-Part 1, p. 1917-1918;
18) Columbia river between Vancouver and Bonneville-Part 1, p. 2000-2002;
19) Columbia river between Chinook, WA and head of Sand Island-Part 1, p. 1923-1924; and
20) Information regarding diking & Improving Districts along lower Columbia-Part 1, p. 1927-1973.

US Army Corps of Engineers. 1978. Columbia river downstream of Bonneville dam- maintenance disposal plan. US Army Corps of Engineers, Portland District, 79 p.
Abstract: Reference provides information regarding shoal/bar patterns of the entrance and estuary of the Columbia river to Bonneville dam, with respect to current and future dredging operations (and disposal areas of materials) for maintenance of the navigation channel. Information (past maintenance, present Oregon side disposal, and present Washington side disposal) for each critical bar/reach is provided; each is illustrated using an aerial photograph that is detailed with data & outlines.
Note: Photographs provide excellent details of inriver, riparian and uplands habitat from an aerial perspective.

US Commission of Fish and Fisheries. 1895. Bulletin of the US Fish Commission for 1894, Vol. XIV. US Commission of Fish and Fisheries, Washington, DC: Government printing office, 1894.
Abstract: Eigenmann, Carl H. Results of explorations in western Canada and the northwestern US (pages 101-132): References to habitat of Umatilla River, Grande Ronde, Snake River (at Idaho Falls); and a milling dam on the Grande Ronde at the town of La Grande. Discussion of species and taxonomic characteristics. NOTE: VERY IMPORTANT REFERENCE. Gilbert, C.H. and B.W. Evermann. A report upon the physical and natural history investigations in the Columbia River basin (pages 169-207): Extensive discussions of habitat characteristics for tributaries of the Lower Columbia (Cowlitz, Yakima, Naches, adn Toutle) and the upper Columbia (Colville, Little Spokane, Spokane, Snake and tributaries. References that large numbers of salmon used to ascend the Yakima River and Columbia River at Kettle Falls; also has stream temperature and flow data for hte Yakima, Naches, and Manatash Creek. NOTE: VERY IMPORTANT REFERENCE. McDonald, Marshall. The salmon Fisheries of the Columbia River, together with a report upon the physical and natural history investigations in the region, by Gilbert and Evermann (Pages 153-207): a presentation of the status of salmon and reasons for decline of salmon in the Columbia basin, that was given to the Congress. NOTE: VERY IMPORTANT REFERENCE.

US Commission of Fish and Fisheries. 1895. Part XIX: Report of the Commissioner for 1893. US Commission of Fish and Fisheries, Washington, DC: Government printing office. 38-41 p.
Abstract: Discussion of the investigations of interior waters of the Columbia River (Clarke Fort, Pend d'Oreille Lake, and Pend d' Oreille River) in terms of habitat, physical impediments to passage/navigation. Reference to occurrence of chinook salmon and steelhead trout in the Pend d'Oreille River. Commissioner stated intentions to expand investigations of habitat/passage of salmon throughout the entire Columbia River and its tributaries. Pages 38-41. Discussion of the operation of the Clackamas station Oregon (Waldo F. Hubbard, superintendent) during 1892; references to adult and egg collection of chinook salmon at the Sandy River. Pages 121-122. Extensive section that elaborates on The Fisheries of The Pacific Coast (text and statistical tables), inclusive of the Columbia River. Pages 143-304.

US Department of Commerce. 1932. Doctor Ellis demonstrates serious effects of mine pollution. Fisheries Service Bulletin No. 211, Bureau of Fisheries, US Department of Commerce, Washington DC, December 1, 1932.
Abstract: Notes the history and results of Dr. M.M. Ellis (US Bureau of Fisheries) who studied the pollution problem of Couer d'Alene River in Idaho, regarding wastes from silver, lead, and zinc mines. Survey extended from Montana to Spokane River in Washington. Provids extensive information on extent and type of habitat degradation to streams and lakes caused from mining wastes. Mentions that aquatic production of Couer d'Alene Lake was showing decline in the southern end from 1911, and species of trout were scarce, p. 3-4.

US House of Representatives. 1881. Annual report of the chief of engineers, US Army, to the Secretary of War for the year 1881 in three parts. 47th Congress, 1st Session, Ex. Doc.1, pt 2, vol.II. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river- Part 3, p. 2534-2552 (includes historical description of river mouth for physical characteristics and projects since early 1839, and bathymetry maps December 1880 and February 1881 opposite p.2546 & 2552 respectively);
(2) Lower Willamette and Columbia rivers from Portland to the sea-Part 1, p. 324-326, Part 3, p. 2531-2534 (surveys & dredging activities);
(3) Cowlitz River-Part 1, p.331, Part 3, p. 2600-2603 (includes brief historical description of river characteristics and commerce in the valley adjacent to the river); and
(4) Young's, Lewis & Clark, and Skipanon rivers, tributaries to Young's Bay-Part 1, p.332.

US House of Representatives. 1887. Annual report of the chief of engineers, US Army, to the Secretary of War for the year 1887 in four parts. 50th Congress, 1st Session, Ex. Doc.1, pt 2, vol.II. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river- Part 1, p. 327, Part 3, p. 2470 etc. (not available at U of W library for review);
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 331, Part 3, p. 2507 etc. (not available at U of W library for review); and
(3) Cowlitz river- Part 1, p. 333, Part 3, p. 2524 etc. (not available at U of W library for review).

US House of Representatives. 1891. Annual report of the chief of engineers, US Army, to the Secretary of War for the year 1891 in six parts. 52D Congress, 1st Session, Ex. Doc.1, pt 2, vol.II. (Annual report).Government Printing Office, Washington. 3284-3293 (incomplete) p.
Abstract: The reference contains comprehensive information regarding projects and activities related

to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 412-413 (channel maintenance and work on low-tide jetty from Fort Stevens to Clatsop Spit), Part 5, p. 3314-3328 (includes bathymetry map of Columbia mouth for June 1891);
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 416-417, Part 5, p. 3362-3367;
(3) Cowlitz river- Part 1, p. 418-419
(4) Willamette river at Swan Island-Part 1, p. 420, Part 5, p.3370-3371;
(5) Young's Bay (improvement of Young's and Klasskuine rivers) at Columbia river mouth-Part 1, p. 420, Part 5, p.3371-3372 (removal of snags and overhanging trees);
(6) Deep, Skamakawa, and Crooked rivers-Part 1, p. 420
(7) Lower Columbia river between Astoria and Woods Landing (snag removal project)-Part 1, p. 420, Part 5, p.3380;
(8) Lewis and Clarke's river (snag & overhanging trees removal project)-Part 1, p. 421, Part 5, p.3384-3385;
(9) Grays river (sand bar, snag & overhanging trees removal project)-Part 1, p. 421, Part 5, p.3386-3387; and
(10) Deep, Skamakawa, and Crooked rivers-Part 5, p. 3378-3379.
General description of attributes for the Snake river from the mouth to Lewiston, ID, Table containing gradient information for various rapids.
General description of attributes for the Snake river from the Seven Devils Mining District (~65 miles below Huntington Bridge) to Huntington Bridge (near the Burnt river mouth).

US House of Representatives. 1892. Annual report of the chief of engineers, US Army, to the Secretary of War for the year 1892 in four parts and atlas. 52D Congress, 2d Session, Ex. Doc.1, pt 2, vol.II. (Annual report).Government Printing Office, Washington. 2374-2485, 2400-2409, 2708-2715 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 386-388 (channel maintenance and work on low-tide jetty from Fort Stevens to Clatsop Spit), Part 3, p. 2808-2818;
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 389-391, Part 3, p. 2829-2835;
(3) Cowlitz river- Part 1, p. 392-393, Part 3, p. 2837-2838;
(4) Young's Bay (improvement of Young's and Klasskuine rivers) at Columbia river mouth-Part 1, p. 393, Part 3, p.2839 (removal of snags and overhanging trees);
(5) Lower Willamette and Columbia rivers, with view of securing 25 feet a low water from Portland to the mouth of the Columbia-Part 1, p. 394-395, Part 3, p. 2851-2869; and
(6) Willamette river at Ross Island-Part 3, p.2842-2844.
Atlas: Map no. 126- Depth sounding of the Columbia river mouth, 9,10, 11 June 1892; Map no. 127- Showing jetty construction at Columbia river mouth
General description of attributes for the Snake river reaches from Riparia to Lewiston, ID.

US House of Representatives. 1893. Annual report of the chief of engineers, US Army, to the Secretary of War for the year 1893 in six parts. 53D Congress, 2d Session, Ex. Doc.1, pt 2, vol.II. (Annual report).Government Printing Office, Washington. 3374-3377 p.

Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:

(1) Mouth of Columbia river-Part 1, p. 447-449 (channel maintenance and work on low-tide jetty from Fort Stevens to Clatsop Spit), Part 4, p. 3488-3503 (includes bathymetry map of mouth, June 1893 opposite of p. 3496);

(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 452-455, Part 4, p. 3515-3522;;

(3) Cowlitz river- Part 1, p. 456, Part 4, p. 3526-3527;

(4) Young's and Klasskuine rivers-Part 1, p. 456-457, Part 4, p.3527-3528 (removal of snags and overhanging trees);

(5) Lewis river from mouth to Speliah creek-Part 1, p. 458, Part 4, p. 3533-3536; and

(6) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 449-450, Part 4, p. 3503-3506.

General description of attributes for the Snake river from the Seven Devils Mining District (~65 miles below Huntington Bridge) to Huntington Bridge (near the Burnt river mouth).

US House of Representatives. 1894. Annual report of the chief of engineers, US Army, to the Secretary of War for the year 1894 in six parts. 53D Congress, 3d Session, Ex. Doc.1, pt 2, vol.II. (Annual report).Government Printing Office, Washington. 2588-2593 p.

Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:

(1) Mouth of Columbia river-Part 1, p. 413-414 (channel maintenance and work on low-tide jetty from Fort Stevens to Clatsop Spit), Part 4, p. 2631-2642 (includes bathymetry map of mouth, June 1894 opposite of p. 2640);

(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 416-417, Part 4, p. 2654-2659;

(3) Cowlitz river- Part 1, p. 417-418, Part 4, p. 2662-2663;

(4) Young's and Klasskuine rivers-Part 1, p. 418, Part 4, p.2663 (removal of snags and overhanging trees); and

(5) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 414-415, Part 4, p. 2643-2645.

General description of attributes for the Snake river from the Seven Devils Mining District (~65 miles below Huntington Bridge) to Huntington Bridge (near the Burnt river mouth). - brief note on original condition of this reach.

US House of Representatives. 1895. Annual report of the chief of engineers, US Army, to the Secretary of War for the year 1895 in seven parts. 54th Congress, 1st Session, Ex. Doc.1, pt 2, vol.II. (Annual report). Government Printing Office, Washington. 3388-3393 p.

Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 460-461, Part 5, p. 3551-3561 (includes bathymetry map of mouth, October-November 1894 opposite of p. 3560);
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 461-462, Part 5, p. 3561-3566;
(3) Cowlitz river- Part 1, p. 466, Part 5, p. 3594-3595;
(4) Young's and Klasskuine rivers-Part 1, p. 466, Part 5, p.3595-3596 (removal of snags and overhanging trees);
(5) Clatskanie river, from mouth to town of Clatskanie -Part 1, p. 467, Part 5, p. 3596-3598 (description of existing conditions prior to project improvements);
(6) Lewis river from La Center to its mouth-Part 1, p. 467, Part 5, p. 3600-3601;
(7) South channel of Columbia river (in front of Astoria, OR-Part 1, p. 468, Part 5, p. 3605-3606 (includes bathymetry map of south channel, Tongue Pt to Smith Point,dated November 1894 opposite p. 3608); and
(8) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 462-463, Part 5, p. 3566-3568.
General description of attributes for the Snake river from the Seven Devils Mining District (~65 miles below Huntington Bridge) to Huntington Bridge (near the Burnt river mouth). - brief note on original condition of this reach.

US House of Representatives. 1896. Annual report of the chief of engineers, US Army, to the Secretary of War for the year 1896 in six parts. 54th Congress, 2d Session, Ex. Doc.1, pt 2, vol.II. (Annual report).Government Printing Office, Washington. 3382-3389 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 400-401, Part 5, p. 3250-3256 (includes bathymetry map of mouth, October-November 1894 opposite of p. 3560);
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 401-422, Part 5, p. 3257-3262;
(3) Cowlitz river- Part 1, p. 415, Part 5, p. 3385-3386;
(4) Young's and Klasskuine rivers-Part 1, p. 405, Part 5, p.3283; and
(5) South channel of Columbia river (in front of Astoria, OR-Part 1, p. 401, Part 5, p. 3256-3257;
(6) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 402-403, Part 5, p. 3263-3266.
General description of attributes for the Snake river from the Seven Devils Mining District (~65 miles below Huntington Bridge) to Huntington Bridge (near the Burnt river mouth). - brief note on original condition of this reach.

Victor, E. 1935. some effects of cultivation upon stream history and upon the topography of the Palouse region. Northwest Science IX(3): 18-19 (September, 1935).
Abstract: Author discusses habitat alterations (bank erosion, channel scouring, etc.) along stream courses in the Palouse region, due to human activities and environmental dynamics; mentions Miller Creek (near Walla Walla), Touchet (near Waitsburg) and Palouse rivers as examples of channel changes.

Ward, H. B. 1939. The migration and conservation of salmon. Publication of the American Association of Advanced Sciences 8: 60-71.
Abstract: Author discusses habitat influences on behavior of salmonid fishes; emphasizes that habitats are not static, and that it is important to understand environmental factors that modify behaviors. Makes continous references to efects of temperature on behavior patterns and outcomes. (Pertinent to life history strategies paper.)

Washington Department of Fisheries. 1938. Report of the preliminary investigations into the possible methods of preserving the Columbia River salmon and steelhead at the Grand Coulee Dam. Report prepared for the US Bureau of Reclamation by the State of Washington Department of Fisheries, in cooperation with the Department of Game and the US Bureau of Fisheries. 121 pp.
Abstract: Comprehensive report of investigative findings regarding fish counts, biology, behavior, habitat of salmon stocks in the tributaries of the Columbia River above Rock Island to Grand Coulee. Includes trap counts of upstream and downstream migrants at Rock Island and tributaries; some biometric data of these trapped fish are presented (Wenatchee, Methow, Twisp, etc.) Some environmental data such as water temperature and water flow are given for some tributaries. Briefly describes water development projects (irrigation) and their associated fish protection facilities. Excellent document for deriving historical background information regarding the planning of fish salvage and mitigation measures associated with the Grand Coulee project.

Washington State. 1907. 16th and 17th annual reports of the state fish commissioner and game warden: 1905-1906. State of Washington Department of Fisheries and Game, Seattle, Washington. C.W. Corham, Public Printer, 1907.
Abstract: The commissioner (John L. Riseland) discusses the situation of fishing, fishing seasons, and disjointed regulations of Oregon and Washington in the lower Columbia River; expresses concern that if the early season is not shortened, the Royal chinook will further decline and lead to situation where packers will have to depend on fall season rather than early and mid seasons. Provides newspaper quotes from the Portland Oregonian that support his statements. pages 10-14. Provides a report on Washington salmon hatcheries in the Columbia basin; notes that the Wenatchee Hatchery is the only hatchery tributary to the Columbia that propagates Silverside salmon (coho). Also mentions that manager of the Colville Hatchery could only acquire 90,000 silverside salmon eggs in the stream (Colville River); and that the facility was deemed not to operate. Notes that the Klickitat hatchery was never completed, and was abandoned in 1902, pages 24-25. Notes that the Wind River Logging company, on the Wind River, flooded the Wind River, carrying all their logs into the Columbia River; this citation documents the use of crib dams to contain logs and flush logs down the Wind River, page 30. Notes that the Methow hatchery is the only remaining salmon hatchery (Colville, Little Spokane and Klickitat hatcheries are closed) on the east side of the Cascades to propagate silverside salmon; infers that Colville, Little Spokane and Klickitat Rivers have or had runs of coho salmon, pages 30-131. Provides letters that note run and habitat conditons on the Klicktat, Colville, Wenatchee, and Lewis Rivers, Page 39-42.

Wilkes, Charles. 1856. Narrative of the United States expedition. During the years 1838, 1839, 1840, 1841, 1842. By Charles Wilkes, USN. Commander of the expedition, member of the american philosphical society, etc. In five volumes, with thirteen maps. Vol IV. G.P. Putnam & Co., 321

Broadway, New York. 1-4 (notes on work) p.
Abstract: Author provides an account of his experiences and observations during his travels in the Columbia river basin; notes habitat/landscapes, fauna, flora of various reach sections of the Columbia river and tributaries.

Wissmar, R. C., J.E. Smith, B.A. McIntosh, H.W. Li, G.H. Reaves, and J.R. Sedell. 1994. A history of resource use and disturbance in riverine basins of eastern Oregon and Washington (early 1800s-1900s). Northwest Science 68, Special Issue: 1-35.
Abstract: Authors provide a historical review of human activities (mining, livestock, irigation, and logging) and habitat alterations in the Okanogan, Methow, Little Naches, Grande Ronde, and John Day basins) Table 1 presents a chronology of major settlement, human activities, and natural resources development in these basins.

Wood, Tallmadge R. 1903. Letters of Tallmadge R. Wood. The Quarterly of the Oregon Historical Society VI(1): 80-85 (March 1903).
Abstract: Author notes in letter of 19 February 1846 (Clatsop, Co. Oregon Territory) that: 1) six sawmills and five flour mills are now in operation (the Clatsop county region), p.81; 2) heavy timber and broken land along each side of the river (Columbia River from Astoria to the mouth of the Cowlitz River),p. 82; Provides general description of the habitat/vegetation/soil along the banks of the Columbia River in the Clatsop County area.

HARVEST

Reference List

Gaumer, Tom, Demory, Darrell, and Osis, Laimons. 1973. 1971 Columbia River Estuarine estuary resource use study. Fish Commission of Oregon, Division of Management and Research, Portland, Oregon.
Abstract: Authors provide information regarding fish species (invertebrate and vertebrate) harvested and observed in the recreation harvest from the seaward end of the south jetty upstream to the area adjacent to Jetty Sands parking lot, from 1 March through 31 October 1971. Figures and tables temporally and spatially illustrate the species and catch statistics for this harvest.

Griffin, L. E. 1935. Certainties and risks affecting fisheries connected with damming the Columbia River. Northwest Science IX(1): 25-30 (February, 1935).
Abstract: Author discusses 1) the economic importance of anadromous and resident fish species, and the effects on dam construction on said species; 2) the importance and distribution of salmon harvest in the Columbia basin; 3) the certainties associated with current state of technology of fish passage systems, and risks associated with designs and plans to be incorporated at the Bonneville project; 4) recommended actions to reduce risks associated with current fish passage technology; 5) certainties and risks associated with sedimentation and submergence of fish habitat (sloughs and shallows) in the Bonneville impoundment; 6) the certainties and risks of power plants to migration of young salmon; and 7) turbine designs and devices to reduce the risks associated with hydropower operaton. Author alludes to a hypothesis that the Columbia impoundments (e.g. Bonneville) may present risks to the importance of the sloughs and shallow ponds contiguous to the river, as being very important as a food source to young salmon during their downstream migration.

Oregon State. 1896. 3rd and 4th Annual Reports of the State Fish and Game Protector of the State of Oregon 1895-1896. State of Oregon, Salem, Oregon. W.H. Leeds, State Printer, 1896. 10,53 p.
Abstract: The Protector (Hollister D. McGuire) discusses failure of the last legislature to enact laws for more effectual regulation and protection related to such topics as concurrent regulations with the state of Washington, protection of salmon through construction of fishways, and harvest limitations

on the columbia River, page 5. Mentions that oregon ahs an 1878 statute on the books requiring fishway construction at barriers to salmon, but his predecessors showed no willingness to enforce the statute. He lists the fishways that have been put in under his direction. pages 8-9. He discusses Indian fishing (Warm Spring Indians) and the earliest date of chinook salmon spawning in vicinity of the upper Clackamas River at its junction with a warm spring where thousands of salmon naturally spawn; this date is July 20th. page 10. Notes that a dam and operation of fishing in the lower Clackamas River (four miles below the hatchery) prevent salmon from ascending to the hatchery racks in 1893 and 1894; mentions that dam was removed last spring 1895. page 31. Mentions that $10,000 was appropriated by the 1893 Oregon legislature for work to construct a fishway on the Willamette River at the falls at Oregon City, and notes that fishway work is completed bu not adequate (except during high water stage) for the March and April migration of chinook at Oregon City falls, and that another $4000 is necessary to effect this passage. pages 50-52. Recommends that a provision in the law should mandate that fish screeens constructed at mill races, irrigation ditches, or canals, taking or receiving water from any river, creek, stream or lake having food fish; his attention to the need for such law was derived from a letter of Dr. C.H. Gilbert (Stanfor University) who noted that water diverters on the Wallowa River killed thousands of young chinook and bludback salmon by diversion of them into irrigated fields. page 53. Notes that an Oregon law of 1893 and reenacted in 1895 created the office of the Fish & Game Protector. page 83.

Oregon State. 1907. Annual Report of the Department of Fisheries of the State of Oregon for year 1907 to the legislative assembly, twenty-fourth regular session (1907). State of Oregon, Salem, Oregon. W.S. Duniway, State Printer, 1907. 78-79 p.
Abstract: The Master Fish Warden (H.G. Van Dusen) states that "in view of the fear that the salmon of the Columbia River was not being rehabilitated through the medium of the system of artificial propagation, I am very pleased to be able to chronicle...that there has been a considerable increase in salmon produced by the Columbia River this year over last year..." This increase was for Chinook and steelhead in both Washington and Oregon. He mentions that chinook and steelhead over past five years, but decreases in silversides and bluebacks; and says that artificial propgation has been of assistance in the increase of chinook and steelhead. Page 7. Notes that hatcheries select to use large and strong fish (males) for egg fertilization, and do not use small males; attributes this selective practice to maintaining the 25 lb. average weight of chinook ovr the past seasons. Page 8. Notes that egg collection at facilities in Snake and Wallowa Rivers was very unsatisfactory, even though the fish racks were operated early, few fish go upstream this far, and those that did were three males to one female. But the eggtake at federal and state hatcheries (Oregon and Washington) below Celilo Falls the eggtake was good. page 13. Notes an inspection of the Santiam River (Willamette tributary) in regards to sites for artificial propagation activities. pages 17-18. Mentions that the first contract for the construction of the fishway over the falls of the Willamette River at Oregon City was completed and accepted by the state engineer on November 29, 1904. Mentions that as the Willamette Pulp and Paper Company completed a concrete dam at the falls, this dam caused water hydraulic problems in the fishway (upper pools) - the gradient of the upper portion of the fishway was too steep. This situation caused problems for the spring chinook migration over the falls. Surveys were conducted to make recommendations and provide cost estimates to remedy the fishway problem. Pages 20-24. Notes that hatchery station was established and operated on the McKenzie River at a site situated a couple of miles below Gates Creek; mentions that they took spawn of the early variety of chinook from August 15 to October 15th. States that liberated approximately 1.5 million fry of this 1905 brood year into the McKenzie River in the immediate vicinity of the station during the months of January and February 1906. Pages 75-76. Notes that Wallowa Hatchery station did not secure any sockeye salmon spawn during the 1905 BY - (note: appears that this BY cycle is extinct or some lower river blockage prevented sockeye from upper area). page 78. Notes that by leaving racks of the Wallowa Hatchery in the river late, they discover a late run of silversides that passed the racks in the month of November, but were unable to hold them to spawning due to severe cold weather

conditions. page 78. Notes that the Ontario hatchery station (Snake River at Swan Falls) left their rack in river late (until November 23rd) in hopes of collecting late running silversides, but none appeared. Page 84. Mentions the 1901 law passed by the Oregon State legislature that prohibited fishing above tide water and established fishing deadlines on all coast streams. page 129. Notes that fishway for the falls of the Willamette River at Oregon City provides excellent passage for early chinook in 1906, Page 132. Mentions request for two special deputy fish wardens to enfore laws regarding water diversions and dam obstructions that are causing mortality of young migrants going to sea; notes causes due to extensive development of power/mill dams across streams and irrigation projects that are taking water for irrigation puroses. Pages 134-135. Notes the needs for laws that assure better escapement to the spawning ground in the Columbia River; infers that hatcheries alone will not solve the problem of diminishing harvest to fishermen in the Columbia River. page 137. Notes that 1906 BY salmon returns (chinook and sockeye) in northeastern Oregon (Wallowa and Ontario Hatcheries) were poor; and that salmon runs in the lower Columbia River below Celilo Falls appeared to have been successful in running the gauntlet of net fishermen in the lower Columbia, Page 139. Mentions that he must secure eggs in order to assure shortage of Snake River stock (at Ontario Hatchery) four to five years hence, based on "...theory that Salmon return to the stream of their nativity to spawn..." Page 140.

Oregon State. 1951. Biennial report of the Fish Commission of the State of Oregon to the governor and forty-sixth legislative assembly, 1951. Fish Commission of the State of Oregon; Salem, Oregon, State Printing Office, 1951.
Abstract: Notes that (1) Fish commission has particular interest in the study of logging effects on salmon production, page 3. (2) On June 1948, the states of Oregon, Washington, and Idaho, and Federal Government (Fish & Wildlife Service, Department of Interior) consummated agreement of the provision of funds for the rehabilitation of the lower tributaries of the Columbia River, under the Lower Columbia River Salmon Rehabilitation Program, page 10. (3) A fishway is installed at a diversion dam (owned by the Vancouver Plywood Company) on Rock, a tributary of the North Santiam River, this reopened considerable area for steelhead spawning. page 12. (4) A new concrete fishway is constructed at the Powerdale Dam (owned by Pacific Power and Light Company) on the Hood River, page 13. (5) A fish screening and by-pass system is completed in the Marmot Dam Canal (Marmot Dam project, owned by Portland General Electric Company) on the Sandy River, page 13. (6) Columbia River investigations are studying five different problems; (a) extension of reduction in productivity of the Columbia River Basin by the encroachment of man, (b) harvest practices, stock timing/migration/distribution; (c) knowledge of growth and survival and limiting factors of young salmon in freshwater, (d) effect contemplated water development projects on Columbia River salmon, and (e) studies on sturgeon. page 15. (7) A need for the development of cheap and nutritional diets alternative to the liver based diets. page 18.

Pollock, C. R. 1930. Fishery conditions in the state of Washington: Puget Sound appears healthy, but Columbia River shows decline. Pacific Fisherman Annual Statistical Number, Vol. 28, No. 2, January 25, 1930, pages 110-111. Seattle, Washington.
Abstract: Supervisor of Fisheries states that there was a shortage of escapement in the Columbia River district. Mentions that there is little hope of increasing spring chinook run until adequate screening installations have been completed on irrigation ditches. Says that summer and fall chinook runs must be looked to as the source of harvest for the fishing industry in the Columbia River district. Also provides a report on hatchery operations in the Columbia River district during 1929.

Washington State. 1921. 30th and 31st annual reports of the state fish commissioner to the governor of the state of Washington: April 1, 1919 to March 31, 1921. State of Washington Department of Fisheries and Game, Olympia, Washington. Frank M. Lamborn, Public Printer, 1921.
Abstract: The commissioner (L.H. Darwin) discusses: 1) the actions and impacts of the 1921

legislative action to create the State Fish Commission, with respect to Washington fisheries resource management, in the context of state and international (Canada) benefits (p. 8-10); 2) discusses "Wastefulness of Natural production," in the context of justifying increased harvest rates through use of efficient fish artificial propagation. NOTE: this reference may be the premise for Washington state fisheries policy over the next 60 years (p. 18-19); 3) Notes negotiations with Northwestern Electric Company to provide mitigation monies for construction of a new hatchery at Chinook, WA (replacement of the old Chinook Salmon Hatchery) in lieu of upgrading and operating the existing fishway over their hydroelectric dam on the Big White Salmon River. Mentions that dam is 160 ft. in height, and that adult steelhead trout are the only species that transcend this dam upstream (p. 24); 4) extensive discussion of the Indian fishing privileges at Prosser Dam, and the fate of salmon resources in the Yakima River, based on the prognosis of irrigation/water developments in the Yakima basin - states that within the next 10 years salmon will not exist in the Yakima (p. 27-29).

HATCHERIES

Reference List

Attwell, J. 1974. Columbia River gorge history, Volume One. Fourth Printing, Talkie Books, 34 Landing Road, Skamania, WA 98648, p. 151.
Abstract: A history of the Columbia River in its early days is provided with respect to early inhabitants (Indians, explorers, white settlers), industry/commerce activities. References regarding fisheries and habitat characteristics of this area in this era are lacking in this reference. The following notes are related to milestones/events; 1) 1825 Fort Vancouver was the first settlement in what is now the state of Washington; p. 41; 2) 1837 John McLoughlin had farms at Fort Vancouver on the Cowlitz River; p. 45; 3) In 1846, Joel Palmer established the Columbia River Pack Trail, down the south side of the river from The Dalles to the Sandy River, for cattle; p. 50; 4) In 1851, Frances A. Chenowith established the Cascades Portage Railroad, the first railroad in the northwest, at the Cascades to portage cargo around the rapids on the Columbia River.

Bayha, Keith. 1974. Anatomy of a river Pacific Northwest River Basins Commission, 1 Columbia River, P.O. Box 908, Vancouver, Washington 98660, Vancouver, Washington.
Abstract: Authors present a comprehensive evaluation of water requirements for the Hell's Canyon reach of the Snake river, based on field surveys of March 1973. Surveys included collection of information regarding the time of travel of the stage wave and water mass, water quality, biological resources, etc. Includes photographs that illustrate the habitat (terrestrial and water) of this area.

Blanchard, R. E. 1977. Columbia River estuary physical alterations. Columbia River estuary, inventory of physical, biological and cultural characteristics 209-1 to-209-22.Columbia River Estuary Taskforce, Astoria, Oregon.
Abstract: The author discusses the man-induced physical alterations river bed, and adjacent riparian/upland areas of the Columbia river estuary, caused by following projects/activities (1) dredging & disposal for improvement and maintenance of river navigation (2) dikes & levees for flood control/protection, and (3) jetties/pile dikes for protection the river mouth entrance. Description of project histories, types, methods, and locations are discussed and supporting illustrations (tables and figures) are presented. Land disposal of dredging spoils are given with respect site, location (approximate river mile), habitat type, wildlife affected, and area size (in acres).
Note: Excellent reference for generally determining the location of projects by typed and general impacts.

Bottom, D. and Jones, K. K. 1990. Species composition, distribution, and invertebrate prey of fish assemblages in the Columbia River estuary. Prog. Oceanogr. 25: 243-270 .

Abstract: Authors note that seasonality of abundance and species in an estuary reflect the timing of migration and the reproductive cycles of marine and anadromous species. Composition of the fish community and dominant species in the Columbia river estuary are similar to many smaller estuaries in the Pacific Northwest; these similarities reflect the influence of the nearshore marine environment on the fish community structure, and considerable physiological tolerance of many euryhaline species. The distribution of fish assemblages in the Columbia river estuary is influenced by large seasonal variation in river discharge and salinity; and within large areas and salinity zones, species assemblages use different habitat and prey. The distribution of abundance and the stomach fullness of fishes vary directly with the density of potential prey; it is hypothesized that fish production may be limited by dynamic physical processes that control prey availability or the feeding efficiencies of predators in the highly turbid water.

Bryant, F. G. 1949. A survey of the Columbia River and its tributaries with special reference to the management of its fishery resources. 2. Washington streams from the mouth of the Columbia River to and including the Klickitat River (Area I). Special Scientific Report No. 62, US Fish and Wildlife Service, Department of Interior, Washington DC.
Abstract: Provides a comprehensive description and perspective of tributaries at period in time, in terms of habitat and water flow/temperature. 103 pages.

Bryant, F. G. and Parkhurst, Z. E. 1950. Survey of the Columbia and its tributaries 4. Area III Washington streams from the Klickitat and Snake Rivers to Grand Coulee Dam, with notes on the Columbia and its tributaries above Grand Coulee Dam. Special Scientific Report Fisheries No. 37, US Fish and Wildlife Service, Department of Interior, Washington, DC.
Abstract: Provides a comprehensive description and perspective of Columbia tributaries (within Washington State), above the Klickitat River (excluding the Snake River) at period in time, in terms of habitat and water flow/temperature.

Burner, C. J. 1951. Characteristics of spawning nests of Columbia River salmon. Fisheries Bulletin 52(61): 97-110.US Fish and Wildlife Service, Department of Interior, Washington, DC.
Abstract: Author describes spawning habitat and characteristics of chinook (spring, summer, fall) coho, chum, and sockeye, based on observations in Columbia tributaries (lower and upper).

Cobb, J. N. 1922. Protecting migrating Pacific salmon. Transactions of the American Fisheries Society 52: 146-153.
Abstract: Author gives extensive information on the Yakima Basin regarding habitat, fish, and water development projects (Kennewick, Wapato, Sunnyside, Prosser) Provides general design and adult fish behavior (steelhead) at Sunnyside, Kennewick, and Prosser.

Columbia Basin Interagency Committee. 1957. Columbia River basin fishery program, part II: Inventory of streams and proposed improvements for the development of the fisheries resources. Fishery Steering Committee, Columbia Basin Interagency Committee, January 1957; 100 pages.
Abstract: Provide a comprehensive inventory and listing of proposed improvements of habitat/rehabilitation projects and considerations for major tributaries of the Columbia basin above McNary Dam. Notes basin descriptions for each tributary, in terms of flow, temperature (air and water). Includes maps of tributary/basins showing geographical orientation of streams and proposed improvements.

Craig, J. A. 1935. The effects of power and irrigation projects on the migratory fish of the Columbia River. Northwest Science IX(1): 19-24 (February, 1935).
Abstract: Author discusses the effects of human land and water uses (logging, mining, power, and irrigation) on fisheries resources in the Columbia basin. Provides examples of habitat alterations

imposed by these human uses. Briefly discusses life history and ecology of all anadromous salmonid species inhabiting the Columbia River basin. Discusses how the use of streams for power and irrigation purposes affect migratory salmon species: 1) obstacles that obstruct or delay migration of adult upstream to natal steams; and 2) injurious or delay impediments to downstream juvenile migration. Presents fishways and screening as mechanisms to protect fish, and the use of artificial propagation in the case of high dams.

Davison, M. A. and Spencer, R. D. 1979. *Columbia river islands land status survey, Columbian White-Tailed Deer Study.* Project E-I, Study 2, Job 4, Section 4. Washington Department of Game, Olympia, Washington.
Abstract: Author provides information regarding the status of habitat and ownership for 28 islands, located within 107 mile section of the lower Columbia river between Bonneville Dam and Cathlamet, Washington. Provides information for each island, with respect to geographic location/acreage, ownership (deed abstract), floral communities/habitat, historical, present, future uses of island. Includes information regarding alterations in terms of dredging, fill, and forest removal, etc. **Note: Excellent Reference**

Downing, Alfred. 1980. The region of the upper Columbia River and how I saw it Ye Galleon Press, Fairfield, Washington.
Abstract: Author provide a general accounting of his adventures and trip with Lt. T. Symons (U.S. Army) during the expedition down the upper Columbia river. No substantive information regarding fisheries-related habitat and stock was derived from a review of this monograph. A listing of books and periods was derived as a source for additional reference candidates.

Downs, J. L., Tiller, B. L., Witter, M., and Mazaika, R. 1996. Monitoring and mapping selected riparian habitat along the lower Snake River. PNNL-10953/UC-702: Pacific Northwest National Laboratory, Richland, Washington.

Dunn, J., Hockman, G., Howerton, J., and Tabor, J. 1984. Key mammals of the Columbia River estuary. Columbia River Estuary Data Development Program, Astoria, Oregon. 116 p. p.
Abstract: Authors provide extensive information about key mammalian species occurring the Columbia river estuary, with respect to 1) habitat use, 2) period of birth, 3) relationship to other trophic levels, and 4) critical habitat. Extensive tables and graphics are provide to illustrate spatial and temporal occurrence and inhabitation of key mammals within the Columbia river estuarine zone.

Franchere, Gabriel. 1969. Journal of a voyage on the north west coast of North America during the years 1811, 1812, 1813, and 1814 The Champlain Society, Toronto. 78,82-83, 96-97, 100-101, 110-111, 142-143, 148-149, 152-157 p.
Abstract: Author provides an account of his observations and experiences during his travels in the Columbia river basin during the early 19th century. Briefly notes habitat, flora, and fauna at various points of travel up and down the Columbia river and its tributaries. General description of attributes for the Snake river mouth.

Glenn, John G. n.d. Diary of John G. Glenn, 1852 14-15 p.
Abstract: Author provides a brief description of the scenery and habitat of the Grand Ronde sub-basin.

Good, James W. 1977. Columbia river tidal marshes. Columbia River estuary, inventory of physical, biological and cultural characteristics, Sect. 302-1 to 302-19. Columbia River Estuary Data Development Program.

Abstract: The author identifies, describes, and enumerates the marsh habitat and communities of the Columbia river estuary. Provides illustrations (figures and tables) describing the location and area of tidal marsh habitat; and discusses each tidal marsh area with respect to community structure and alterations/impacts induced by human interventions (dredging, diking, etc.).
Note: Excellent reference for deriving a perspective of the estuarine habitat and associated communities prior to and after human intervention.

Good, James W. and Potter, George D. 1977. Columbia river estuary shoreline habitat and wildlife resources. Columbia River estuary, inventory of physical, biological and cultural characteristics, Sect. 303-1 to 303-33. Columbia River Estuary Data Development Program,
Abstract: The authors identify, describe, and enumerate the shoreline/riparian habitat and wildlife communities (waterfowl, birds, big game, furbearers, small mammals, reptiles, amphibians, and marine mammals) of the Columbia river estuary. Provide illustrations (figures and tables) describing the kinds, location and area of various wildlife and their associated habitat that presently occur within the estuarine zone of the Columbia river.
Note: Excellent reference for deriving a perspective of the estuarine habitat and associated wildlife communities occurring in the shoreline/riparian zone of the Columbia river estuary.

Griffin, L. E. 1935. Certainties and risks affecting fisheries connected with damming the Columbia River. Northwest Science IX(1): 25-30 (February, 1935).
Abstract: Author discusses 1) the economic importance of anadromous and resident fish species, and the effects on dam construction on said species; 2) the importance and distribution of salmon harvest in the Columbia basin; 3) the certainties associated with current state of technology of fish passage systems, and risks associated with designs and plans to be incorporated at the Bonneville project; 4) recommended actions to reduce risks associated with current fish passage technology; 5) certainties and risks associated with sedimentation and submergence of fish habitat (sloughs and shallows) in the Bonneville impoundment; 6) the certainties and risks of power plants to migration of young salmon; and 7) turbine designs and devices to reduce the risks associated with hydropower operaton. Author alludes to a hypothesis that the Columbia impoundments (e.g. Bonneville) may present risks to the importance of the sloughs and shallow ponds contiguous to the river, as being very important as a food source to young salmon during their downstream migration.

Harden, Absolom B. 1847. Diary of Absolom B. Harden 1, 14-30 (incomplete) p.
Abstract: Author provides descriptions of his activities and the habitat in various sub-basins (e.g. Grand Ronde) of the Snake and Columbia river.

Hardesty, W. P. 1923. Drainage project on the Columbia adjoining Portland, Ore.: levees and pumping plant with three types of motor-driven pumps --new sluice gate --design --assessment system. Engineering News-Record 90(9): 395, 398.
Abstract: Reference discusses a drainage project on the Columbia river that encompasses the use of levees and a pumping plant for reclamation of 8,478 acres of low land in Multnomah County Drainage District No. 1 (near Portland, Oregon). The project affects the habitat characteristics of Columbia Slough and adjacent lands. An eleven mile levee borders and is set back 50-100 ft from the river; a fringe of willows and cottonwoods lies between the river and levee. The enlargement of the slough is considered for use as a dilution vehicle for municipal sewage. Includes a map illustrating the Columbia Slough/project area and its orientation with the Columbia river reach adjacent to the Vancouver/Portland area.

Hazel, C. R. 1984. Avifauna of the Columbia River estuary. Columbia River Estuary Data Development, Astoria, Oregon. 85 p. p.
Abstract: Author presents and describes information regarding key avian species and their associated

habitat, key avian habitats and their avian species composition, and food habits of key avian species within the Columbia river estuary. Tables and graphics are used to illustrate the spatial and temporal distribution of key avian species, and their associated habitats and food habits.

Hines, H. K. 1893. An illustrated history of the State of Washington. The Lewis Publishing Company, Chicago. 933 pages.
Abstract: Author provides a very comprehensive history of the Washington and Oregon areas, during the pre-and post-Oregon Territory period (late 1770s to late 1880s); provides biographical sketches of principals of Washington state history. Limited notes regarding fisheries resources and habitat alternations are provided. NOTE: excellent reference for Washington and Oregon territorial history.

Idaho State. 1927. Eleventh biennial report of the Fish & Game Warden of the State of Idaho, 1925-1926. R.E. Thomas, State Game Warden; Boise, Idaho.
Abstract: (1) Photograph of the riparian zone of a section of the Selway River; near the junction with the Clearwater River, is illustrated on page 6. (2) The topography and status of lands of Idaho is generally described in terms of its habitat zones and types of development, page 7. (3) Photograph of the riparian zone of a section of the Middle Fork of the Salmon River is illustrated on page 18. (4) Photograph of the riparian zone near the junction of Camas Creek and the Middle Fork of the Salmon River is illustrated on page 28. (5) Description of the resident fish planting program in the Redfish Lake section of Idaho in 1925; this program illustrates the emphasis of the resident fishes management in lieu of anadromous species (e.g. Blueback salmon), page 47-48. (6) Photograph of the riparian zone of a section of the upper inlet to Redfish lake is illustrated on page 55. (7) Photograph of the Vernon and Edna Lakes area in the headwaters of the south fork of the Payette River is illustrated on page 58. (8) Note that a landlocked salmon, weighing slightly over six pounds was taken in the Salmon River a short distance below the outlet of Redfish Lake. NOTE: This fish may have been anadromous variety of blueback salmon? page 59. (9) Photograph of the riparian zone of a section (with a road along stream-side) of the Lochsa River, near Kooskia, Idaho County is illustrated on page 66.

Johnson, Overton and Winter, W. H. 1906. Route across the Rocky Mountains with a description of Oregon and California, their geographical features, their resources, soil, climate, productions, etc., 1843. Chapters I & II. The Quarterly of the Oregon Historical Society VII(1): 62-63, 88-103 p.
Abstract: Authors provide descriptive information regarding the habitat, geology, and flora/fauna of Oregon Territory between the Blue Mountains and the coast. Provides general descriptions of riparian habitat in terms of flora. NOTE: Excellent reference to derive habitat status/description prior to significant alteration due to settlement and resources development.

Johnson, Overton and Winter, W. H. 1906. Route across the Rocky Mountains with a description of Oregon and California, their geographical features, their resources, soil, climate, productions, etc., 1843. Chapters III & IV. The Quarterly of the Oregon Historical Society VII(2): 163-165, 174-179 p.
Abstract: Authors provide descriptive information regarding the habitat, geology, and flora/fauna of Oregon Territory in the Willamette River valley region and the Columbia River estuarine area (p. 175-76). Provides general descriptions of riparian habitat in terms of flora. NOTE: Excellent reference to derive habitat status/description prior to significant alteration due to settlement and resources development.

Lancaster, Samuel C. 1915. The Columbia America's great highway. Press of Kilham Stationary and Printing Company, Portland, Oregon.
Abstract: Author provides a general history of the Columbia basin, in terms of the human activities along the Columbia river. Excellent color photographs of the various locations along the Columbia

river, viewed from the old Columbia highway route, are presented; illustrates various morphological attributes, habitat structure, etc. of these locations, situated on the lower Columbia river (Cascades area to Astoria).

Lelbhardt, Barbara. 1990. Law, environment, and social change in the Columbia basin: the Yakima Indian Nation as a case study, 1840-1933. Dissertation for Doctor of Philosophy in Jurisprudence and Social Policy, University of California at Berkeley, 1990, 488 pages.
Abstract: A. Author provides a comprehensive history and legal premise of water rights and fishing issues of the Yakima Indian Nation within the Yakima and Columbia rivers basin; includes an extensive bibliography. Documents the social and economic dependence of the Yakima Indians on fisheries resources; provides some insight of salmon, water, and habitat of the Yakima Basin prior to and during development of fisheries and agricultural industries in the Yakima basin. The following historical notes of historical milestones and fisheries resources information were derived: 1) In 1850, the US Congress passes the Land Donation Act which provided for the appropriation of lands from the public domain in the terriitories (e.g. Oregon Territory); p. 104; 2) In 1873, the Washington Territorial legislature passed an act that allowed Yakima County farmers, miners, manufacturers- or anyone that could use water for "beneficial purposes" to construct diversion works necessary to convey water onto their non-riparian lands (An Act Regulating Irrigation and Water Rights in the County of Yakima, Washington Territory, 13 November 1873, Washington Laws 520-522), p. 245; 3) In 1890, the Washington State Legislature passed a statute that provided for the appropria tion of any unclaimed waters 'from any natural streams or lakes in the state" for irrigation and permitted the condemnation of rights of ways for ditches to carry water 91890 Washington laws 706, paragraph 1), p. 246; 4) In 1917, Washington State Legisla ture passed a law adopting an administrative water code that recognized prior appropriation as the only means by which an individual could acquire water rights (Riparian and Appropriation Rights, Washington laws 447-68), p. 247; 5) Around 1867, the Menin ick/Shumit Ditch on Simcoe Creek (tributary to the yakima River) was constructed on the Yakima Indian Reservation; p. 250; 6) In 1906, the US Congress passed the Jones Act, that provided for funding the on-reservation portion of the US Reclamation Servic e's larger yakima irrigation project by allowing each Indian allottee to sell 60 acres of his or her allotment for bring water to the remaining twenty acres under the project; p. 254-255; 7) In 1891, the Northern Pacific, Yakima, Kittitas Irrigation Company, who filed on 1000 cfs of Yakima River water (in 1890) began construction of the Sunnyside irrigation project, and in that year built an adjustable dam (at the old Yakima dance house site) that was believed to have the capability to appropriate virutally the entire low flow when the river was at its lowest point; p. 258; 8) In 1892, the first 25 miles of the Sunnyside irrigation project is dedicated; p. 259; 9) In 1893, the Northern Pacific Railroad (owner of the Northern Pacific, Yakima, Kittitas Irrigation Company) declares bankruptcy during the Panic of 1893; p. 259; 10) In 1894, the US Congress passed the Carey Act which allowed states to choose up to one million acres of arid land for irrigation development; p. 260; 11) In 1895, the Washington State legislature set up the Arid Lands Commission to investigate the possibility of developing lands between the Yakima and Columbia Rivers, above the Sunnyside irrigation project; p. 260; 12) Up to and through the 1890s individuals, farmers cooperatives, and ditch companies invested in their own small scale irrigation systems; p. 260; 13) In 1902, the US Congress passed the Newlands Act which created the Reclamation Service with the US Department of Interior; the Reclamation Service was empowered to provide planning, engineering, and financial assistance for irrigation projects; p. 261; 14) In 1906, the US Reclamation Service purchases the Sunnyside irrigation project from the Northern Pacific, Yakima, Kittitas Irrigation company, p. 241; 15) In 1908, the US Supreme Court issued its decision on the Winters vs US, where the court held that Indians reserve water rights even when their treaties made no express mention of water; p. 270; 16) In 1905, the Washington irrigation Company, on their attorneys' advice blew up the dam of Union Gap irrigation Company at Lake Cle Elum when insufficient water thretened to destroy the crops on the Sunnyside Project; . p. 272; 17) In 1889, the Ahtaneum Creek (tributary of the Yakima River) was virtually drained of water by

irrigators on the north side of stream where it bordered the Yakima Indian Reservation; p. 275; 18) In 1891, the Ahtaneum Creek (tributary of the Yakima River) was virtually drained of water by irrigators on the north side of stream where it bordered the Yakima Indian Reservation; . p. 275; 19) In 1892, (a dry summer), the US Bureau of Reclamation attempted to re divert water of Ahtaneum Creek, virtually drained of water by irrigators on the north side of stream where it bordered the Yakima Indian Reservation, but the north-side irrugation users brought suit against the Bureau's action; . p. 276; 20) In 1905 the US Secretary of Interior allocated 2065 cfs and 147 cfs of yakima River water respectively to the white water users and Yakima Indian water users; p. 292; 21) J.H. Lynch (in 1901) noted that the more water flowed in the Ahtaneum Creek (tributary of the Yakima River) in the early days than at present, and the runoff was also later, coming mostly after July 1st; he said " the watershed had not been burned off nor grazed excessively by sheep, hence more water". ; p. 310; 22) In 1908, the Washington State Fish Commissioner asked the Reclamation Service to include fish ladders at Yakima project dams, but was told that fish ladders were not feasible, nor was the Reclamation Service responsible for meeting state fishery laws; p. 310-311; 23) The Washington State Fish commissioner (Mr. Darwin) closed the Klickitat River to food fishing (white commercial and Indian fishing) - not sport fishing - between 1915 and 1917, p. 373.

Mattson, C. R. 1948. Spawning ground studies of Willamette River spring chinook salmon. Oregon Fish Commission, Research Briefs 1(2): 21-32.
Abstract: Provides extensive and comprehensive environment/habitat/distribution information for chinook salmon in the Willamette River and its tributaries.

May, Dean L. 1994. Three frontiers - family, land, and society in the American west, 1850-1900. Cambridge University Press, 313 pages.
Abstract: Author provides the history of settlement and development of the Willamette Valley region (Oregon), the Utah Valley region (Utah), and the Boise Valley region (Idaho) from the 1840-1900. He documents and illustrates agrarian development in these regions (during and after the mining era); provides a perspective of milestones/events affecting settlement and expansion of population in these regions. Note: an excellent documentation of mining and agriculture development in terms of habitat alteration of the Boise River basin/upper Snake river region of Idaho during the 1850-1900 era. The following notes are related to this development in Boise and Willamette basins: 1) An excellent description of the habitat surrounding the Boise River is provided by early explorers/settlers such as John C. Fremont (1843) and Basil Nelson Longsworth (18 August 1853)p. 20-21; 2) Short description of the habitat in the region of the Santiam and Pudding Rivers region in the 1840s..."largely open prairie land begins to break into rolling hills...scattered thickets of Douglas fir, hemlock, spruce, incense cedar in the 1840s", p. 26; 3) Short description of the habitat in the Middleton region of the lower Boise River in 1863..."bottoms were wooded, covered with brush, and often cut through with sloughs...and subirrigated by the low water table throughout the season." p. 37 (Map of Middleton area, and rivers, p. 36).

McClung, James S. 1862. Journal to Oregon, April 22nd 1862 1, 71-80 (incomplete) p.
Abstract: Author provides descriptions of habitat (e.g. forest/timber) and water resources (e.g. springs) in various sub-basins (e.g. Powder and Grande Ronde) to the Snake and Columbia Rivers.

McIntosh, B. A., J.R. Sedell, J.E. Smith, R.C. Wissmar, S.E. Clarke, G.H. Reeves, and L.A. Brown. 1994. Historical changes in fish habitat for select river basins of eastern Oregon and Washington. Northwest Science 68, Special Issue: 36-53.
Abstract: Authors compare the changes in and condition of fisheries habitat in a subset of historical surveyed streams (Tucannon, Asotin, Grande Ronde, yakima, Wenatchee and Methow basins) by comparing the US Bureau of Fisheries surveys (1934-1942) with resurveys of 1990-1992. Habitat information and analyses regarding pool habitat, substrate composition, and riparian zone are

provided.

McIntosh, Bruce A. 1992. Historical changes in anadromous fish habitat in the Upper Grande Ronde River, Oregon, 1941-1990. Masters Thesis. Oregon State University, Corvallis, Oregon. 1-88 (complete) p.

McIntosh, Bruce A., Sedell, James R., Smith, Jeanette E., Wissmar, R. C., Clarke, S. E., Reeves, G. H., Brown, L. A., Hessburg, Paul F., and Everett, Richard L. Management history of eastside ecosystems: changes in fish habitat over 50 years, 1935 to 1992. General Technical Report PNW-GTR-321. US Department of Agriculture, Forest Service, Pacific Northwest Research Station in cooperation with Pacific Northwest Region, 8-25 p.

Merrel, T. R. 1951. Stream improvement as conducted in Oregon on the Clatskanie River and tributaries. Oregon Fish Commission, Research Briefs 3(2): 41-47.
Abstract: Provides information regarding the habitat of this river system, and associated recommendations for habitat improvements in tributaries/areas negatively impacted by logging activities 15 years previous.

Moore, Cecil R. 1939. The Willamette river project. Military Engineer 31(177): 208-211.
Abstract: Author provides a brief history, and geophysical, hydrologic, climatologic description of the Willamette river basin. Discusses and describes the Willamette basin plan that will includes 1) navigation improvement from the mouth to upstream of Willamette Falls, 2) irrigation (seven storage projects of 335,000 acre ft) and stream purification projects. Mentions loss and mitigation of fish habitat and mitigating factors for this loss in terms of improved water flows and quality. Provides illustrative tables for reservoir projects and project costs- pp. 208-211.

Mudd, D., Boe, L., and Bugert, R. 1980. Evaluation of wildlife habitat developed on government project lands along Snake river in Washington. Washingtn Department of Game, Habitat Management Division, 62, maps p.
Abstract: Report provides a baseline of wildlife resources and habitat in areas of the lower Snake river affected by the Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dam projects.

Nielson, R. S. 1950. Survey of the Columbia and its tributaries, Part 5. Special Scientific Report Fisheries No. 38, US Fish and Wildlife Service, Department of Interior, Washington, DC.
Abstract: Provides a comprehensive description and perspective of the Deschutes, John Day, Umatilla and Walla Walla River systems at period in time, in terms of habitat and water flow/temperature.

O'Malley, H. 1935. Some problems which confront the fishery experts in the construction of dams in the Inland Empire. Northwest Science IX(1): 23-24 (February, 1935).
Abstract: Author presents the problems of dam construction in the Columbia River as 1)successful passing of adults over dams, 2) getting small fish and steelhead kelts back to the sea, and 3) the complex problem of changed conditions brought about by the dams and artificial lakes. Mentions the four commissions that control the destiny of commercial and game fishes in the States of Washington and Oregon; the annual value and employment associated with the fishing industry; the budget and employment figure projected for construction of the Bonneville dam; fishways associated with the Rock Island dam; and the impassability of Grand Coulee dam. Discussion of the biological effects on native fish species, based on experiences in New England and other parts of the US; generalizes and predicts the ecological changes of the habitat and species resulting from water impoundments on the Columbia River. Briefly mentions the requirement for proper screening of power intakes and immediate steps to combat pollution, due to industrialization of the Inland Empire.

Oregon State. 1903. Annual Reports of the Department of Fisheries of the State of Oregon to the legislative assembly, Twenty-second regular session, 1903. State of Oregon, Salem, Oregon. W.H. Leeds, State Printer, 1903. 14-21, 34-37, 64-79, 116-119 p.
Abstract: The Master Fish Warden (H.G. Van Dusen) provides detailed accounts for investigations of various waters/streams, such as the Salmon River (tributary to the Sandy River), Clackamas River, the McKenzie River (tributary to the Willamette River), Gate Creek and Blue River (tributary to the McKenzie River), Santiam River (tributary to the Willamette River), Molalla River (tributary to the Willamette River), Tanner and Eagle Creek (tributary to the Columbia River near Bonneville), Deschutes River (tributary to the Columbia River), Crooked River (tributary to the Deschutes River), John Day River (tributary to the Columbia River), Grande Ronde River and its tributaries including Wallowa lake (tributary to the Columbia River), Imnaha River (tributary to the Snake River), Powder River (tributary to the Snake River), Malheur River (tributary to the Snake River), Owyhee River (tributary to the Snake River), and Snake River. Includes notations of salmon species presence and timing, utilization, habitat/habitat alteration, etc. pages 10-21. Notes fish investigative/propagation activities at the Grande Ronde River Experimental Station at the mouth of the Wenaha River (tributary to Grande Ronde River at approximately RM 50); provides information on fish species passage to a fish rack across the Wenaha River; blueback pass this point between June 20th and July 20th, silversides begin showing on September 14th (silverside eggtake conducted mid-October into early December, summary table, Page 36. Notes during investigations/field work at the Swan Falls Experimental Station on the Snake River, that chinook salmon began to arrive at this point on September 1st, and fish were spawned from October 12th to November 13th. page 37. Notes that Oregon State passed a law in 1899 that required the licensing of the salmon and sturgeon industry (fishing and processing) some of funds derived from this licensing law were to be used for artificial propagation of fishes. page 88. Notes on the Grande Ronde River Hatchery Station: chinook salmon begin arriving immediately after rakc is emplaced in the Wenaha River completed on July 4th. Holding rack enclosre is full by September 1st, and first eggs are taken on September 13th and completed October 31. First sockeye eggs were taken october 21st. Pages 116-118. Notes on the Ontario hatchery Station on the Snake River (lies on the left bank of the Snake River directly opposite Morton's Island, near Ontario Oregon); rack barrier is emplaced on August 25th, and next day 300 chinook salmon were already in the racks; run continued at this rate per day until last of September; eggtake was conducted from October 13th through November 8th. pages 119-121.

Oregon State. 1947. Biennial report of the Fish Commission of the State of Oregon to the governor and forty-fourth legislative assembly, 1947. Fish Commission of the State of Oregon; Salem, Oregon, State Printing Office, 1947.
Abstract: Notes that (1) the State of Oregon is entering a period of expansion and industrialization, and population increase where development of rivers will deplete fisheries resources; the early history of the state saw the destruction of salmon spawning habitat. (2) the policy of the Oregon Fish Commission is (a) to study the causes and effects of decline of varios fisheries, (b) to study methods of rehabilitation of species involved, and (c) to evaluate and increase efficiency of artificial propagation and to use hatcheries to supplant and rehabilitate, but not replace, natural spawning. (3) A new fishway is constructed by the Oregon Iron and Steel Company at their dam in the Tualatin River, tributary of the Willamette River, under the supervision of the Division of Engineering (Oregon Fish Commission) page 13. (4) A fishway at Eagle Creek Falls on Eagle Creek (tributary to the Clackamas River) is removed under the supervision of the Division of Engineering (Oregon Fish Commission), page 13. (6) A new dam is constructed by the Hines Lumber Company on the North Fork of the Willamette River, at Westfir (Oregon) construction of an adequate fishway will be completed by early summer 1947. page 14.

Parkhurst, Z. E. 1950. Survey of the Columbia and its tributaries, Part 6 Area V - Snake River system from mouth through Grande Ronde River. Special Scientific Report Fisheries No. 39, US Fish and

Wildlife Service, Department of Interior, Washington, DC.
Abstract: Provides a comprehensive description and perspective of the Snake and Grande Ronde River systems at period in time, in terms of habitat and water flow/temperature.

Parkhurst, Z. E. 1950. Survey of the Columbia and its tributaries, Part 7 - Snake River from above the Grande Ronde River through the Payette River. Special Scientific Report Fisheries No. 40, US Fish and Wildlife Service, Department of Interior, Washington, DC.
Abstract: Provides a comprehensive description and perspective of the Snake above the Grande Ronde, Salmon, Weiser, and Payette Systems at period in time, in terms of habitat and water flow/temperature.

Parkhurst, Z. E. 1950. Survey of the Columbia and its tributaries, Part 8 Area VII - Snake River from above the Payette River to Upper Salmon Falls. Special Scientific Report Fisheries No. 57, US Fish and Wildlife Service, Department of Interior, Washington, DC.
Abstract: Provides a comprehensive description and perspective of the main Snake and its tributaries above the Payette River at period in time, in terms of habitat and water flow/temperature.

Parkhurst, Z. E., Bryant, F. G., and Nelson, R. S. 1950. Survey of the Columbia River and its tributaries - Part III. Special Scientific Report Fisheries No. 36, US Fish and Wildlife Service, Department of Interior, Washington, DC.
Abstract: Provides a comprehensive description and perspective of Columbia River tributaries in Oregon and the Willamette system at period in time, in terms of habitat and water flow/temperature.

Porter, Elizabeth Lee. 1864. Crossing the plains, a diary by Elizabeth Lee Porter 1864 1, 6-7 (incomplete) p.
Abstract: Author gives abbreviated diary of her activities and observations from Iowa to Oregon; some brief notes of climate and habitat of various sub-basins (e.g. Burnt, Powder and Grand Ronde) to the Snake and Columbia river.

Renshaw, Robert Harvey. 1851. Diary of Robert Harvey Renshaw 1, 24-35 (incomplete) p.
Abstract: Author notes his activities and habitat of various sub-basins (e.g. upper Snake tributaries, Burnt, Powder, and Grand Ronde)to the Snake and Columbia rivers. Gives brief mention to the timber and water of the Grand Ronde area.

Rich, E. E. 1950. Peter Skene Ogden's Snake country journals, 1824-25 abd 1825-26 The Hudson's Bay Record Society, London. 92-93, 126-135, 166-171, 190-193 p.
Abstract: Author provides an account of his observations and experiences during his travels in the Columbia river basin during the early 19th century. Briefly notes habitat, flora, and fauna at various points of travel in the various sub-basins (e.g. Bruneau, Payette, Malheur, Owyhee, etc.)of the Upper Snake river, and the Umatilla, John Day, Deschutes, Hood, and Willamette sub-basins of the Columbia river.
General description of attributes for the upper Snake river in the vicinity of the Payette river to the Burnt river (River Brule). - observation of dead salmon (carcasses) along the river.
General description of attributes for the upper Snake river in the vicinity of Burnt river (River Brule) to the Malheur River.
General description of attributes for the upper Snake river in the vicinity of Burnt river (River Brule) to the King Hill creek.- note of sturgeon present in this area during spring.
General description of attributes for the upper Snake river in the vicinity of the Payette river mouth.
General description of attributes for the upper Snake river in the vicinity of the Owyhee river mouth.
General description of attributes for the upper Snake river in the vicinity of the Owyhee river mouth to the Malheur river mouth-notes water flow (spring freshet condition).

General description of attributes for the upper Snake river in the vicinity above the Owyhee river mouth to the Bruneau river mouth.
General description of attributes for the upper Snake river in the vicinity of the Bruneau river mouth.
General description of attributes for the upper Snake river in the vicinity above the Owyhee river mouth to the Bruneau river mouth - notes seeing salmon ascending the stream.
General description of attributes for the upper Snake river in the vicinity above the Owyhee river mouth to the Bruneau river mouth - notes regarding Indian fishing success/salmon presence in the vicinity.
General description of attributes for the upper Snake river in the vicinity above the Bruneau river mouth to Alkali creek mouth.
General description of attributes for the upper Snake river in the vicinity of the Bruneau and Snake river confluence.
General description of attributes for the upper Snake river in the vicinity below Big Wood river to the Bruneau river.
General description of attributes for the upper Snake river in the vicinity of King Hill Creek.

Scheufele, Roy W. 1970. History of the Columbia Basin Inter-Agency Committee. Prepared under sponsorship of the Pacific Northwest River Basins Committee.

Abstract: A. Author presents a comprehensive details regarding the genesis, policy & objectives, actions, and chronology of meeting/events for the Columbia Basin Inter-Agency Committee, during the period of 1946-1967. Provides information regarding governmental legislation (laws) and policy framework, institutional relationships with other state and federal agencies in the Columbia basin, and accomplishments of the agency. NOTE: Reference is very important in terms of its description of policy and philosophy governing water and fisheries policy in the Columbia River basin during the period of 1946-1967. B. Genesis of Agency and Federal Action (pages 3-9): 1) In 1902, the US Congress passes the Reclamation Act; 2) In 1905, the US Congress establishes the US Forest Service; 3) In 1920, the US Congress passes the Federal Power Act; 4) In 1925, the US Congress passes a statute that directed the inventory of those streams in the US where power development appeared feasible and practical in coombination with navigation, flood control, and irrigation; 5) In 1927, the US Congress passes the River and Harbor Act, which commenced the survey of Pacific Northwest streams, that were inventoried under the 1925 congressional statute; 6) In 1936, the US Congress passes the Flood Control Act; 7) In 1936 (?) the US Congress establishes the US Soils Conservation Service; 8) In 1943, the Pacific Northwest Regional Planning Commission, an arm of the National Resources Planning Board, is abolished by the US Congress; 9) In July 1943, the governors of the Pacific Northwest States establish the Northwest States' Development Association to coordinate and correlate plans of member states as they relate to unified development of all the resources of the Pacific Northwest; 10) In December 1943, the Northwest States' Development Association prepares a program and governing principles of emergency and immediate post-war projects for the development of the Columbia Drainage Basin; 11) In summer 1939, the US Departments of Interior, Agriculture, and War (Corps of Engineers) enter a tripartitie agreement to coordinate their work, both in Washington DC and field regions; 12) In December 1943, the US Federal Power Commission joins the tripartite of the US Departments of Interior, Agriculture, and War (Corps of Engineers), and execute a quadpartite agreement that provided monthly meetings of these agencies to discuss restuls of studies/investigations, to adjust differences of opinions, and to promote ways/means for implementing other provisions of the agreement-representatives of these four Departments constituted the Federal Inter-Agency River Basin Commission (FIABRC); 13) In February 1946, the Columbia Basin Inter-Agency Committee, the second field committee of Federal Inter-Agency River Basin Commission, is established to facilitate progress on the multipurpose development projects presetnly authorized by congress (p. 7-9 provides details of conditions of the agreement.); 14) In 1965, the US Congress passes the Water Resources Planning Act; 15) In June

1967, the Pacific River Basins Commission takes over the functions of the Columbia Basin Inter-Agency Committee. C. A chonicle of agency meetings and general outcomes from these meetings is presented (pages 10-123) 1) In March 1947, the Assistant Secretary of Interior (Warner W. Gardner) sends a memorandum/recommendations to the Federal Inter-Agency River Basin Commission (FIABRC) that propose the construction of mainstem dams on the Columbia below Okanogan R. and on the Snake below the Salmon R., with the exception of the proposed McNary Dam, be postponed until 1958 (for 10 years) provided that alternate sources of power could be devloped to meet Bonneville Power Administration load demands; this moratorium period would allow the US Fish & Wildlife Service and state fisheries agencies to determine remedial measures (per research, studies, and planning) that could be taken to preserve the Columbia River fishery; p. 22-23); 2) On 2 April 1947, the Assistant Secretary of Interior (Warner W. Gardner) memorandum was forwarded by the Federal Inter-Agency River Basin Commission (FIABRC) to the Columbia Basin Inter-Agency Committee for study, discussion, and recommendations; 3) On 23 July 1947 at the 11th meeting of the columbia Basin Inter-Agency Committee, (a) Fred Foster (US Fish & Wildlife Service) outlined the Lower Columbia River Fishery Program, consisting of obstruction removal, pollution abatement, diversion screening, fishway construction, hatchery construciton and fish sanctuaries - a program estimated at a cost of $20 million, and (b) a Fish & Wildlife subcommittee was established to coordinate and integrate fish and wildlife programs with water esource program; p. 25; 4) On 22 September 1947, the Fish & Wildlife Subcommittee (Columbia Basin Inter-Agency Committee) filed a report that summarized factual data relating to navigation, power, fish, irrigation, Indians, and National Defense, p. 26; 5) On 8 October 1947, at its 12 meeting, the columbia Basin Inter-Agency Committee unanimously approved and forwarded a letter to the Federal Inter-Agency river basin Commission (FIABRC) recommending that a) Grand Coulee power installations proceed, construction of Hungry Horse, Foster Creek, Detroit, and McNary Dam proceed, etc. b) authorized dams on the columbia River system not to be rescheduled, approval of the Lower Columbia River Fishery Program, and compensaiton of Treaty Indians, and c) upstream dams be authorized promptly and if authorized before 1958 they be constructed ahead of planned/unauthorized The Dalles, John Day and Arlington Dams unless the fish problem has been solved in the interim, etc., p. 26; 6) In 1950, the columbia Basin Inter-Agency Committee establishes the Fisheries Steering Committee, and this subcommittee prepares a comprehensive program of research and construction (to cost 25-50 million dollars) and proposed to finance it by a tax of fifty cents per kilowatt year (note proposal failed and caused an outcry from power interests) p. 27; 7) On 17 September 1948, at its 21st meeting, the Columbia Basin Inter-Agency Committee authorized a Technical Subcommittee for Operating Plan to prepare an integrated and coordinated operating plan for the release and control of waters in connection with Columbia River development program (note plan was never consummated) p. 32; 8) On 10 November 1948 at its 22nd meeting of the columbia Basin Inter-Agency Committee, the Corps of Engineers presented an eight volume "Review of the Columbia River and its Tributaries,: a report costing $5 million; p. 33; 9) On 28 June 1950 at its 40th meeting, the Columbia Basin Inter-Agency committee approved an interim fishery research program (prepared by the Fish & Wildlife Subcommittee) that called for studies of fish passage at river obstructions, impoundment studies, artificial propagation, and studies of life history, trends and abundance, trout habitat and pollution, at an estimated $600,000 per year - another $500,000 was included for stream development and improvement; p. 46; 10) On 19 January 1955, the Columbia Basin Inter-Agency Committee directed the Fisheries Steering Committee to a) prepare an Upper Columbia River fishery program comparable to that in effect on the Lower Columbia River, b) a program of needed fishery research for the whole area, and c) explore ways and means of implementing/financing both programs; p. 83; 1) On 13 March 1957, the Columbia Basin Inter-Agency Committee accepted the Fisheries Steering Committee report with respect to a) prepare an Upper Columbia River fishery program comparable to that in effect on the Lower Columbia River, and b) a program of needed fishery research for the whole area - established resarch priorities and recommendaitons as to what agency would carry out specific studies recommended; p. 91; 12) On

13-14 November 1963, the Columbia Basin Inter-Agency Committee heard a panel of University of Washington academicians (James Crutchfield, W.F. Royce, D. Bevan, Robert Fletcher, R.C. Van Cleave, and R.W. Johnson) carry on extensive dialogues on "Fisheries in the Pacific Northwest - the academicians view this controversial issue," Don Bevan was very critical of fishery regulation; p. 114; 13) On 14 December 1965 at the 132 meeting of the Columbia Basin Inter-Agency Committee, the Executive Subcommittee presented its recommendations on seven fishery proposals (previously submitted by the Fisheries Steering Committee on 6 October 1965) summarized as follows: Proposal 1 - Greater Committee representation for salmon and steelhead, Proposal 2 - Reduction of the use of the Columbia River water for nuclear production to reduce heat pollution of the river, Proposal 3 - Establishment of working contract with Canada on Fishery problem, Proposal 4 - Development of small watersheds for power production should be discontinued, Proposal 5 - Assure proper attention to fish requirements in any inter-basin water transfer studies, Proposal 6 - Fishery research should be continued, the Proposal 7 - The Columbia River Fishery Development program should be retained; 14) On 29 September 1966 at its second Columbia-North Pacific study review, the Columbia Basin Inter-Agency Committee accepted the report of the Water Supply and Pollution Subcommittee entitled "Columbia River - Water Temperature Conditions and Research Requirements" report stemmed from one of the seven fishery proposals (previously submitted by the Fisheries Steering committee on 6 October 1965; p. 21); (15) On 9 June 1967, the Columbia Basin Inter-Agency committee held its last meeting, and handed over its responsiblities, function and records to the new River Basins Commission, p. 122.

Seaman, Margaret H. 1977. Columbia River estuary inventory of physical, biological and cultural characteristics. Columbia River Estuary Study Taskforce,
Abstract: Author provides a document containing a compilation of work contributions by various experts for the Columbia river basin, with respect to physical characteristics (e.g. climate, freshwater, estuarine tides, etc.); biological characteristics (e.g. tidal marshes, shoreline habitat, plankton, fishes, etc.); and cultural characteristics (e.g. land & water uses, recreation, etc.).

Shippen, H. 1954. Columbia River survey, ecological section. (Final report to the US Fish Wildl. Serv.). contract 14-19-008-2220. 178 p. p.
Abstract: Author provides a listing of fish species reported in the Columbia river drainage, based on various published and unpublished references; associates fish species with reference sources contained in listing of abstracts/annotations. These references within the abstracts/annotations section of this report contain information regarding species description, distribution, habitat, food habits, reproduction, and predation. Some but limited information for fishes species inhabiting the estuarine zones of the Columbia rive. **Note: Excellent Source For Old References Regarding the Fish Species and Habitat (including anadromous salmonids) within the Columbia River Basin.**

Simenstad, C. A., Jay, D., McIntire, C. D., Nehlsen, W., Sherwood, C., and Small, L. 1984 . The dynamics of the Columbia River estuarine ecosystem, Vol. I and II. Columbia River Estuary Data Development Program, Astoria, Oregon. 695 p. p.
Abstract: Authors present a synthesis of ecological information & data, derived the physical and biological studies carried out in the Columbia river estuary by CREDDP.The general sections of this reference are:
1. Regional setting and previous studies;
2. Circulatory processes;
3. Sedimentary geology;
4. Historical changes in Columbia river estuarine physical processes;
5. Conceptual framework for physical-biological integration;
6. Ecosystem processes; and
7. Ecosystem analyses by regions and habitat types.

Simenstad, C. A., Jay, D. A., and Sherwood, C. R. 1992. Impacts of watershed management on land-margin ecosystems: the Columbia River estuary. 266-306. Watershed Management: balancing sustainability and environmental change. Springer-Verlag, New York, NY. 543 p.
Abstract: Authors describe the pattern of land use development, changes in estuarine dynamics/process, and habitat alterations of the Columbia river estuary, with respect to river flow, physical properties, and discharge of sediments. State a reduction in 1) mean river flow by ~20%, 2) spring freshet discharge by ~50% of natural flow, 3) sediment inflow by ~25%, and 4) tidal prism by ~15% since the 19 th century. Modifications of the estuary have had significant effects on the estuarine processes that occur in the estuarine turbidity maximum (ETM). Subject of headings of reference are: 1) Watershed impacts on land-margin ecosystems, 2) Land margin ecosystems of illustrative of watershed impacts, 3) River characteristics and the influence of watershed alterations, 4) River flow dynamics, 5) Water characteristics and constituents, 6) Historic alterations to the Columbia river from the watershed to the land margin (includes subsections specifying/describing alterations to (a) watershed, (b) river flow frequency spectrum, & (c) sediment transport), 7) Effects of modifications to watershed on land-margin ecosystem processes (ETM, estuarine heat budget, organic input and food web, consumer populations & ecology). Reference contains excellent descriptive tables and figures that illustrate estuarine alterations, historical trends of specific physical/hydrologic factors in the estuary, and historical trends in anadromous salmon landings in the Columbia river.

Simenstad, C. A., Small, L. F., McIntire, C. D., Jay, D. A., and Sherwood, C. 1990. Columbia River estuary studies: An introduction to the estuary, a brief history, and prior studies. Prog. Ocean. 25: 1-13.
Abstract: Authors provide a short synopsis on: 1) a description of the Columbia river estuary, 2) previous investigations and the Columbia River Estuary Data Development Program (CREDDP), and Definitions and Conventions in CREDDP. Figures illustrate the various regions & zones and bathymetry of the Columbia estuary. A table illustrates and quantifies the area of habitat types within each region of the Columbia estuary. Extensive reference list included.

Smith, C. 1979. Salmon fishers of the Columbia. Oregon State University Press, Corvallis.
Abstract: Author describes a history of the Columbia River fishing industry, from the early Indian fishing activities through the modern day, using numerous reference sources. Provides fish landing and pack statistics over this period. Discusses the habitat alterations/ losses, due to water development, and artificial propagation activites in the Columbia River. Also discusses management history of the Columbia River, and regulatory actions of the States of Oregon and Washington since the late 1800s.

Stanley, G. F. 1970. Mapping the frontier - Charles Wilson's diary of the survey of the 49th parallel, 1858-1862, while secretary of the British Boundary Commission. University of Washington Press, Seattle, 182 pages.
Abstract: Charles William Wilson, a British Army officer, documents his travels, activities during his assignment in the survey and mapping of the region around the British Columbia and US boundary. Lieutenant Wilson provides excellent notes and observations of fisheries resources, Indian fishing, and habitat in the upper Columbia basin (e.g. Columbia, Okanogan, Ketttle, Pend d'Oreille rivers basins); ;and also documents fisheries/habitat in the Fraser River basin and Skagit River basin. (NOTE: an excellent reference to fish stocks and habitat that have not been documented in other references/publications related to the Columbia River fisheries resources). The following historical notes of historical milestones and fisheries/natural resources information were derived: 1) Mentions the survey (late 1850s) of the DD.G.F. Macdonald (civil engineer) in the region between the Chilliwack Lake and the Skagit river; p. 13; 2) An illustration of a map of the area (Chilliwack, Skagit, Pasayten, Ashnola (Rosalia), Similkameen, and Okanogan Rivers basin) surveyed in 1858-

1860, p. 34-35; 3) Indian fishing and processing for winter use noted on the Fraser River opposite Fort langley on 16 October 1858, p. 37; 4) Description of habitat surrounding the Chillawack River (tributary to the Fraser R.) at Chilukweyuk Prairie Headquarters camp on 16 June 1859; also mentions that salmon abound in this area; p. 49; 5) On 30 July 1859, Lt. Wilson mentions that a "fearful fire was raging" in the Skagit Valley beyond the Cascades that originated from an American camp fire, which the Americans were too lazy to put out properly; p. 65; 6) On 9 October 1859, Lt. wilson mentions, in respect to the Chillawack river and tributaries that "at this season of the year is the quantity of dead salmon on the banks of the river; in some of the smaller streams the quantities are so numerous that it produces a most intolerable smell and renders the water anything but pleasant for drinking purposes...who has been dissecting several of them, thinks this arises from the want of insects to feed enormous numbers of salmon that run up the rivers." p. 73; 7) On 22 May 1860, Lt. Wilson describes Indian fishing activities at The Dalles (Celilo Falls) and notes that the fish "average 25 to 40 lbs. weight..." p. 95; 8) An illustration (map) of the region survey in the upper Columbia River basin (e.g. Kettle, Colville, Spokane, Pend d'Oreille Rivers) in 1860-1861; p. 104-5; 9) On 29 June 1860, lt. Wilson briefly describes the habitat of the Spokane River basin in the area between Willow Springs and Deep Creek; p. 108-9; 10) On 30 June 1860, Lt. Wilson briefly describes the habitat of the Colville River; p. 109; 11) On 2 July 1860, Lt. Wilson reported that the American Commission has been brought to a standstill at Pend d'Oreille Lake dur to extensive flooding..."I hear a tract of nearly 60 miles of land is flooded there." p. 112; 12) On 1 August 1860, Lt. Wilson extensively describes Indian fishing activities at Kettle Falls on the Columbia River, and notes that the Indians catch 700 to 1000 fish per day; p. 113-114; 13) On 12 August 1860, Lt. Wilson briefly describes the habitat surrounding the Okanogan River in the vicinity of Lake Osoyoos; and mentions the salmon fishing methods of the Indians "catching the salmon running at this time in great numbers...: p. 118; 14) On 26 August 1860, Lt. Wilson mentions gold miners at work on the Similkameen River near the forks of the Similkameen and Ashnolon (Rosalia) rivers, and notes that there were about 150 miners in the lower Similkameen basin; p. 124; 15) On 29 August 1860 Lt. Wilson briefly describes the habitat of Rock Creek (tributary to Kettle River); p. 125; 16) On 30 August 1860, lt. Wilson briefly describes the habitat of the Kettle River (Nehoialpitku") in the vicinity of the town of Rock Creek and also describes the gold mining activity and methods on Rock Creek; p. 126-6; 17) On 31 August 1860, Lt. Wilson briefly again describes the habitat of the Kettle River ("Nehoialpitku"); p. 128; 18) On 2 September 1860, Lt. Wilson notes that "salmon are running in great numbers up the river (the Kettle River "Nehoialpitku"); p. 129; 19) Lt. Wilson describes the habitat in the Little Spokane River basin; p. 146. General description of attributes in the vicinity of the confluence of the Snake and Columbia Rivers. General description of attributes in the vicinity of the Palouse river mouth.

Stone, L. 1885. Explorations on the Columbia River from the head of the Clarks Fork to the Pacific Ocean, made in the summer 1883, with reference to the selection of suitable place for establishing a salmon breeding station. US Bureau of Fisheries Report, 1883 (1885), p. 237-258. Doc. 97 issued 1886; F11-241. US Bureau of Fisheries, Washington, DC.
Abstract: Derived reference from Appendix V: An analytical subject bibliography of the publications of the Bureau of Fisheries, 1871-1920, by Rose M.E. MacDonald. Document review: Author generally describes his investigation of the various Columbia tributaries in terms as potential fish hatchery sites; provides some habitat characteristics of the tributaries.

Sutton, Sarah. 1854. Diary of Sarah Sutton 1, 69-86 (incomplete) p.
Abstract: Author provides some detailed descriptions of activities, habitat and surroundings of various sub-basins (e.g. Burnt, Powder, and Grande Ronde) during her journey to Oregon; diary abruptly ends since the author died at an unknown place in transit of the Grande Ronde valley.

Symons, Thomas W. 1882. Report of an examination of the upper Columbia River and the territory in its

vicinity in September and October 1881. 47th congress, 1st Session, Senate, Ex. Doc. No. 186, Washington; Government Printing Office, 1882. 1-135, maps (complete) p.
Abstract: Author presents a comprehensive account of observations (geologic, botanical, hydraulic/topographic characteristics) and surveys of the upper Columbia River and its tributaries (e.g. Pend d'Oreille, Kootenay, Colville, Spokane, San Poil, Methow River, etc.) Note: Excellent reference to derive habitat information and inferences of the upper Columbia River.

Thomas, D. W. 1983. Changes in the Columbia River estuary habitat types over the past century. Columbia River Estuary Data Development Program, Astoria, Oregon. 51 p. (complete) p.
Abstract: The author provides and compares information for habitat of the Columbia river from the period predating most human interventions (circa 1870) to the present day (1980). Qualitative and quantitative changes in various estuarine habitat are described and illustrated (figures & tables) according to:
(1) Area- river mouth, mixing zone,Youngs Bay, Baker Bay, Grays Bay, Cathlamet Bay, Upper Estuary, and Estuary;
(2) Habitat type- deep water, medium depth, shallows/ flats, tidal marshes, tidal swamps, developed floodplain, uplands (natural & filled), non-estuarine swamp, and non-estuarine water;
(3) Acreage by period- 1870 and present;
(4) Change- acreage (plus or minus) and percentage;
(5) 1870 acreage, Present estuarine acreage, estuarine area removed, and non-estuarine wetlands added.
Includes appendices providing information regarding:
(1) Excerpts from Annual Reports of Superintendent of the US Coast Survey concerning the Columbia river survey for 1868-1873;
(2) Verification of the US Coast Survey charts;
(3) An explanation of the boundaries of the historical subarea map;
(4) Subarea reports for the River Mouth, Mixing Zone, Youngs Bay, Baker Bay, Grays Bay, Cathlamet Bay, and Upper Estuary;
(5) The nineteen intertidal vegetation communities of the Columbia river, with tables showing their present acreage per subarea and their former acreage and importance (Thomas, 1980).
Note: Excellent reference.

United States. Army Corps of Engineers. 1974. Draft environmental statement of Lower Monumental lock and dam, Snake river, Washington U.S. Army Engineer District, Walla Walla, Washington.
Abstract: This draft environmental impact statement addresses the proposed Lower Monumental dam project. Includes information that describes the Lower Monumental project and the existing environment (terrestrial and water habitat/resources) in the area of the project; and describes the impacts of proposed project alternatives.

United States. Army Corps of Engineers. 1975. Draft environmental statement of Lower Granite project, Snake river, Washington U.S. Army Engineer District, Walla Walla, Washington.
Abstract: This draft environmental impact statement addresses the proposed Lower Granite dam project. Includes information that describes the Lower Granite project and the existing environment (terrestrial and water habitat/resources) in the area of the project; and describes the impacts of proposed project alternatives.

United States. Army Corps of Engineers. 1975. Draft environmental statement of lower Snake river fish and wildlife compensation U.S. Army Engineer District, Walla Walla, Washington. 1, I-4, 46-47, 70-106, maps p.
Abstract: This draft environmental impact statement addresses proposed actions to compensate fish

and wildlife losses resulting from four multi-purpose water resources development projects on the lower Snake river. Includes information that describes the existing environment (terrestrial and water habitat/resources) in the area of the project; and describes the impacts of proposed project alternatives.

United States. Army Corps of Engineers. 1979. Final environmental statement of Ice Harbor lock and dam, Snake river, Washington U.S. Army Engineer District, Walla Walla, Washington. 1,11, 2(1)-2(19), 2(33)-2(36) p.
Abstract: This draft environmental impact statement addresses the proposed Ice Harbor dam project. Includes information that describes the Ice Harbor project and the existing environment (terrestrial and water habitat/resources) in the area of the project; and describes the impacts of proposed project alternatives.

United States. Army Corps of Engineers and Department of Commerce. 1994. (Draft environmental statement.). Lower Snake river biological drawdown test.
Abstract: This draft environmental impact statement addresses a proposed biological drawdown test to be conducted a Lower Granite Reservoir, possibly as early as 1995. Include information describing the Lower Granite project and the existing environment (terrestrial and water habitat/resources) in the area of the project.

US Army. 1897. Report of the chief of engineers 1897 in six parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1897. (Annual report).Government Printing Office, Washington. 3456-3463 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 502-503, Part 4, p. 3404-3406;
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 503, Part 4, p. 3407-3414;
(3) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 504, Part 4, p. 3414-3416.
(4) Cowlitz river- Part 1, p. 520, Part 4, p. 3463-3465;
(5) Young's and Klasskuine rivers-Part 1, p. 466, Part 5, p.3595-3596 (removal of snags and overhanging trees);
(6) Clatskanie river, from mouth to town of Clatskanie-Part 1, p. 467, Part 4, p. 3596-3598;
(7) Lewis river (survey)-Part 1, p. 523, Part 4, p. 3469-3478; and
(8) South channel of Columbia river (in front of Astoria, OR-Part 1, p. 468, Part 4, p. 3406-3407. General description of attributes for the Snake river in the vicinity of Wild Goose Island (~74 miles above the Snake river mouth)- human alterations. General description of attributes for the Snake river in the vicinity of Log Island (~38 miles below Lewiston, ID)- human alterations.

US Army. 1898. Report of the chief of engineers 1898 in six parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1898. (Annual report). Government Printing Office, Washington. 3014-3025 (incomplete) p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis,

Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 507-508, Part 4, p. 3040;
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 505-506, Part 4, p. 3031-3038;
(3) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 499, Part 4, p. 3414-3416.
(4) Cowlitz river- Part 1, p. 508-509, Part 4, p. 3041-3042;
(5) Willamette Slough (Scappoose Creek/ Bay)- Part 4, p. 3043-3044;
(6) Clatskanie river, from mouth to town of Clatskanie-Part 1, p. 510, Part 4, p. 3049-3050; and
(7) South channel of Columbia river (in front of Astoria, OR-Part 1, p. 507, Part 4, p. 3039.
Detailed description of attributes for the Snake river from mouth to Riparia- derived from House Document No. 411, Fifty-Fifth Congress, Second Session: Survey of the Snake River, Washington, From Its Mouth to Riparia (with maps in four sheets). General description of attributes for the Snake river in the vicinity of Wild Goose Island (~74 miles above the Snake river mouth)- human alteration. General description of attributes for the Snake river in the vicinity of Log Island (~38 miles below Lewiston, ID)- human alterations.

US Army. 1899. Report of the chief of engineers 1899 in six parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1899. (Annual report).Government Printing Office, Washington.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 595 Part 4, p. 3246-3247 (includes bathymetry map, dated June 1899, of mouth);
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 592-593, Part 4, p. 3239-3245;;
(3) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 586-588, Part 4, p. 3229-3231 (includes map of Hayden Slough characteristics & 6 pages of photographs);
(4) Cowlitz river- Part 1, p. 597-598, Part 4, p. 3249-3250;
(5) Lewis river-Part 1, p. 596-597, Part 4, p. 3248-3249;
(6) Clatskanie river-Part 1, p. 595-596, Part 4, p. 3247-3248; and
(7) Columbia river below Tongue Point-Part 1, p. 594, Part 4, p. 3245-3246.

US Army. 1900. Report of the chief of engineers 1900 in nine parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1900. (Annual report).Government Printing Office, Washington. 4338-4343 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results,

etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 671-672 & p. 676,-Part 6, p. 4361-4362 & p. 4434-4455 (includes bathymetry map, dated June 1900, of mouth);
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 669-670 & p. 676, Part 6, p. 4352-4360 & p. 4416-4433 (includes bar above Tongue Pt, Dobelbower Bar, Walker Is. Bar, Martin Is., Hunters Bar, Martin Is.-Upper Bar, & Pillar Rock Bar);
(3) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 661-663, Part 6, p. 4334-4337 (includes map of Hayden Slough characteristics;
(4) Cowlitz river- Part 1, p. 674-675, Part 6, p. 4366-4367;
(5) Lewis river-Part 1, p. 673-674, Part 6, p. 4364-4365;
(6) Clatskanie river-Part 1, p. 672-673, Part 6, p. 4363-4364; and
(7) Columbia river below Tongue Point-Part 1, p. 670-671, Part 6, p. 4360-4361.
General description of attributes for the Snake river in the vicinity of Wild Goose Island (~74 miles above the Snake river mouth)- human alteration. General description of attributes for the Snake river in the vicinity of Log Island (~38 miles below Lewiston, ID)- human alterations. General description of attributes for Steptoe Rapids, located ~20 miles below Lewiston, ID. Detailed description of attributes for the Snake R. from Asotin to Wolf Cr. vicinity- derived from House Document No. 75, Fifty-Sixth Congress, 1st Session: Preliminary examination of Snake River from Asotin, WA to Pittsburg, OR (photos and maps included).

US Army. 1901. Report of the chief of engineers 1901 in five parts plus supplement. Annual Reports, War Department, Fiscal Year Ended June 30, 1901. (Annual report).Government Printing Office, Washington. 3528-3544 (incomplete) p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 635-637,-Part 5, p. 3567-3570;
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 633-634, Part 5, p. 3557-3565;
(3) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 627-628, Part 5, p. 3499-3501;
(4) Cowlitz river- Part 1, p. 639-640, Part 5, p. 3573-3575;
(5) Lewis river-Part 1, p. 638-639, Part 5, p. 3572-3573;
(6) Clatskanie river-Part 1, p. 637-638, Part 5, p. 3571-3572; and
(7) Columbia river below Tongue Point-Part 1, p. 634-635, Part 5, p. 3565-3567.
Detailed description of attributes for the Snake river from the mouth to Lewiston, ID. Vicinity-derived from House Document No. 127, Fifty-Sixth Congress, 2nd Session: Preliminary examination of Snake River from Lewiston, ID to Riparia, WA.

US Army. 1902. Report of the chief of engineers 1902 in four parts plus supplement. Annual Reports, War Department, Fiscal Year Ended June 30, 1902. (Annual report).Government Printing Office, Washington.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce &

development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 556-558,-Part 3, p. 2400-2402;
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 554-555, Part 3, p. 2393--2398;
(3) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 549-550, Part 3, p. 2383-2384;
(4) Cowlitz river- Part 1, p. 559-560, Part 3, p. 2404-2405;
(5) Lewis river-Part 1, p. 560-561, Part 3, p. 2406-2407;
(6) Clatskanie river-Part 1, p. 558-559, Part 3, p. 2403-2404; and
(7) Columbia river below Tongue Point-Part 1, p. 556-558, Part 3, p. 2398-2400.

US Army. 1903. Report of the chief of engineers 1903-Volume 9, Part 1, Volume 10, Part 2, Volume 11, Part 3, Volume 12, Part 4, & Volume 13, Supplement.. Annual Reports, War Department, Fiscal Year Ended June 30, 1903. (Annual report).Government Printing Office, Washington. 2246-2255, 2270-2319 and maps p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 614-616,-Part 3, p. 2271-2318 (includes a comprehensive synopsis for the Columbia river entrance, with respect to description, history, physical data, sand movements, projects such as jetties, dredging, etc, and appendices with historical surveys & bathymetric maps);
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 612-614, Part 3, p. 2263-2270 (includes an index map of the lower Columbia and Willamette rivers, opposite p. 2266);
(3) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 608-609, Part 3, p. 2228-2229;
(4) Cowlitz river- Part 1, p. 616-618, Part 3, p. 2319;
(5) Lewis river-Part 1, p. 618-619, Part 3, p. 2320-2321 (includes index map of Lewis river);
(6) Clatskanie river-Part 1, p. 616-617, Part 3, p. 2318; and
(7) Columbia river below Tongue Point-Part 1, p. 614, Part 3, p. 2398-2400.
Note: Excellent reference that provides the history of the Columbia entrance from late 1700's to present.
Detailed description of attributes for the Snake R. from Lewiston (ID) to Imnaha river mouth- 14 maps included. Detailed description of attributes for the Snake R. from Lewiston (ID) to Imnaha river mouth- 13 maps to scale of 1:5000 with an index sheet and profile of the river (not printed in report?)

US Army. 1904. Report of the chief of engineers 1904- Volume 5, Part 1, Volume 6, Part 2, Volume 7, Part 3, Volume 8, Part 4, & Volume 9, Supplement. Annual Reports, War Department, Fiscal Year Ended June 30, 1904. (Annual report).Government Printing Office, Washington . 3468-3471, maps p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the

river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 678-681,-Part 3, p. 3543-3553 (includes a bathymetric map of the Columbia river entrance for June 1904, opposite p. 3548);
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 675--677, Part 3, p. 3534-3542 (includes an index map of the lower Columbia and Willamette rivers, opposite p. 3538);
(3) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 670-671, Part 3, p. 3496-3506;
(4) Cowlitz river- Part 1, p. 682-683, Part 3, p. 3555-3557;
(5) Lewis river-Part 1, p. 683-685, Part 3, p. 3557-3558 (includes index map of Lewis river);
(6) Clatskanie river-Part 1, p. 681-682, Part 3, p. 3554-3555; and
(7) Columbia river below Tongue Point-Part 1, p. 678, Part 3, p. 3543.

US Army. 1905. Report of the chief of engineers 1905- Volume 5, Part 1, Volume 6, Part 2, Volume 7, Part 3, Volume 8, Supplement.. Annual Reports, War Department, Fiscal Year Ended June 30, 1905. (Annual report). Government Printing Office, Washington. 2454-2469, 2482-2495 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 685-687,-Part 3, p. 2484-2492 (includes a bathymetric map of the Columbia river entrance for June 1905, opposite p. 2488);
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 681-684, Part 3, p. 2475-2483 (includes an index map of the lower Columbia and Willamette rivers, opposite p. 2478);
(3) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 676-678, Part 3, p. 2467-2468;
(4) Cowlitz river- Part 1, p. 688-689, Part 3, p. 2493-2494;
(5) Lewis river-Part 1, p. 689-691, Part 3, p. 2495-2496;
(6) Clatskanie river-Part 1, p. 687-688, Part 3, p. 2492-2493; and
(7) Columbia river below Tongue Point-Part 1, p. 684, Part 3, p. 2483-2484.

US Army. 1906. Report of the chief of engineers US Army 1906 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1906. (Annual report).Government Printing Office, Washington . 1984-1999, 2004-2019, 2044-2047 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 757-760,-Part 2, p. 2012-2017-(includes a bathymetric map of the Columbia river entrance for May-June 1906, opposite p. 2016);
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 754-756, Part 2, p. 2006-2012 -

(includes an index map of the lower Columbia and Willamette rivers, opposite p. 2010);
(3) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 750-751, Part 2, p. 1998-2000;
(4) Cowlitz river- Part 1, p. 761-763, Part 2, p. 2018-2019;
(5) Lewis river-Part 1, p. 763-765, Part 2, p. 2019; and
(6) Clatskanie river-Part 1, p. 760-761, Part 2, p. 2017-2018.
Detailed description of the attributes for the Snake R. from Imnaha river mouth to Wolf creek vicinity (Pittsburg, OR)- seven map sheets not included. Detailed description of the attributes for the Snake R. from Imnaha river mouth to Wolf creek vicinity (Pittsburg, OR)- index map of upper Columbia and Snake rivers from Ceilo to Pittsburg Landing.

US Army. 1907. Report of the chief of engineers US Army 1907 in three parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1907. (Annual report).Government Printing Office, Washington. 2168-2179, 2188-2205, 2226-2227 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Columbia river- mouth to mouth of Willamette river-Part 1, p. 767-768;
2) Columbia and lower Willamette rivers below Portland- Part 1, p.771-772;
3) Mouth of Columbia river- Part 1, p. 773-774, Part 3, p. 2196-2203;
5) Dredge for improving lower Willamette and Columbia rivers- Part 2, p. 1105-1106, Part 3, p. 2190-2196;
6) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 775-776, Part 3, p. 2203-2204;
7) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 777-778, Part 3, p. 2204-2207;
8) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 776-777, Part 3, p. 2204-2207; and
9) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 779, Part 3, p. 2207.

US Army. 1908. Report of the chief of engineers US Army 1908 in three parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1908. (Annual report).Government Printing Office, Washington. 2244-2257, 2264-2279, 2305-2307 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Columbia and lower Willamette rivers below Portland- Part 1, p.820-822, Part 3, p.2264-2270;
2) Mouth of the Columbia river- Part 1, p. 822-825, Part 3, p. 2270-2274 (**Note**: opposite page 2272 is survey map of Columbia river entrance for the year 1908);
3) Dredge for improving lower Willamette and Columbia rivers- Part 1, p. 1143-1144;

4) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 825-826, Part 3, p. 2274-2275;
5) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 827-829, Part 3, p. 2277-2278;
6) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 826-8277, Part 3, p. 2275-2277; and
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 829-830, Part 3, p. 2278-2279.

US Army. 1909. Report of the chief of engineers US Army 1909 in three parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1909. (Annual report).Government Printing Office, Washington. 2210-2217, 2222-2223, 2230-2238, 2240-2243, 2260-2263 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Columbia and lower Willamette rivers below Portland- Part 1, p. 859-982, Part 3, p. 2230-2236;
2) Mouth of the Columbia river- Part 1, p.862-864, Part 3, p. 2236-2239;
3) Dredge for improving lower Willamette and Columbia rivers- Part 1, p.1153 (**Note**: opposite page 2238 is survey map of Columbia river entrance for the year 1909);
4) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 865-866, Part 3, p. 2239-2240;
5) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 867-869, Part 3, p. 2241-2242;
6) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 866-867, Part 3, p. 2240-2241; and
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 869-870, Part 3, p. 2242-2243.

US Army. 1913. Report of the chief of engineers US Army 1913 in three parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1913. (Annual report).Government Printing Office, Washington. 3068-3085, 3092-3095, 3100-3105,3108-3115, 3140-3143 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Oregon Slough (part of the former channel of the Columbia river which separates Hayden Island from the Oregon mainland)- Part 1, p. 1338-1340 (**Note:** Includes table of references to examination or survey reports or maps not in the project documents for years 1892, 1896, 1904, & 1912), Part 3, p. 3083-3084;
2) Columbia and lower Willamette rivers below Portland- Part 1, p. 13501354 (**Note:** Includes table of references to examination or survey reports or maps including the project documents for years

1877, 1891, 1892, & 1900), Part 3, p. 3092-3100;
3) Mouth of the Columbia river- Part 1, p. 1354-1359, Part 3, p. 3100-3108 (**Note**: opposite page 3104 is survey map of Columbia river entrance for the year 1913);
4) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1359-1361 & p. 1367-1368 (Note: Snag removal projects), Part 3, p. 3108-3109 & p. 3115 (Note: Snag removal projects);
5) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1364-1367 & p. 1367-1368 (Note: Snag removal projects), Part 3, p. 3113-3114 & p. 3115 (Note: Snag removal projects);
6) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1362-1364 & p. 1367-1368 (Note: Snag removal projects), Part 3, p. 3110-3112 & p. 3115 (Note: Snag removal projects); and
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1368-1369, Part 3, p. 3115-3116.

US Army. 1914. Report of the chief of engineers US Army 1914 in three parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1914. (Annual report).Government Printing Office, Washington. 3197-3215, 3222-3245, 3266-3267 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Oregon Slough (part of the former channel of the Columbia river which separates Hayden Island from the Oregon mainland)- Part 1, p.1387-1389 (**Note:** Includes table of references to examination or survey reports or maps not in the project documents for years 1892, 1896, 1904, & 1912),
2) Columbia and lower Willamette rivers below Portland- Part 1, p. 1400-1403 (**Note:** Includes table of references to examination or survey reports or maps including the project documents for years 1877, 1891, 1892, & 1900),
3) Mouth of the Columbia river- Part 1, p. 1403-1409 (**Note:** Includes (1) Table of references to examination or survey reports or maps including the project documents for years 1879, 1880, 1883, 1886,1890, 1893, 1895,1900 & 1903, and (2) Information on the amount of stone used for the 1884 and 1903 jetty projects);
4) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1409-1411 & p. 1417-1418 (Note: Dredge & snag removal projects), Part 3, p. 3239-3240 & p. 3245 (Note: Dredge & snag removal projects);
5) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1414-1417 & p. 1417-1418 (Note: Dredge & snag removal projects), Part 3, p. 3243-3444 & p. 3455 (Note: Dredge & snag removal projects);
6) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1411-1414 & p. 1417-1418 (Note: Dredge & snag removal projects), Part 3, p. 3240-3243 & p. 3455 (Note: Dredge & snag removal projects); and
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1418-1419, Part 3, p. 3245-3246.

US Army. 1915. Report of the chief of engineers US Army 1915 in three parts. Annual Reports, War

Department, Fiscal Year Ended June 30, 1915. (Annual report).Government Printing Office, Washington. 3370-3375, 3388-3389, 3396-3419, 3442-3443 p.

Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:

1) The Columbia river between Vancouver, WA and the mouth of the Willamette river- Part 1, p. 1513-115;
2) Oregon Slough (part of the former channel of the Columbia river which separates Hayden Island from the Oregon mainland)- Part 1, p. 1515-1518, Part 3, p. 3389-3390;
3) Columbia and lower Willamette rivers below Portland- Part 1, p. 1527-1532, Part 2, p. 1998-1999, Part 3, p. 3397-3404;
4) Mouth of the Columbia river- Part 1, p.1533-1538, Part 2, p. 1999-2000, Part 3, p. 3404-3414 (**Note**: opposite page 3408 are survey maps of Columbia river entrance for the September and December 1914, and March and June 1915);
5) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1538-1540 & p. 1546-1547 (Note: Dredge & snag removal projects), Part 2, p. 2000, Part 3, p. 3414-3415 & p. 3418-3419 (Note: Dredge & snag removal projects);
6) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1543-1546 & p. 1546-1547 (Note: Dredge & snag removal projects), Part 2, 2001, Part 3, p. 3417--3418 & p. 3418-3419 (Note: Dredge & snag removal projects);
7) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1540-1542 & p. 1546-1547 (Note: Dredge & snag removal projects), Part 2, p. 2000, Part 3, p. 3415-3417 & p. 3418-3419 (Note: Dredge & snag removal projects); and
8) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1547-1549, Part 3, p. 3245-3246.

US Army. 1916. Report of the chief of engineers US Army 1916 in three parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1916. (Annual report).Government Printing Office, Washington. 3207-3219, 3226-3227, 3232-3245, 3270-3273 p.

Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:

1) Columbia and lower Willamette rivers below Portland- Part 1, p. 1649-1655, Part 3, p.3227-3233;
2) Mouth of the Columbia river- Part 1, p. 1655-1658, Part 3, p. 3233-3238 (**Note**: opposite page 3408 is survey map of Columbia river entrance for the June 1916).
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1658-1661 & p. 1668 (Note: Dredge & snag removal projects), Part 3, p. 3239-3240 & p. 3244-3245 (Note: Dredge & snag removal projects);
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East

Fork and Woodland on the North Fork)- Part 1, p. 1663-1667 & p. 1668 (Note: Dredge & snag removal projects), Part 3, p. 3242--3244 & p. 3244-3245 (Note: Dredge & snag removal projects);
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1661-1663 & p. 1668 (Note: Dredge & snag removal projects), Part 3, p. 3240-3242 & p. 3244-3245 (**Note**: Dredge & snag removal projects); and
6) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1668-1670, Part 3, p. 3245-3246.

US Army. 1917. Report of the chief of engineers US Army 1917 in three parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1917. (Annual report).Government Printing Office, Washington. 3322-3323, 3328-3335, 3344-3349, 3376-3377 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1716-1719, Part 2, p. 3329-3333;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1719-1726, Part 2, p. 3333-3340;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1726-1729, Part 2, p. 3340-3342;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1735-1739, Part 2, p. 3345--3347;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1739-1741, Part 2, p. 3347-3349; and
6) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1742-1744, Part 2, p. 3349-3350.

US Army. 1918. Report of the chief of engineers US Army 1918 in three parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1918. (Annual report).Government Printing Office, Washington. 3370-3371, 3377-3385, 3394-3397 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p. 1763-1766, Part 3, p. 3377-3380 (**Note**: opposite page 3378 is survey map of Columbia river entrance for the June 1918).;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p.1766-1772, Part 3, p. 3381-3388;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1773-1775, Part 3, p. 3389-3390;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East

Fork and Woodland on the North Fork)- Part 1, p. 1782-1786, Part 3, p. 3394--3395;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1786-1789, Part 3, p. 3395-3397; and
6) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1789-1791, Part 3, p. 3397-3398.

US Army. 1919. Report of the chief of engineers US Army 1919 in three parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1919. (Annual report).Government Printing Office, Washington . 3424-3441 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p. 1857-1861, Part 3, p. 3433-3437 (**Note**: opposite page 3434 is survey map of Columbia river entrance for the June 1919).;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p.1861-1867, Part 3, p. 3437-3445.
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1867-1870, Part 3, p.3445-3446 ;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1877-1880, Part 2, p. 3450-3451;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1881-1883, Part 3, p. 3452-3453;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1883-1885, Part 3, p. 3453-3454; and
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1885-1888, Part 3, p. 3454-3455.

US Army. 1920. (Annual report).Government Printing Office, Washington. 2926-2945 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1851-1854, Part 2, p. 2935-2937 (**Note**: opposite page 2936 is survey map of Columbia river entrance for the June 1920);
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1854-1861, Part 2, p. 2937-2940;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1861-1863, Part 2, p.2941 ;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1870-1873, Part 2, p. 2943-2944;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)-

Part 1, p. 1874-1876, Part 2, p. 2944;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1876-1878, Part 2, p. 2945; and
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1878-1881, Part 2, p. 2945.

US Army. 1921. Report of the chief of engineers US Army 1921 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1921. (Annual report).Government Printing Office, Washington . 1850-1877, 1886-1895, 1944-1947 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1867-1870 (**Note**: opposite page 1868 is survey map of Columbia river entrance for the June 1921);
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1870-1877;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1877-1880;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1886-1889;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1889-1892;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1892-1894; and
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1894-1897.

US Army. 1922. Report of the chief of engineers US Army 1922 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1922. (Annual report).Government Printing Office, Washington . 1868-1899, 1909-1921, 1964-1967 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1887-1889;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1890-1897;
3) Willamette Slough (also known as Multnomah Channel- 21 miles in length, flowing in northerly direction, connecting the Willamette and Columbia rivers at St. Helens, OR)- Part 1, p. 1897-1899 (**Note**: a new project in the fiscal year 1922);
4) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1900-1902;
5) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East

Fork and Woodland on the North Fork)- Part 1, p. 1909-1912;
6) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1912-1914;
7) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1915-1916; and
8) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1916-1919.

US Army. 1923. Report of the chief of engineers US Army 1923 in three parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1923. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1743-11746;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1746-1754;
3) Willamette Slough (also known as Multnomah Channel- 21 miles in length, flowing in northerly direction, connecting the Willamette and Columbia rivers at St. Helens, OR)- Part 1, p. 1754-1756;
4) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1756-1759;
5) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1764-1767;
6) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1767-1769;
7) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1769-1771; and
8) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1772-1774.

US Army. 1924. Report of the chief of engineers US Army 1924 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1924. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1748-1751;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1751-1759;
3) Willamette Slough (also known as Multnomah Channel- 21 miles in length, flowing in northerly direction, connecting the Willamette and Columbia rivers at St. Helens, OR)- Part 1, p. 1760-1762;
4) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1762-1764;
5) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1769-1772;
6) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)-

Part 1, p. 1772-1774;
7) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1775-1776; and
8) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1777-1779.

US Army. 1925. Report of the chief of engineers US Army 1925 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1925. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1676-1679;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1679-1686;
3) Willamette Slough (also known as Multnomah Channel- 21 miles in length, flowing in northerly direction, connecting the Willamette and Columbia rivers at St. Helens, OR)- Part 1, p. 1686-1688;
4) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1688-1691;
5) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1699-1701;
6) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1702-1704;
7) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1704-1705;
8) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1706-1707; and
9) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1708-1709.

US Army. 1926. Report of the chief of engineers US Army 1926 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1926. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1665-1668;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1668-1677;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1677-1680;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1688-1691;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1691-1694;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1694-1696;

7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1696-1698; and
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1698-1701.

US Army. 1927. Report of the chief of engineers US Army 1927 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1927. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1664-1667;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1667-1675;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1675-1678;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1700-1702;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1702-1705;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1705-1707;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1707-1709; and
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1709-1711.

US Army. 1928. Report of the chief of engineers US Army 1928 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1928. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1725-1728;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1728-1736;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1736-1739;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1761-1763;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1764-1766;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1766-1768;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1769-1770; and
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1771-1773.

US Army. 1929. Report of the chief of engineers US Army 1929 in two parts. nnual Reports, War Department, Fiscal Year Ended June 30, 1929. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1753-1756;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1756-1764;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1764-1767;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1790-1793;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1793-1796;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1796-1798;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1798-1800; and
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1800-1802.

US Army. 1930. Report of the chief of engineers US Army 1930 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1930. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1844-1847;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1849-1856;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1856-1859;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1886-1889;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1889-1892;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1893-1895;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1895-1897;
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1897-1900;
9) Skipanon Channel (located at Warrenton, OR; originally called Skipanon river, a narrow crooked stream with ~1.8 mi tidal)- Part 1, p. 1847-1849 (**Note**: reference provides a short history of the stream & condition);
10) Lake river (enters Columbia river near the mouth of the Lewis river)- Part 1, p. 1885-1886 (**Note**:

a short history of the stream and associated activities/description is provided); and
11) Steamboat Slough (also known as Skamokama Slough)- Part 1, p. 1892-1893.

US Army. 1931. Report of the chief of engineers US Army 1931 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1931. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1854-1857;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1861-1869;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1869-1872;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1899-1901;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1901-1905;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1906-1910;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1895-1897;
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1911-1913;
9) Skipanon Channel (located at Warrenton, OR; originally called Skipanon river, a narrow crooked stream with ~1.8 mi tidal)- Part 1, p. 1857-1860 (**Note**: reference provides a short history of the stream & condition);
10) Lake river (enters Columbia river near the mouth of the Lewis river)- Part 1, p. 1896-1899 (**Note**: a short history of the stream and associated activities/description is provided); and
11) Steamboat Slough (also known as Skamokama Slough)- Part 1, p. 1905-1906.

US Army. 1932. Report of the chief of engineers US Army 1932 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1932. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1756-1760;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1762-1771;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1771-1773;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1794-1796;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1796-1799;

6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1800-1802;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1802-1803;
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1803-1805;
9) Lake river (enters Columbia river near the mouth of the Lewis river)- Part 1, p. 1792-1794 (**Note**: a short history of the stream and associated activities/description is provided); and
10) Steamboat Slough (also known as Skamokama Slough)- Part 1, p. 1799-1800.

US Army. 1933. Report of the chief of engineers US Army 1933 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1933. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1140-1143;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 11145-1150;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1150-1152;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1164-1165;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1166-1168;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1168-1169;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1802-1803;
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1169-1170; and
9) Skipanon Channel (located at Warrenton, OR; originally called Skipanon river, a narrow crooked stream with ~1.8 mi tidal)- Part 1, p. 1143-1145 (**Note**: reference provides a short history of the stream & condition).

US Army. 1934. Report of the chief of engineers US Army 1934 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1934. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1313-1316;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1318-1325;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1325-1326;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East

Fork and Woodland on the North Fork)- Part 1, p. 1343-1344;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1344-1347;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1347-1348;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1348-1350;
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1350-1351;
9) Lake river (enters Columbia river near the mouth of the Lewis river)- Part 1, p. 1341-1343 (**Note**: a short history of the stream and associated activities/description is provided);
10) Columbia river at Bakers Bay- Part 1, p. 1351-1352;
11) Columbia river at Bonneville-Part 1, p. 1334-1337; and
12) Skipanon Channel (located at Warrenton, OR; originally called Skipanon river, a narrow crooked stream with ~1.8 mi tidal)- Part 1, - Part 1, p. 1316-1318 (**Note**: reference provides a short history of the stream & condition).

US Army. 1935. Report of the chief of engineers US Army 1935 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1935. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1475-1477;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1479-1487;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1487-1488;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1499-1501;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1501-1503;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1503-1504;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1504-1505;
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1505-1507;
9) Lake river (enters Columbia river near the mouth of the Lewis river)- Part 1, p. 1498-1499 (**Note**: a short history of the stream and associated activities/description is provided);
10) Columbia river at Bakers Bay- Part 1, p. 1507-1508;
11) Columbia river at Bonneville-Part 1, p. 1513-1516;
12) Skipanon Channel (located at Warrenton, OR; originally called Skipanon river, a narrow crooked stream with ~1.8 mi tidal)- Part 1, - Part 1, p. 1477-1478 (**Note**: reference provides a short history of the stream & condition);
13) Youngs Bay and Youngs river (lower 8 mi. tidal)-Part 1, p. 1478-1479; and
14) Multnomah Channel (also known as Willamette Slough)-Part 1, p. 1489-1490.

US Army. 1936. Report of the chief of engineers US Army 1936 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1936. Washington Government Printing Office,

Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1476-1478;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1481-1487;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1487-1489;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1500-1502;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1502-1504;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1504-1505;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1505-1506;
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1506-1507;
9) Lake river (enters Columbia river near the mouth of the Lewis river)- Part 1, p. 1499-1500 (**Note**: a short history of the stream and associated activities/description is provided);
10) Columbia river at Bakers Bay- Part 1, p. 1507-1508;
11) Columbia river at Bonneville-Part 1, p. 1517-1524;
12) Skipanon Channel (located at Warrenton, OR; originally called Skipanon river, a narrow crooked stream with ~1.8 mi tidal)- Part 1, - Part 1, p. 1479-1480 (**Note**: reference provides a short history of the stream & condition);
13) Youngs Bay and Youngs river (lower 8 mi. tidal)-Part 1, p. 1480;
14) Multnomah Channel (also known as Willamette Slough)-Part 1, p. 1489-1490; and
15) Oregon Slough (also known as North Portland Harbor)-Part 1, p. 1498-1499.

US Army. 1937. Report of the chief of engineers US Army 1937 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1937. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1487-1489;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1492-1498;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1499-1500;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1509-1510;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1510-1512;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1513-

1514;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1514-1515;
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1515-1516;
9) Lake river (enters Columbia river near the mouth of the Lewis river)- Part 1, p. 1508-1509 (**Note**: a short history of the stream and associated activities/description is provided);
10) Columbia river at Bakers Bay- Part 1, p. 1516-1517;
11) Columbia river at Bonneville-Part 1, p. 1529-1536;
12) Skipanon Channel (located at Warrenton, OR; originally called Skipanon river, a narrow crooked stream with ~1.8 mi tidal)-Part 1, p. 1489-1491 (**Note**: reference provides a short history of the stream & condition);
13) Youngs Bay and Youngs river (lower 8 mi. tidal)-Part 1, p. 1491-1492;
14) Multnomah Channel (also known as Willamette Slough)-Part 1, p. 1500-1501;
15) Oregon Slough (also known as North Portland Harbor)-Part 1, p. 1498-1499;
16) Westport Slough (side channel of the Columbia river located 70 mi. below Portland, OR)-Part 1, p. 1498-1499;
17) Elockomin Slough (3.5 mi. in length, located 75 mi. below Portland)-Part 1, p. 1512-1513; and
18) Columbia river between Vancouver and Bonneville-Part 1, p. 1528-1529.

US Army. 1938. Report of the chief of engineers US Army 1938 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1938. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1740-1742;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1746-1750;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1751-1753;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1762-1763;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1763-1765;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1766-1767;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1767-1768;
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1768-1769;
9) Lake river (enters Columbia river near the mouth of the Lewis river)- Part 1, p. 1761-1762 (**Note**: a short history of the stream and associated activities/description is provided);
10) Columbia river at Bakers Bay- Part 1, p. 1769-1770;
11) Columbia river at Bonneville-Part 1, p. 1829-1838;
12) Skipanon Channel (located at Warrenton, OR; originally called Skipanon river, a narrow crooked stream with ~1.8 mi tidal)-Part 1, p. 1742-1744 (**Note**: reference provides a short history of the stream & condition);
13) Youngs Bay and Youngs river (lower 8 mi. tidal)-Part 1, p. 1745-1746;
14) Multnomah Channel (also known as Willamette Slough)-Part 1, p. 1753-1754;

15) Oregon Slough (also known as North Portland Harbor)-Part 1, p. 1498-1499;
16) Westport Slough (side channel of the Columbia river located 70 mi. below Portland, OR)-Part 1, p. 1751;
17) Elockomin Slough (3.5 mi. in length, located 75 mi. below Portland)-Part 1, p. 1765-1766;
18) Columbia river between Vancouver and Bonneville -Part 1, p. 1828-1829;
19) Columbia river between Chinook, WA and head of Sand Island-Part 1, p. 1770-1771; and
20) Information regarding diking & Improving Districts along lower Columbia -Part 1, p. 1774-1808.

US Army. 1939. Report of the chief of engineers US Army 1939 in two parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1939. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
1) Mouth of the Columbia river- Part 1, p.1890-1893;
2) Columbia and lower Willamette rivers below Vancouver and Portland- Part 1, p. 1897-1903;
3) Clatskanie river (empties through Beaver and Wallace Sloughs into the Columbia river 65 mi below Portland)- Part 1, p. 1903-1904;
4) Lewis river (empties into Columbia 26 miles below Portland, stream is tidal to La Center on East Fork and Woodland on the North Fork)- Part 1, p. 1914-1915;
5) Cowlitz river (empties into Columbia river 45 mi. below Portland; tidal to 9 miles above mouth)- Part 1, p. 1915-1917;
6) Skamokawa Creek (empties into Columbia river at RM 34, lower 1.5 mi. tidal)- Part 1, p. 1918-1919;
7) Grays river (empties into Grays Bay at mouth; tidal in lower 8 mi.)- Part 1, p. 1919-1920;
8) Deep river (formerly known as Alamicut river- a tidal slough extending 4 mi. inland from a northerly direction of Grays Bay- Part 1, p. 1920-1922;
9) Lake river (enters Columbia river near the mouth of the Lewis river)- Part 1, p. 1913-1914 (**Note**: a short history of the stream and associated activities/description is provided);
10) Columbia river at Bakers Bay- Part 1, p. 1922-1923;
11) Columbia river at Bonneville -Part 1, p. 2002-2011;
12) Skipanon Channel (located at Warrenton, OR; originally called Skipanon river, a narrow crooked stream with ~1.8 mi tidal)-Part 1, p. 1893-1895 (**Note**: reference provides a short history of the stream & condition);
13) Youngs Bay and Youngs river (lower 8 mi. tidal)-Part 1, p. 1895-1897;
14) Multnomah Channel (also known as Willamette Slough)-Part 1, p. 1904-1905;
15) Oregon Slough (also known as North Portland Harbor)-Part 1, p. 1498-1499;
16) Westport Slough (side channel of the Columbia river located 70 mi. below Portland, OR)-Part 1, p. 1751;
17) Elockomin Slough (3.5 mi. in length, located 75 mi. below Portland)-Part 1, p. 1917-1918;
18) Columbia river between Vancouver and Bonneville -Part 1, p. 2000-2002;
19) Columbia river between Chinook, WA and head of Sand Island-Part 1, p. 1923-1924; and
20) Information regarding diking & Improving Districts along lower Columbia -Part 1, p. 1927-1973.

US Army Corps of Engineers. 1978. Columbia river downstream of Bonneville dam- maintenance disposal plan. US Army Corps of Engineers, Portland District, 79 p.
Abstract: Reference provides information regarding shoal/bar patterns of the entrance and estuary of

the Columbia river to Bonneville dam, with respect to current and future dredging operations (and disposal areas of materials) for maintenance of the navigation channel. Information (past maintenance, present Oregon side disposal, and present Washington side disposal) for each critical bar/reach is provided; each is illustrated using an aerial photograph that is detailed with data & outlines.
Note: Photographs provide excellent details of inriver, riparian and uplands habitat from an aerial perspective.

US Commission of Fish and Fisheries. 1895. Bulletin of the US Fish Commission for 1894, Vol. XIV. US Commission of Fish and Fisheries, Washington, DC: Government printing office, 1894.
Abstract: Eigenmann, Carl H. Results of explorations in western Canada and the northwestern US (pages 101-132): References to habitat of Umatilla River, Grande Ronde, Snake River (at Idaho Falls); and a milling dam on the Grande Ronde at the town of La Grande. Discussion of species and taxonomic characteristics. NOTE: VERY IMPORTANT REFERENCE. Gilbert, C.H. and B.W. Evermann. A report upon the physical and natural history investigations in the Columbia River basin (pages 169-207): Extensive discussions of habitat characteristics for tributaries of the Lower Columbia (Cowlitz, Yakima, Naches, adn Toutle) and the upper Columbia (Colville, Little Spokane, Spokane, Snake and tributaries. References that large numbers of salmon used to ascend the Yakima River and Columbia River at Kettle Falls; also has stream temperature and flow data for hte Yakima, Naches, and Manatash Creek. NOTE: VERY IMPORTANT REFERENCE. McDonald, Marshall. The salmon Fisheries of the Columbia River, together with a report upon the physical and natural history investigations in the region, by Gilbert and Evermann (Pages 153-207): a presentation of the status of salmon and reasons for decline of salmon in the Columbia basin, that was given to the Congress. NOTE: VERY IMPORTANT REFERENCE.

US Commission of Fish and Fisheries. 1895. Part XIX: Report of the Commissioner for 1893. US Commission of Fish and Fisheries, Washington, DC: Government printing office. 38-41 p.
Abstract: Discussion of the investigations of interior waters of the Columbia River (Clarke Fort, Pend d'Oreille Lake, and Pend d' Oreille River) in terms of habitat, physical impediments to passage/navigation. Reference to occurrence of chinook salmon and steelhead trout in the Pend d'Oreille River. Commissioner stated intentions to expand investigations of habitat/passage of salmon throughout the entire Columbia River and its tributaries. Pages 38-41. Discussion of the operation of the Clackamas station Oregon (Waldo F. Hubbard, superintendent) during 1892; references to adult and egg collection of chinook salmon at the Sandy River. Pages 121-122. Extensive section that elaborates on The Fisheries of The Pacific Coast (text and statistical tables), inclusive of the Columbia River. Pages 143-304.

US Department of Commerce. 1932. Doctor Ellis demonstrates serious effects of mine pollution. Fisheries Service Bulletin No. 211, Bureau of Fisheries, US Department of Commerce, Washington DC, December 1, 1932.
Abstract: Notes the history and results of Dr. M.M. Ellis (US Bureau of Fisheries) who studied the pollution problem of Couer d'Alene River in Idaho, regarding wastes from silver, lead, and zinc mines. Survey extended from Montana to Spokane River in Washington. Provids extensive information on extent and type of habitat degradation to streams and lakes caused from mining wastes. Mentions that aquatic production of Couer d'Alene Lake was showing decline in the southern end from 1911, and species of trout were scarce, p. 3-4.

US House of Representatives. 1881. Annual report of the chief of engineers, US Army, to the Secretary of War for the year 1881 in three parts. 47th Congress, 1st Session, Ex. Doc.1, pt 2, vol.II. Washington Government Printing Office,
Abstract: The reference contains comprehensive information regarding projects and activities related

to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river- Part 3, p. 2534-2552 (includes historical description of river mouth for physical characteristics and projects since early 1839, and bathymetry maps December 1880 and February 1881 opposite p.2546 & 2552 respectively);
(2) Lower Willamette and Columbia rivers from Portland to the sea-Part 1, p. 324-326, Part 3, p. 2531-2534 (surveys & dredging activities);
(3) Cowlitz River-Part 1, p.331, Part 3, p. 2600-2603 (includes brief historical description of river characteristics and commerce in the valley adjacent to the river); and
(4) Young's, Lewis & Clark, and Skipanon rivers, tributaries to Young's Bay-Part 1, p.332.

US House of Representatives. 1887. Annual report of the chief of engineers, US Army, to the Secretary of War for the year 1887 in four parts. 50th Congress, 1st Session, Ex. Doc.1, pt 2, vol.II. Washington Government Printing Office,
<u>Abstract</u>: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river- Part 1, p. 327, Part 3, p. 2470 etc. (not available at U of W library for review);
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 331, Part 3, p. 2507 etc. (not available at U of W library for review); and
(3) Cowlitz river- Part 1, p. 333, Part 3, p. 2524 etc. (not available at U of W library for review).

US House of Representatives. 1891. Annual report of the chief of engineers, US Army, to the Secretary of War for the year 1891 in six parts. 52D Congress, 1st Session, Ex. Doc.1, pt 2, vol.II. (Annual report).Government Printing Office, Washington. 3284-3293 (incomplete) p.
<u>Abstract</u>: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 412-413 (channel maintenance and work on low-tide jetty from Fort Stevens to Clatsop Spit), Part 5, p. 3314-3328 (includes bathymetry map of Columbia mouth for June 1891);
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 416-417, Part 5, p. 3362-3367;
(3) Cowlitz river- Part 1, p. 418-419
(4) Willamette river at Swan Island-Part 1, p. 420, Part 5, p.3370-3371;
(5) Young's Bay (improvement of Young's and Klasskuine rivers) at Columbia river mouth-Part 1, p.

420, Part 5, p.3371-3372 (removal of snags and overhanging trees);
(6) Deep, Skamakawa, and Crooked rivers-Part 1, p. 420
(7) Lower Columbia river between Astoria and Woods Landing (snag removal project)-Part 1, p. 420, Part 5, p.3380;
(8) Lewis and Clarke's river (snag & overhanging trees removal project)-Part 1, p. 421, Part 5, p.3384-3385;
(9) Grays river (sand bar, snag & overhanging trees removal project)-Part 1, p. 421, Part 5, p.3386-3387; and
(10) Deep, Skamakawa, and Crooked rivers-Part 5, p. 3378-3379.
General description of attributes for the Snake river from the mouth to Lewiston, ID, Table containing gradient information for various rapids.
General description of attributes for the Snake river from the Seven Devils Mining District (~65 miles below Huntington Bridge) to Huntington Bridge (near the Burnt river mouth).

US House of Representatives. 1892. Annual report of the chief of engineers, US Army, to the Secretary of War for the year 1892 in four parts and atlas. 52D Congress, 2d Session, Ex. Doc.1, pt 2, vol.II. (Annual report).Government Printing Office, Washington. 2374-2485, 2400-2409, 2708-2715 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 386-388 (channel maintenance and work on low-tide jetty from Fort Stevens to Clatsop Spit), Part 3, p. 2808-2818;
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 389-391, Part 3, p. 2829-2835;
(3) Cowlitz river- Part 1, p. 392-393, Part 3, p. 2837-2838;
(4) Young's Bay (improvement of Young's and Klasskuine rivers) at Columbia river mouth-Part 1, p. 393, Part 3, p.2839 (removal of snags and overhanging trees);
(5) Lower Willamette and Columbia rivers, with view of securing 25 feet a low water from Portland to the mouth of the Columbia-Part 1, p. 394-395, Part 3, p. 2851-2869; and
(6) Willamette river at Ross Island-Part 3, p.2842-2844.
Atlas: Map no. 126- Depth sounding of the Columbia river mouth, 9,10, 11 June 1892; Map no. 127- Showing jetty construction at Columbia river mouth
General description of attributes for the Snake river reaches from Riparia to Lewiston, ID.

US House of Representatives. 1893. Annual report of the chief of engineers, US Army, to the Secretary of War for the year 1893 in six parts. 53D Congress, 2d Session, Ex. Doc.1, pt 2, vol.II. (Annual report).Government Printing Office, Washington. 3374-3377 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 447-449 (channel maintenance and work on low-tide jetty from Fort Stevens to Clatsop Spit), Part 4, p. 3488-3503 (includes bathymetry map of mouth, June

1893 opposite of p. 3496);
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 452-455, Part 4, p. 3515-3522;;
(3) Cowlitz river- Part 1, p. 456, Part 4, p. 3526-3527;
(4) Young's and Klasskuine rivers-Part 1, p. 456-457, Part 4, p.3527-3528 (removal of snags and overhanging trees);
(5) Lewis river from mouth to Speliah creek-Part 1, p. 458, Part 4, p. 3533-3536; and
(6) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 449-450, Part 4, p. 3503-3506.
General description of attributes for the Snake river from the Seven Devils Mining District (~65 miles below Huntington Bridge) to Huntington Bridge (near the Burnt river mouth).

US House of Representatives. 1894. Annual report of the chief of engineers, US Army, to the Secretary of War for the year 1894 in six parts. 53D Congress, 3d Session, Ex. Doc.1, pt 2, vol.II. (Annual report).Government Printing Office, Washington. 2588-2593 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 413-414 (channel maintenance and work on low-tide jetty from Fort Stevens to Clatsop Spit), Part 4, p. 2631-2642 (includes bathymetry map of mouth, June 1894 opposite of p. 2640);
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 416-417, Part 4, p. 2654-2659;
(3) Cowlitz river- Part 1, p. 417-418, Part 4, p. 2662-2663;
(4) Young's and Klasskuine rivers-Part 1, p. 418, Part 4, p.2663 (removal of snags and overhanging trees); and
(5) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 414-415, Part 4, p. 2643-2645.
General description of attributes for the Snake river from the Seven Devils Mining District (~65 miles below Huntington Bridge) to Huntington Bridge (near the Burnt river mouth). - brief note on original condition of this reach.

US House of Representatives. 1895. Annual report of the chief of engineers, US Army, to the Secretary of War for the year 1895 in seven parts. 54th Congress, 1st Session, Ex. Doc.1, pt 2, vol.II. (Annual report). Government Printing Office, Washington. 3388-3393 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 460-461, Part 5, p. 3551-3561 (includes bathymetry map of mouth, October-November 1894 opposite of p. 3560);
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 461-462, Part 5, p. 3561-3566;
(3) Cowlitz river- Part 1, p. 466, Part 5, p. 3594-3595;
(4) Young's and Klasskuine rivers-Part 1, p. 466, Part 5, p.3595-3596 (removal of snags and

overhanging trees);
(5) Clatskanie river, from mouth to town of Clatskanie -Part 1, p. 467, Part 5, p. 3596-3598 (description of existing conditions prior to project improvements);
(6) Lewis river from La Center to its mouth-Part 1, p. 467, Part 5, p. 3600-3601;
(7) South channel of Columbia river (in front of Astoria, OR-Part 1, p. 468, Part 5, p. 3605-3606 (includes bathymetry map of south channel, Tongue Pt to Smith Point,dated November 1894 opposite p. 3608); and
(8) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 462-463, Part 5, p. 3566-3568.
General description of attributes for the Snake river from the Seven Devils Mining District (~65 miles below Huntington Bridge) to Huntington Bridge (near the Burnt river mouth). - brief note on original condition of this reach.

US House of Representatives. 1896. Annual report of the chief of engineers, US Army, to the Secretary of War for the year 1896 in six parts. 54th Congress, 2d Session, Ex. Doc.1, pt 2, vol.II. (Annual report).Government Printing Office, Washington. 3382-3389 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 400-401, Part 5, p. 3250-3256 (includes bathymetry map of mouth, October-November 1894 opposite of p. 3560);
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 401-422, Part 5, p. 3257-3262;
(3) Cowlitz river- Part 1, p. 415, Part 5, p. 3385-3386;
(4) Young's and Klasskuine rivers-Part 1, p. 405, Part 5, p.3283; and
(5) South channel of Columbia river (in front of Astoria, OR-Part 1, p. 401, Part 5, p. 3256-3257;
(6) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 402-403, Part 5, p. 3263-3266.
General description of attributes for the Snake river from the Seven Devils Mining District (~65 miles below Huntington Bridge) to Huntington Bridge (near the Burnt river mouth). - brief note on original condition of this reach.

Victor, E. 1935. some effects of cultivation upon stream history and upon the topography of the Palouse region. Northwest Science IX(3): 18-19 (September, 1935).
Abstract: Author discusses habitat alterations (bank erosion, channel scouring, etc.) along stream courses in the Palouse region, due to human activities and environmental dynamics; mentions Miller Creek (near Walla Walla), Touchet (near Waitsburg) and Palouse rivers as examples of channel changes.

Ward, H. B. 1939. The migration and conservation of salmon. Publication of the American Association of Advanced Sciences 8: 60-71.
Abstract: Author discusses habitat influences on behavior of salmonid fishes; emphasizes that habitats are not static, and that it is important to understand environmental factors that modify behaviors. Makes continous references to efects of temperature on behavior patterns and outcomes. (Pertinent to life history strategies paper.)

Washington Department of Fisheries. 1938. Report of the preliminary investigations into the possible methods of preserving the Columbia River salmon and steelhead at the Grand Coulee Dam. Report prepared for the US Bureau of Reclamation by the State of Washington Department of Fisheries, in cooperation with the Department of Game and the US Bureau of Fisheries. 121 pp.
Abstract: Comprehensive report of investigative findings regarding fish counts, biology, behavior, habitat of salmon stocks in the tributaries of the Columbia River above Rock Island to Grand Coulee. Includes trap counts of upstream and downstream migrants at Rock Island and tributaries; some biometric data of these trapped fish are presented (Wenatchee, Methow, Twisp, etc.) Some environmental data such as water temperature and water flow are given for some tributaries. Briefly describes water development projects (irrigation) and their associated fish protection facilities. Excellent document for deriving historical background information regarding the planning of fish salvage and mitigation measures associated with the Grand Coulee project.

Washington State. 1907. 16th and 17th annual reports of the state fish commissioner and game warden: 1905-1906. State of Washington Department of Fisheries and Game, Seattle, Washington. C.W. Corham, Public Printer, 1907.
Abstract: The commissioner (John L. Riseland) discusses the situation of fishing, fishing seasons, and disjointed regulations of Oregon and Washington in the lower Columbia River; expresses concern that if the early season is not shortened, the Royal chinook will further decline and lead to situation where packers will have to depend on fall season rather than early and mid seasons. Provides newspaper quotes from the Portland Oregonian that support his statements. pages 10-14. Provides a report on Washington salmon hatcheries in the Columbia basin; notes that the Wenatchee Hatchery is the only hatchery tributary to the Columbia that propagates Silverside salmon (coho). Also mentions that manager of the Colville Hatchery could only acquire 90,000 silverside salmon eggs in the stream (Colville River); and that the facility was deemed not to operate. Notes that the Klickitat hatchery was never completed, and was abandoned in 1902, pages 24-25. Notes that the Wind River Logging company, on the Wind River, flooded the Wind River, carrying all their logs into the Columbia River; this citation documents the use of crib dams to contain logs and flush logs down the Wind River, page 30. Notes that the Methow hatchery is the only remaining salmon hatchery (Colville, Little Spokane and Klickitat hatcheries are closed) on the east side of the Cascades to propagate silverside salmon; infers that Colville, Little Spokane and Klickitat Rivers have or had runs of coho salmon, pages 30-131. Provides letters that note run and habitat conditons on the Klicktat, Colville, Wenatchee, and Lewis Rivers, Page 39-42.

Wilkes, Charles. 1856. Narrative of the United States expedition. During the years 1838, 1839, 1840, 1841, 1842. By Charles Wilkes, USN. Commander of the expedition, member of the american philosphical society, etc. In five volumes, with thirteen maps. Vol IV. G.P. Putnam & Co., 321 Broadway, New York. 1-4 (notes on work) p.
Abstract: Author provides an account of his experiences and observations during his travels in the Columbia river basin; notes habitat/landscapes, fauna, flora of various reach sections of the Columbia river and tributaries.

Wissmar, R. C., J.E. Smith, B.A. McIntosh, H.W. Li, G.H. Reaves, and J.R. Sedell. 1994. A history of resource use and disturbance in riverine basins of eastern Oregon and Washington (early 1800s-1900s). Northwest Science 68, Special Issue: 1-35.
Abstract: Authors provide a historical review of human activities (mining, livestock, irigation, and logging) and habitat alterations in the Okanogan, Methow, Little Naches, Grande Ronde, and John Day basins) Table 1 presents a chronology of major settlement, human activities, and natural resources development in these basins.

Wood, Tallmadge R. 1903. Letters of Tallmadge R. Wood. The Quarterly of the Oregon Historical

Society VI(1): 80-85 (March 1903).
Abstract: Author notes in letter of 19 February 1846 (Clatsop, Co. Oregon Territory) that: 1) six sawmills and five flour mills are now in operation (the Clatsop county region), p.81; 2) heavy timber and broken land along each side of the river (Columbia River from Astoria to the mouth of the Cowlitz River),p. 82; Provides general description of the habitat/vegetation/soil along the banks of the Columbia River in the Clatsop County area.

LIFE-HISTORY

Reference List

Bayha, Keith. 1974. Anatomy of a river Pacific Northwest River Basins Commission, 1 Columbia River, P.O. Box 908, Vancouver, Washington 98660, Vancouver, Washington.
Abstract: Authors present a comprehensive evaluation of water requirements for the Hell's Canyon reach of the Snake river, based on field surveys of March 1973. Surveys included collection of information regarding the time of travel of the stage wave and water mass, water quality, biological resources, etc. Includes photographs that illustrate the habitat (terrestrial and water) of this area.

Craig, J. A. 1935. The effects of power and irrigation projects on the migratory fish of the Columbia River. Northwest Science IX(1): 19-24 (February, 1935).
Abstract: Author discusses the effects of human land and water uses (logging, mining, power, and irrigation) on fisheries resources in the Columbia basin. Provides examples of habitat alterations imposed by these human uses. Briefly discusses life history and ecology of all anadromous salmonid species inhabiting the Columbia River basin. Discusses how the use of streams for power and irrigation purposes affect migratory salmon species: 1) obstacles that obstruct or delay migration of adult upstream to natal steams; and 2) injurious or delay impediments to downstream juvenile migration. Presents fishways and screening as mechanisms to protect fish, and the use of artificial propagation in the case of high dams.

Davis, H. S. 1903. The migrations and growth of salmon fry. Pacific Fisherman I(4): 9-10.Seattle, Washington and Vancouver, B.C. complete p.
Abstract: Author provides an excellent synopsis of the state of knowledge for life history information regarding young salmon species in the Pacific Northwest region (including the Columbia River). Describes life history in terms of summer residents, and rate of growth. Proposes 1) application of information and results to other salmon streams and 2) bearing of these facts on artificial propagation, notes the following: 1) growth of salmon in lower Columbia tributaries is faster than that of upper Columbia basin tributaries (east of the Cascades) and 2) nothing is known of the age at which fry in the Columbia reach the sea. NOTE: excellent reference.

Franchere, Gabriel. 1969. Journal of a voyage on the north west coast of North America during the years 1811, 1812, 1813, and 1814 The Champlain Society, Toronto. 78,82-83, 96-97, 100-101, 110-111, 142-143, 148-149, 152-157 p.
Abstract: Author provides an account of his observations and experiences during his travels in the Columbia river basin during the early 19th century. Briefly notes habitat, flora, and fauna at various points of travel up and down the Columbia river and its tributaries. General description of attributes for the Snake river mouth.

Harts William W. 1899. Preliminayr examination of Snake river, from Asotin, Wash., to Pittsburg Landing, Oreg. 56th Congress, 1st Session, House Document No. 75: U.S. House of Representatives,
Abstract: Author provides a survey report describing the Snake river from *Asotin (Washington) to Pittsburg (Oregon)*; report includes information describing the river channel (slope, width,

obstructions) and lands peripheral to the river. Includes photographs of various river reaches that present problems/obstacles to water navigation.

Harts, William W. 1900. Survey of Snake river from Lewiston, Idaho, to Riparia, Wash. 56th Congress, 2nd Session, House Document No. 127: U.S. House of Representatives,
Abstract: Author provides a survey report describing the Snake river from *Lewiston to Riparia*; report includes information describing the river channel (slope, width, obstructions) and lands peripheral to the river. Includes a table of survey data for various river sections from Lewiston to Riparia, that present problems/obstacles to water navigation.

Jones, W. A. 1888. The salmon fisheries of the Columbia River. (Letter from the Secretary of War).50th Congress, 1st Session, Senate Document 123: Washington D.C. 18-21 p.
Abstract: Author presents a comprehensive perspective of the status and various facets on the salmon fisheries of the Columbia River, in a report (seven chapters) to the Secretary of War. Chapters of the report cover the following: Chapter I - General descriptions of the anadromous salmon species and their life history and habits in the Columbia and Snake Rivers; Chapter II - the depletion of salmon in streams of the Columbia River; Chapter III - the fisheries of the Columbia River; Chapter IV - the question of salmon fisheries being an obstruction to navigation; Chapter V - Artificial propagation of salmon; Chapter VI - Suggestions; and Chapter VII - Quantity, value, and price of salmon paid to fishermen over the past 20 years. Includes photographs of salmon and fishing apparatus. Excellent reference.

Karr, M. B. Tanovan R. Turner and D. Bennett. 1992. Water temperature control project Snake river interim report: model studies and 1991 operations A report from the Columbia River Inter-Tribal Fish Commission Public Policy Department, U.S. Army Corps of Engineers North Pacific Division Reservoir Control Center, and University of Idaho Fish and Wildlife Resources Department.
Abstract: Authors model and provide water temperature data for the Snake river downstream of Lewiston, Idaho for the water year 1991. Figure 3 of the report illustrates the water temperature profile of the Snake river at its mouth (1955-1958) and below Ice Harbor Dam (1987 and 1990). Figure 4 of the report compares the water temperatur profile of the Snake river above and below the mouth of the Imnaha & Salmon rivers and below Hells Canyon Dam.

McMurrick, J. P. 1910. The life history of the Pacific salmon. Transactions of the Canadian Institute IX(20), Part I, August 1910: 23-44.
Abstract: Author gives background on the biology and distribution of the species of family Salmonidae in North America, with emphasis on the genus Salmo and Oncorhynchus. Comprehensively discusses the life history and biology of Pacific salmon species in the Columbia and Fraser rivers; also gives observations of big run years, and canning statistics for British Columbia and Washington.

McMurrick, J. P. 1912. The life cycles of the Pacific coast salmon belonging to the genus Oncorhynchus as revealed by their otolith and scale markings. Proceedings and Transactions of the Royal Society of Canada, Third Series VI(Transactions Section IV): 9-28, 10 plates.
Abstract: Author describes the life history of chinook, coho, chum, sockeye, and pink salmon based on comprehensive analyses and comparisons of scales and otolith structures; derived scales and otoliths from salmon canneries in the Esquimalt and Claxton Canneries in British Columbia, Canada. Includes photographic plates of scales.

Mudd, D., Boe, L., and Bugert, R. 1980. Evaluation of wildlife habitat developed on government project lands along Snake river in Washington. Washingtn Department of Game, Habitat

Management Division, 62, maps p.
Abstract: Report provides a baseline of wildlife resources and habitat in areas of the lower Snake river affected by the Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dam projects.

Netboy, Anthony. 1958. Salmon of the Pacific Northwest: fish versus dams. Binfords & Mort, Publishers, Portland, Oregon. 122 pages.
Abstract: Author discusses: (1) Life history and migrations of Pacific species in the Columbia River; (2) Indian fisheries and methods prior to and after the settlement of white men in the Columbia basin; (3) Historical and contemporary alterations of the Columbia River (e.g. land use, pollution, and dams); (4) Fish passage, management, and propagation methods to overcome the human alterations in the Columbia River.

Netboy, Anthony. 1980. The Columbia River salmon and trout; their fight for survival. University of Washington Press, Seattle and London. 180 pages.
Abstract: Author documents and describes (1) the pristine Columbia River; (2) The Columbia River Indian fishery; (3) life history of Columbia River salmon and steelhead trout species; (4) Intrusive alterations (e.g. irrigation, pollution, dams) of the watershed and consequences (e.g. decline of Pacific salmon species); (5) Fishery compensation programs in the Columbia River; and (6) Endanger species. Contains a comprehensive bibliography of Columbia River related historical and contemporary references.

Park, Donn. 1993. Snake river water temperature- 1950 's Unpublished memorandum from Donn Park (Biomark Inc.) to Dennis Dauble (Battelle Richland, Washington, 19 February 1993.
Abstract: Author provides water temperature data for the Snake river at Oxbow, Oregon (1957 and 1958) and at Clarkston, Washington (1958); these data were cited from U.S. Fish and Wildlife Service (Department of Interior) publications.

Rich, W. H. 1935. The biology of the Columbia River salmon. Northwest Science IX(1): 3-14.
Abstract: Author provides an historical background and purposes of biological investigations of salmon in the Columbia River basin; and the general distribution of anadromous salmonid species. A general discussion of the biology, life history, and behavior of anadromous salmonid species is presented. Extensive information provided in support of the Home Stream Theory for homing behavior of anadromous salmonids, and the effects of environmental factors (e.g. water quality) on homing to parent stream/tributary thereof.

Rich, W. H. and Holmes, H. B. 1929. Experiments in marking young chinook salmon on the Columbia River, 1916-1927. US Bureau of Fisheries Bulletin 44, pages 215-264.
Abstract: Report on the marking experiments of the US Bureau of Fisheries during an 11 year period. Provides the methods, procedures and results for various marking experiments conducted at Bonneville, Klaskanie, Little White Salmon, Herman Creek, and Big White Salmon hatcheries. Purpose of marking experiments was to test relative efficiencies of various artificial propagation procedures, and to determine life history strategies of salmon. Provides extensive morphometric information (fish scale, body weight, body length, age etc.) for chinook salmon. Conclusions on experiments are categorized as Percentage of Returns, Success of Long and Short Term Periods of Rearing, Interpretation of Scale, Time of Entering Freshwater, Age at Maturity, and Homing Instinct.

Rutter, C. 1902. Natural history of the quinnat salmon. Bulletin US Bureau of Fisheries, pages 65-141.
Abstract: Author provides a comprehensive treatment of the life history of chinook salmon in the Sacramento River basin. Extensive life history and behavioral information of young chinook salmon are provided Hatchery plantings of chinook are observed during their freshwater residency, and evalution of adult returns of these plantings are evaluated.

Scheufele, Roy W. 1970. History of the Columbia Basin Inter-Agency Committee. Prepared under sponsorship of the Pacific Northwest River Basins Committee.
Abstract: A. Author presents a comprehensive details regarding the genesis, policy & objectives, actions, and chronology of meeting/events for the Columbia Basin Inter-Agency Committee, during the period of 1946-1967. Provides information regarding governmental legislation (laws) and policy framework, institutional relationships with other state and federal agencies in the Columbia basin, and accomplishments of the agency. NOTE: Reference is very important in terms of its description of policy and philosophy governing water and fisheries policy in the Columbia River basin during the period of 1946-1967. B. Genesis of Agency and Federal Action (pages 3-9): 1) In 1902, the US Congress passes the Reclamation Act; 2) In 1905, the US Congress establishes the US Forest Service; 3) In 1920, the US Congress passes the Federal Power Act; 4) In 1925, the US Congress passes a statute that directed the inventory of those streams in the US where power development appeared feasible and practical in coombination with navigation, flood control, and irrigation; 5) In 1927, the US Congress passes the River and Harbor Act, which commenced the survey of Pacific Northwest streams, that were inventoried under the 1925 congressional statute; 6) In 1936, the US Congress passes the Flood Control Act; 7) In 1936 (?) the US Congress establishes the US Soils Conservation Service; 8) In 1943, the Pacific Northwest Regional Planning Commission, an arm of the National Resources Planning Board, is abolished by the US Congress; 9) In July 1943, the governors of the Pacific Northwest States establish the Northwest States' Development Association to coordinate and correlate plans of member states as they relate to unified development of all the resources of the Pacific Northwest; 10) In December 1943, the Northwest States' Development Association prepares a program and governing principles of emergency and immediate post-war projects for the development of the Columbia Drainage Basin; 11) In summer 1939, the US Departments of Interior, Agriculture, and War (Corps of Engineers) enter a tripartitie agreement to coordinate their work, both in Washington DC and field regions; 12) In December 1943, the US Federal Power Commission joins the tripartite of the US Departments of Interior, Agriculture, and War (Corps of Engineers), and execute a quadpartite agreement that provided monthly meetings of these agencies to discuss restuls of studies/investigations, to adjust differences of opinions, and to promote ways/means for implementing other provisions of the agreement-representatives of these four Departments constituted the Federal Inter-Agency River Basin Commission (FIABRC); 13) In February 1946, the Columbia Basin Inter-Agency Committee, the second field committee of Federal Inter-Agency River Basin Commission, is established to facilitate progress on the multipurpose development projects presetnly authorized by congress (p. 7-9 provides details of conditions of the agreement.); 14) In 1965, the US Congress passes the Water Resources Planning Act; 15) In June 1967, the Pacific River Basins Commission takes over the functions of the Columbia Basin Inter-Agency Committee. C. A chonicle of agency meetings and general outcomes from these meetings is presented (pages 10-123) 1) In March 1947, the Assistant Secretary of Interior (Warner W. Gardner) sends a memorandum/recommendations to the Federal Inter-Agency River Basin Commission (FIABRC) that propose the construction of mainstem dams on the Columbia below Okanogan R. and on the Snake below the Salmon R., with the exception of the proposed McNary Dam, be postponed until 1958 (for 10 years) provided that alternate sources of power could be devloped to meet Bonneville Power Administration load demands; this moratorium period would allow the US Fish & Wildlife Service and state fisheries agencies to determine remedial measures (per research, studies, and planning) that could be taken to preserve the Columbia River fishery; p. 22-23); 2) On 2 April 1947, the Assistant Secretary of Interior (Warner W. Gardner) memorandum was forwarded by the Federal Inter-Agency River Basin Commission (FIABRC) to the Columbia Basin Inter-Agency Committee for study, discussion, and recommendations; 3) On 23 July 1947 at the 11th meeting of the columbia Basin Inter-Agency Committee, (a) Fred Foster (US Fish & Wildlife Service) outlined the Lower Columbia River Fishery Program, consisting of obstruction removal, pollution abatement, diversion screening, fishway construction, hatchery construciton and fish sanctuaries - a program estimated at a cost of $20 million, and (b) a Fish & Wildlife

subcommittee was established to coordinate and integrate fish and wildlife programs with water esource program; p. 25; 4) On 22 September 1947, the Fish & Wildlife Subcommittee (Columbia Basin Inter-Agency Committee) filed a report that summarized factual data relating to navigation, power, fish, irrigation, Indians, and National Defense, p. 26; 5) On 8 October 1947, at its 12 meeting, the columbia Basin Inter-Agency Committee unanimously approved and forwarded a letter to the Federal Inter-Agency river basin Commission (FIABRC) recommending that a) Grand Coulee power installations proceed, construction of Hungry Horse, Foster Creek, Detroit, and McNary Dam proceed, etc. b) authorized dams on the columbia River system not to be rescheduled, approval of the Lower Columbia River Fishery Program, and compensaiton of Treaty Indians, and c) upstream dams be authorized promptly and if authorized before 1958 they be constructed ahead of planned/unauthorized The Dalles, John Day and Arlington Dams unless the fish problem has been solved in the interim, etc., p. 26; 6) In 1950, the columbia Basin Inter-Agency Committee establishes the Fisheries Steering Committee, and this subcommittee prepares a comprehensive program of research and construction (to cost 25-50 million dollars) and proposed to finance it by a tax of fifty cents per kilowatt year (note proposal failed and caused an outcry from power interests) p. 27; 7) On 17 September 1948, at its 21st meeting, the Columbia Basin Inter-Agency Committee authorized a Technical Subcommittee for Operating Plan to prepare an integrated and coordinated operating plan for the release and control of waters in connection with Columbia River development program (note plan was never consummated) p. 32; 8) On 10 November 1948 at its 22nd meeting of the columbia Basin Inter-Agency Committee, the Corps of Engineers presented an eight volume "Review of the Columbia River and its Tributaries,: a report costing $5 million; p. 33; 9) On 28 June 1950 at its 40th meeting, the Columbia Basin Inter-Agency committee approved an interim fishery research program (prepared by the Fish & Wildlife Subcommittee) that called for studies of fish passage at river obstructions, impoundment studies, artificial propagation, and studies of life history, trends and abundance, trout habitat and pollution, at an estimated $600,000 per year - another $500,000 was included for stream development and improvement; p. 46; 10) On 19 January 1955, the Columbia Basin Inter-Agency Committee directed the Fisheries Steering Committee to a) prepare an Upper Columbia River fishery program comparable to that in effect on the Lower Columbia River, b) a program of needed fishery research for the whole area, and c) explore ways and means of implementing/financing both programs; p. 83; 1) On 13 March 1957, the Columbia Basin Inter-Agency Committee accepted the Fisheries Steering Committee report with respect to a) prepare an Upper Columbia River fishery program comparable to that in effect on the Lower Columbia River, and b) a program of needed fishery research for the whole area - established resarch priorities and recommendaitons as to what agency would carry out specific studies recommended; p. 91; 12) On 13-14 November 1963, the Columbia Basin Inter-Agency Committee heard a panel of University of Washington academicians (James Crutchfield, W.F. Royce, D. Bevan, Robert Fletcher, R.C. Van Cleave, and R.W. Johnson) carry on extensive dialogues on "Fisheries in the Pacific Northwest - the academicians view this controversial issue," Don Bevan was very critical of fishery regulation; p. 114; 13) On 14 December 1965 at the 132 meeting of the Columbia Basin Inter-Agency Committee, the Executive Subcommittee presented its recommendations on seven fishery proposals (previously submitted by the Fisheries Steering Committee on 6 October 1965) summarized as follows: Proposal 1 - Greater Committee representation for salmon and steelhead, Proposal 2 - Reduction of the use of the Columbia River water for nuclear production to reduce heat pollution of the river, Proposal 3 - Establishment of working contract with Canada on Fishery problem, Proposal 4 - Development of small watersheds for power production should be discontinued, Proposal 5 - Assure proper attention to fish requirements in any inter-basin water transfer studies, Proposal 6 - Fishery research should be continued, the Proposal 7 - The Columbia River Fishery Development program should be retained; 14) On 29 September 1966 at its second Columbia-North Pacific study review, the Columbia Basin Inter-Agency Committee accepted the report of the Water Supply and Pollution Subcommittee entitled "Columbia River - Water Temperature Conditions and Research Requirements" report stemmed from one of the seven fishery proposals (previously submitted by the Fisheries Steering

committee on 6 October 1965; p. 21); (15) On 9 June 1967, the Columbia Basin Inter-Agency committee held its last meeting, and handed over its responsiblities, function and records to the new River Basins Commission, p. 122.

Symons, Thomas W. 1882. Examination of Snake river from Lewiston to the mouth of Salmon river, Idaho 47th Congress, 1st Session, Senate Executive Document No. 112: U.S. Senate,
Abstract: Author provides a survey report describing the Snake river from *Lewiston (Idaho) to the mouth of the Salmon river*; report includes information describing the river channel (slope, width, obstructions) and lands peripheral to the river. Includes survey maps of various river reaches that present problems/obstacles to water navigation.

Taylor, Harry. 1898. Survey of Snake river, Washington, from its mouth to Riparia 55th Congress, 2nd Session, House Document No. 411: U.S. House of Representatives,
Abstract: Author provides a survey report describing the Snake river from *its mouth to Riparia*; report includes information describing the river channel (slope, width, obstructions) and lands peripheral to the river. Includes survey maps of various river reaches that present problems/obstacles to water navigation.

United States. Army Corps of Engineers. 1947. Columbia river and tributaries review report, interim report no. 3, Hells Canyon, appendix A- hydrology U.S. Army Engineer District, Portland, Oregon.
Abstract: This report includes comprehensive information regarding the hydrological characteristics of the Snake river in the Hells Canyon area. Report includes general information describing the topography, uplands, plain, drainage area, tributaries, geology, soils, stream flow, etc. for this area of the Snake river.

United States. Army Corps of Engineers. 1974. Draft environmental statement of Lower Monumental lock and dam, Snake river, Washington U.S. Army Engineer District, Walla Walla, Washington.
Abstract: This draft environmental impact statement addresses the proposed Lower Monumental dam project. Includes information that describes the Lower Monumental project and the existing environment (terrestrial and water habitat/resources) in the area of the project; and describes the impacts of proposed project alternatives.

United States. Army Corps of Engineers. 1975. Draft environmental statement of Lower Granite project, Snake river, Washington U.S. Army Engineer District, Walla Walla, Washington.
Abstract: This draft environmental impact statement addresses the proposed Lower Granite dam project. Includes information that describes the Lower Granite project and the existing environment (terrestrial and water habitat/resources) in the area of the project; and describes the impacts of proposed project alternatives.

United States. Army Corps of Engineers. 1975. Draft environmental statement of lower Snake river fish and wildlife compensation U.S. Army Engineer District, Walla Walla, Washington. 1, I-4, 46-47, 70-106, maps p.
Abstract: This draft environmental impact statement addresses proposed actions to compensate fish and wildlife losses resulting from four multi-purpose water resources development projects on the lower Snake river. Includes information that describes the existing environment (terrestrial and water habitat/resources) in the area of the project; and describes the impacts of proposed project alternatives.

United States. Army Corps of Engineers. 1979. Final environmental statement of Ice Harbor lock

and dam, Snake river, Washington U.S. Army Engineer District, Walla Walla, Washington. 1,11, 2(1)-2(19), 2(33)-2(36) p.
Abstract: This draft environmental impact statement addresses the proposed Ice Harbor dam project. Includes information that describes the Ice Harbor project and the existing environment (terrestrial and water habitat/resources) in the area of the project; and describes the impacts of proposed project alternatives.

United States. Army Corps of Engineers and Department of Commerce. 1994. (Draft environmental statement.). Lower Snake river biological drawdown test.
Abstract: This draft environmental impact statement addresses a proposed biological drawdown test to be conducted a Lower Granite Reservoir, possibly as early as 1995. Include information describing the Lower Granite project and the existing environment (terrestrial and water habitat/resources) in the area of the project.

United States. Commissioner of Fish and Fisheries. 1894. Report of the Commissioner of Fish and Fisheries on investigations in the Columbia river basin in regard to the salmon fisheries. 53 rd Congress, 2nd Session Senate Miscellaneous Document No. 200. Government Printing Office, Washington. 3-57, figures, maps p.
Abstract: Document contains three reports:
1) "The salmon fisheries of the Columbia river basin" by Marshall McDonald; this report discusses (a) conditions determining the salmon production of a river basin, (b) the limits of migration of salmon, (c) decrease of salmon in the head waters of the Columbia river, (d) detailed statistics of the salmon industry of the Columbia river, 1889-92, (e) artificial propagation of salmon on the Columbia river, (f) the fishing grounds, and (g) the fishing season.
2) "A report upon investigations in the Columbia river basin, with descriptions of four new specie" by C. H. Gilbert and B.W. Barton; this report generally describes salmon resources in terms of their status, biology and distribution in the mainstem and tributaries of the lower Columbia, upper Columbia and Snake rivers.
3) "Notes on Willamson's whitefish in breeding color, from Little Spokane river, Washington, and remarks on the distribution of the species" by B. A. Bean.
Document includes photographs for sections of the Little Spokane river and the Kettle Falls of the upper Columbia river; also includes a plan view maps of the Columbia river from Ceilo Falls to the mouth.

US Army. 1897. Report of the chief of engineers 1897 in six parts. Annual Reports, War Department, Fiscal Year Ended June 30, 1897. (Annual report).Government Printing Office, Washington. 3456-3463 p.
Abstract: The reference contains comprehensive information regarding projects and activities related to the channelization, diking, and channel/bank maintenance of the mouth, estuarine, tidal river zones of the Columbia and Willamette rivers and other tributaries thereof (e.g. Clatskanie, Cowlitz, Lewis, Skamokawa, Grays, and Deep). Includes information regarding original and existing conditions of the river section/surrounding area (may be relative to habitat conditions) and notes commerce & development activities of adjacent area.The following estuarine/tidal river zone (of the lower Columbia region) and associated activities information (e.g. surveys, project history, costs & results, etc.) are covered:
(1) Mouth of Columbia river-Part 1, p. 502-503, Part 4, p. 3404-3406;
(2) Columbia and Willamette rivers below Portland, OR- Part 1, p. 503, Part 4, p. 3407-3414;
(3) Columbia river between Vancouver, WA and mouth of Willamette river-Part 1, p. 504, Part 4, p. 3414-3416.
(4) Cowlitz river- Part 1, p. 520, Part 4, p. 3463-3465;
(5) Young's and Klasskuine rivers-Part 1, p. 466, Part 5, p.3595-3596 (removal of snags and

overhanging trees);
(6) Clatskanie river, from mouth to town of Clatskanie-Part 1, p. 467, Part 4, p. 3596-3598;
(7) Lewis river (survey)-Part 1, p. 523, Part 4, p. 3469-3478; and
(8) South channel of Columbia river (in front of Astoria, OR-Part 1, p. 468, Part 4, p. 3406-3407. General description of attributes for the Snake river in the vicinity of Wild Goose Island (~74 miles above the Snake river mouth)- human alterations. General description of attributes for the Snake river in the vicinity of Log Island (~38 miles below Lewiston, ID)- human alterations.

US Department of Commerce. 1921. Results of salmon marking experiments. Fisheries Service Bulletin No. 72, Bureau of Fisheries, US Department of Commerce, Washington DC, May 2, 1921.
Abstract: Notes a report of Willis H. Rich, entitled "Returns from experimentation on the marking of young chinook salmon on the Columbia River," Mentions that experiments 1) corroborate the theory that the arrangement of the scale circuli provides an accurate record of the previous life history of fish, 2) contributes to the knowledge of the biology of salmons as it relates to the hereditary character of the factors determining adult run entry into freshwater and upward migration to spawning grounds, and 3) provides evidence that spring run progeny produce spring run returns, and fall run produce fall run returns., p.3.

US Department of Commerce. 1923. Notes from the division of fish culture. Fisheries Service Bulletin No. 97, Bureau of Fisheries, US Department of Commerce, Washington DC, June 1, 1923.
Abstract: Mentions a recently published US Bureau of Fisheries pamphlet "The Story of the Salmon" that briefly discusses the salmon life history, development of the salmon canning industry, the growing depletion of salmon runs in Alaska and the Pacific Coast States, the need for conservation, and methods that have been adopted to preserve salmon runs, p. 5.

US Department of Commerce. 1929. Treaty in regard to the sockeye salmon fisheries. Fisheries Service Bulletin No. 167, Bureau of Fisheries, US Department of Commerce, Washington DC, April 1, 1929.
Abstract: Notes the signing of a treaty for the preservation and extension of the sockeye salmon fisheries of the Fraser River system; the treaty provides for the establishment of an International Fisheries Commission. The Commission was in charge of making a thorough investigation into the life history of sockeye salmon, was given the power to maintain and develop hatcheries and to develop the fisheries, and to regulate the sockeye salmon fisheries, p.1.

Ward, H. B. 1939. The migration and conservation of salmon. Publication of the American Association of Advanced Sciences 8: 60-71.
Abstract: Author discusses habitat influences on behavior of salmonid fishes; emphasizes that habitats are not static, and that it is important to understand environmental factors that modify behaviors. Makes continous references to efects of temperature on behavior patterns and outcomes. (Pertinent to life history strategies paper.)

Ward, H. B. 1939. Salmon psychology. Journal Washington Academy of Science 29: 1-14.
Abstract: Author's early studies were focused how far and in what way the activities of Pacific salmon in freshwater were determined or modified by external factors; and the correlation of external factors with environmental conditions and the life of fish. Discussion on stimuli/factors (stream current, water temperature, etc.) affecting migratory behavior of adult and juvenile sockeye salmon; notes racial differences in temperature tolerance (minimum, maximum and optimum) Mentions removal of perceived objectionable feature in Sulfur Creek that made the stream less turbid and colder that caused salmon to select another stream. This reference illustrates life history strategies and associated race/stocks.

Wilkes, Charles. 1856. Narrative of the United States expedition. During the years 1838, 1839, 1840,

1841, 1842. By Charles Wilkes, USN. Commander of the expedition, member of the american philosphical society, etc. In five volumes, with thirteen maps. Vol IV. G.P. Putnam & Co., 321 Broadway, New York. 1-4 (notes on work) p.
Abstract: Author provides an account of his experiences and observations during his travels in the Columbia river basin; notes habitat/landscapes, fauna, flora of various reach sections of the Columbia river and tributaries.

PRODUCTIVITY

Reference List

Anderson, George C. 1963. Columbia river effluent in the northeast Pacific ocean, 1961, 1962: selected aspects of phytoplankton distribution and production. Univ. of Washington, Dept. of Oceanogr., Tech. Rep. No. 96. 77 p.
Abstract: Author describes the distribution of chlorophyll a and phytoplankton productivity of the Washington and Oregon coasts, during 1961-1962, with respect to the surface waters in the area covered by the Columbia river effluent. Notes that these surface waters (Columbia river effluent area) generally contain more phytoplankton and had a higher rate of photosynthesis than ambient waters. Describes the rate of productivity and standing crop for phytoplankton on a seasonal basis. Reference contains figures illustrating hydrography of Columbia river effluent off the Washington-Oregon coast, nutrient chemistry, and seasonal distribution and annual production of chlorophyll a and primary production.

Dahm, C. N., Gregory, S. V., and Park, P. K. 1981. Organic carbon transport in the Columbia River. Est. Coast. Shelf Sci. 13: 645-658.
Abstract: Authors discuss the monthly measurements of total organic carbon (TOC) and dissolved organic carbon (DOC) in the Columbia river, based on sampling behind the Bonneville dam spillway and at Kalama, Washington (128 km above the mouth) during May 1973 - December 1974. They estimate total, dissolved and particulate organic carbon output from the Columbia river into the northeastern Pacific ocean. Discuss diel and monthly variations in TOC and DOC, and their correlations with oxygen saturation and river discharge. Correlate particulate organic carbon (POC) with instream primary productivity per pH and oxygen saturation.

Ebel, W. J., Becker, C. D., Mullan, J. W., and Raymond, H. L. 1986. The Columbia River-Towards a holistic understanding. Proceedings of the International Large River Symposium, Can. Spec. Publ. Aquat. Sci 106: 205-219.
Abstract: Authors provide synopses of the Morphometry, Hydrology, Mainstem Flow Regimes, Sedimentation, Water Quality, Mainstem Temperatures, Productive Potential, Primary Production, Zooplankton, Secondary Production, General Productivity, Fish Species/Salmonid Resources & Fisheries of the Columbia River basin. They briefly discuss and provide a historical perspective of the Regional Exploitation and Development of fisheries and water resources of the Columbia river, and associated fish problems and mitigation strategies. Also discuss Institutional Arrangements in the Columbia basin per federal legislation. Brief notes of sedimentation and sediment load in the Columbia river estuary and adjacent ocean waters- p. 208

Fleming, Richard H. 1955. Review of the oceanography of the northern Pacific. International North Pacific Fisheries Commission Bulletin No. 2. International North Pacific Fisheries Commission, Vancouver, B.C. 1-43 (complete) p.
Abstract: Author provides comprehensive information regarding the northern Pacific Ocean in terms of (1) Characteristics of natural regions; (2) Description of area- bathymetry and bottom sediments;

(3) Climatogy- winds, precipitation, sea ice, comparisons to Atlantic; (4) Water descriptions- surface temperatures & salinities, comparisons with Atlantic, vertical circulation, thickness of mixed layers, and distribution of phosphate; (5) Water movements, (6) Factors affecting productivity, (7) Longterm temperature trends; (8) State of knowledge, (9) Comprehensive bibliography, (10) Illustrative figures. Figure 20 illustrates the range of major oceanographic expeditions conducted in the northern Pacific Ocean- Challenger (1872-1876), Albatross (1882-1905), Shintoku Maru (1924, 1930-1933), International Fish Commission (1927, 1928, 1929), Bushell (August 19340 etc. Note: Excellent reference.

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Abstract: Author presents an examination, information and illustrations of the seasonal and spatial characteristics for the physical, biological, chemical and cultural processes governing the concentrations of nutrients, dissolved oxygen, suspended particulate matter and pollutants in the Columbia river, its estuary, and the adjacent ocean waters. This presentation includes the following categories:
A. Chemical budgets of the Columbia river, in terms of (1) Sources of variability, (2) Limiting factors in primary productivity, and (3) Nutrient ratios and limiting factors;
B. Mixing of water masses and the spatial distribution of nutrients and particular matter, in terms of (1) Water mass analysis, (2) Mixing processes at the mouth of the Columbia river, (3) Nutrient distribution, transport and utilization, and (4) Cycling of particulate organic matter; and
C. Water quality, in terms of (1) Water quality management in Washington & Oregon, and (2) Municipal and industrial waste.

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Oregon State. 1951. Biennial report of the Fish Commission of the State of Oregon to the governor and forty-sixth legislative assembly, 1951. Fish Commission of the State of Oregon; Salem, Oregon, State Printing Office, 1951.
Abstract: Notes that (1) Fish commission has particular interest in the study of logging effects on salmon production, page 3. (2) On June 1948, the states of Oregon, Washington, and Idaho, and Federal Government (Fish & Wildlife Service, Department of Interior) consummated agreement of the provision of funds for the rehabilitation of the lower tributaries of the Columbia River, under the Lower Columbia River Salmon Rehabilitation Program, page 10. (3) A fishway is installed at a diversion dam (owned by the Vancouver Plywood Company) on Rock, a tributary of the North Santiam River, this reopened considerable area for steelhead spawning. page 12. (4) A new concrete fishway is constructed at the Powerdale Dam (owned by Pacific Power and Light Company) on the Hood River, page 13. (5) A fish screening and by-pass system is completed in the Marmot Dam Canal (Marmot Dam project, owned by Portland General Electric Company) on the Sandy River, page 13. (6) Columbia River investigations are studying five different problems; (a) extension of reduction in productivity of the Columbia River Basin by the encroachment of man, (b) harvest practices, stock timing/migration/distribution; (c) knowledge of growth and survival and limiting factors of young salmon in freshwater, (d) effect contemplated water development projects on Columbia River salmon, and (e) studies on sturgeon. page 15. (7) A need for the development of cheap and nutritional diets alternative to the liver based diets. page 18.

Rich, W. H. 1939. Local populations and migration in relation to the conservation of Pacific salmon in the western states and Alaska. Publication of the American Association of Advanced Science No. 8: 45. Migration and Conservation of Salmon.
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Abstract: Author reports on productivity of bottom fauna in Wenatchee River and its tributary Nason Creek. Notes that fish population in Wenatchee has increased 7 fold since 1939.

RUN SIZE

Reference List

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Abstract: Author provides a short synopsis of the Columbia River basin and its conflict between water users (dams and irrigation) and salmon fisheries resources; notes data regarding some Columbia River dam projects, number fish screen projects, and sockeye run size.

APPENDIX K-1

METHODS USED TO ANALYZE KEY ECOLOGICAL FUNCTIONS AND FUNCTIONAL REDUNDANCY OF WILDLIFE SPECIES.

This appendix describes the methods used to analyze key ecological functions (KEFs) and functional redundancy of wildlife species. At the time of this analysis, databases on habitats and KEFs of fish species were not yet developed but could be included in such analyses later.

INTRODUCTION AND DEFINITIONS

The analyses were conducted at the resolution of subwatersheds (6-HUC or hydrologic unit code level) and then summarized to the broader areas of provinces and the Columbia River Basin.

"Key ecological functions" refers to a classification of the major ecological roles played by each wildlife species (Marcot and Vander Heyden 2001), as coded in the Washington-Oregon Species Habitat Project (SHP) database (Johnson and O'Neil 2001). "Functional redundancy" refers to the number of wildlife species coded as sharing the same categories of KEFs (Brown 1995).

This analysis provides a basis for determining the potential array of KEFs present in a wildlife habitat, how those KEFs can change over time historically or under management alternatives, and how patterns of KEFs can vary geographically among wildlife habitats. The ecological basis for the analysis of functional redundancy is in the presumption that KEFs with higher levels of functional redundancy can be more resilient or resistant to changes in the environment (Jaksic et al. 1996), and that, overall, systems with greater average functional redundancy will be more diverse and functionally stable over time (Naeem 1998, Rastetter et al. 1999, Walker 1992, MacNally 1995, Peterson et al. 1998). Such assertions have not been well studied for the wildlife communities of the Columbia River Basin, so analyses of KEFs and functional redundancy should be taken as testable, working hypotheses of effects on ecosystem diversity, productivity, and resilience.

ANALYSIS METHODS

Methods are presented here using an example subwatershed to illustrate the procedure. The example subwatershed is 6-HUC 170601040901, located in the Upper Grande Ronde subbasin (4-HUC), in the Blue Mountains Province.

Step 1. Map wildlife habitats and calculate area and proportion within the subwatershed.

Northwest Habitat Institute produced GIS maps and data tables that display the types and areas of wildlife habitats for this subwatershed at historic and current time periods (Fig. K1, Table K1). (Wildlife habitat was also mapped at future time periods under management alternatives, but for purpose of this example we discuss only historic and current; analyses are the same.)

Data on acres of each wildlife habitat type for each time period was converted to proportions (Table K1); these will become the weighting factors for functional redundancy values.

Step 2. Determine functional redundancy by wildlife habitat.

In this step, the SHP database is queried to first list all wildlife species associated with each of the wildlife habitats that occur in the subwatershed, at each time period. The query is then linked to their KEFs so that a list of all KEF categories for all species in each wildlife habitat is produced. Next, the number of wildlife species is counted for each KEF category, in each wildlife habitat. This is a measure of functional redundancy for each KEF category, for each wildlife habitat. In practice, all this can be done simply in a single relational database query.

Two minor twists to this procedure were necessary for this specific subwatershed. (1) The wildlife habitat type "regenerating forests" is an additional habitat type created for these maps that does not appear in the original SHP list of wildlife habitats. Regenerating forests pertains to early successional stages resulting strictly from timber harvesting (mostly clearcutting) of what would otherwise be mapped as forested habitats. For this example, we cross-indexed the specific SHP wildlife habitat type represented by the "regenerating forest" category, with SHP structural condition classes representing early, post-harvest successional stages. (2) This subwatershed contains the "agriculture" wildlife habitat type. The SHP database codes for wildlife species associated with the agriculture wildlife habitat type presume the occurrence of many other native wildlife habitats adjacent to, or included within, the agricultural type. We felt this greatly overstated the wildlife species richness associated purely with agricultural conditions, so we narrowed the query of wildlife species associated with agriculture by specifying the specific structural conditions of agriculture found in this particular subwatershed, that is, "unimproved pasture" and "improved pasture." In addition, we included wildlife species only if they were "closely associated" with the agriculture type. This narrowed the field from 342 wildlife species to just over a hundred, which is far more reasonable given other experience in the interior Columbia River Basin.

With these minor tweaks, we listed the number of wildlife species associated with each KEF category, for each wildlife habitat type (Table K2).

Step 3. Account for proportion of wildlife habitats within the subwatershed.

This does not complete the process, because the amounts and proportions of each wildlife habitat type differ among types and over the time periods. To account for this, we then multiplied the (uncorrected, raw) values of functional redundancy for each KEF category for each pertinent wildlife habitat type (Table K2), by the percent of each wildlife habitat type in the subwatershed (Table K1), keeping these products separate for historic and current time periods. We called these products "weighted redundancy values." This is an interim step only and does not have any specific ecological meaning.

For example, the raw functional redundancy value for KEF category 1.1.1 (the key ecological function category "Primary consumer") in the Eastside Mixed Conifer Forest wildlife habitat type, is 121 wildlife species (Table K2). The historic proportion of this wildlife habitat type in the example subwatershed is 0.058 (Table K1). Multiplying these values gives 121 x 0.058 = 7.1. This is the weighted redundancy value for this wildlife habitat type in this subwatershed, for this particular time period. Such calculations were done for all other wildlife habitat types in this subwatershed, and then carried into the next step.

We next summed the weighted redundancy values across all wildlife habitat types for each KEF category, again separately for historic and current conditions. This resulted in what we called the "**summed weighted redundancy values** across all habitats" within the subwatershed for historic and current time periods, for each category KEF. This is the final result of functional redundancy for each KEF category across all wildlife habitats within a subwatershed.

Following the above calculation example, the summed weighted redundancy values for KEF category 1.1.1 in the example watershed was 101 for the historic time period and 97 for the current time period. These values are the area-averaged number of wildlife species associated with this KEF category, across all wildlife habitats present in this watershed at each time period.

Using another example, KEF 3.6.3 (the key ecological function category of "creates aquatic structures potentially used by other species") had summed weighted redundancy values across all wildlife habitats of 0.2 for the historic period and 2.9 for the current period. The value increased from historic to current periods because this particular KEF is associated with open water and herbaceous wetlands, which were introduced, created, or at least newly mapped since historic times (according to the NHI database for this HUC; however, there may also be a mapping resolution or representation problem of not correctly showing open water and herbaceous wetland types under historic conditions, but this was not a problem for most terrestrial, upland wildlife habitat types).

Further, we calculated the rate of change of the summed weighted redundancy values between time periods. For historic and current periods, this is calculated as [(current - historic)/historic]. For example, for KEF 3.6.3, the change from 0.2 to 2.9 was calculated as (2.9-0.2)/0.2 = 13.5. This means that the summed weighted functional redundancy for KEF 3.6.3 increased by a factor of 13.5 (or 1,350 %) from historic to current conditions. In contrast, KEF 1.1.1 changed by (97-101)/101 = -0.04, that is, decreased by a factor of 0.04 (or 4 percent). Comparing time periods in this way aided identifying which KEFs increased or decreased the most.

We also averaged the summed weighted functional redundancy values, across all KEF categories, by adding the values across KEF categories and dividing by the number of KEF categories. This provided a value representing the **mean functional redundancy** (number of wildlife species) across all KEF categories and wildlife habitat types, for each time period. In the example watershed, mean redundancy values were 22.2 wildlife species for the historic time period and 20.6 for the current. The value decreased, but probably not significantly so. Such mean functional redundancy values do not reveal which KEFs changed, however, so one would also want to inspect the KEF category-specific values and changes. Similar mean functional redundancy values compared across time periods or subwatersheds may still result for major shifts in KEF-specific values. Still, mean functional redundancy values may be useful to track when values vary substantially.

Step 4. Graph and summarize results.

We then created a series of graphs showing, variously, (a) changes in the wildlife habitats for this subwatershed (Figs. K2, K3), and (b) changes in the summed weighted functional redundancy values by KEF category (Figs. K4a, K4b), as well as (c) changes in **functional richness** (the total number of KEF categories present) and mean functional redundancy (weighted functional redundancy averaged over all KEF categories), for historic and current periods (Fig. K5).

Step 5. Tally across provinces and basin

The final step entailed summarizing results across all subwatersheds with a broader area, such as province and the entire Columbia River Basin. Graphs of such tallies depict the number of subwatersheds in which the temporal changes in the summed weighted functional redundancy values increased, decreased, or remained the same.

GIS maps of such changes were particularly useful for quickly identifying geographic areas with consistent and salient changes in KEF redundancy across time periods. For instance, results for the example subwatershed suggest a decline in functional redundancy of KEF 5.1, the key ecological function category of "potentially improving soil structure and aeration by digging" (Fig. K4b). But where, geographically, have such declines occurred? Mapping subwatershed-specific changes (Fig. K6) clearly shows major areas of decline of this function, namely Willamette Valley, Columbia Basin, and Snake River Basin (the example subwatershed in the Blue Mountains also shows up as having a major decline in this function). Such maps can be produced to compare other time periods (e.g., historic to future, or current to future), to compare outcomes of management alternatives at a given time period, or to compare changes in total functional diversity or mean functional richness.

RESULTS AND DISCUSSION

For the example subwatershed explored here, there are indeed changes from historic to current time periods in the specific KEF categories. However, at the broad geographic scope of the entire Columbia River Basin, total functional richness and mean functional redundancy (Fig. K5) seem resilient to changes in wildlife habitats. This not unexpected when values are averaged across all wildlife habitats and KEF categories.

However, this example linked wildlife species (and their KEFs) only to presence of the broad wildlife habitat types, and ignored the presence and influence of specific structural conditions of each widlife habitat, as well as specific key environmental correlates (the specific substrates and habitat elements) occurring within the wildlife habitats. Many of the KEF parameters explored here may be far more sensitive when all these factors are accounted for in the calculation steps presented here.

CAVEATS AND CONFERENCES

Some caveats and cautions need to be highlighted for this kind of analysis (also see Marcot and

Vander Heyden 2001). For example:

- KEF changes are scale-sensitive and -specific, being more robust and less sensitive the larger the area is considered (HUCs, provinces)

- The changes displayed in this example do not account for vegetation structural conditions (except for regenerating forest and agricultural land) and for specific key environmental correlates. Accounting for these conditions may greatly affect KEF analysis results, that is, the KEF categories, redundancy levels, functional richness, mean functional redundancy, mapped outcomes, and changes between time periods, may all become more sensitive.

- Because such habitat factors were not considered here, the calculated levels of functional redundancy in the example presented may seem misleadingly similar between historic and current periods. It may be more ecologically meaningful to stress the *percent change* across time periods (e.g., Figs. K4a, K4b).

SUMMARY

- "(Key) ecological functions" refers to the set of ecological roles played by (fish and) wildlife in their ecosystems. Such roles can influence the capacity of the ecosystem to support other species and are important new ways of tracking effects of land planning.

- Our analysis method can aptly display the trends in ecological functions across time periods, such as historic to current, and current to future under planning alternatives.

- The trends are shown as levels of "functional redundancy" which is the average number of wildlife species playing each functional role.

- Higher redundancy may mean more resilient and robust ecosystems.

- In general, ecosystems that have "all their marbles" – that is, with all the original ecological functions still present -- can be said to be "fully functional." Our analyses can help trace the degree to which ecosystems remain fully functional under each alternative.

- The example analysis presented in this appendix can be conducted at the subbasin (or other) scale. It is more meaningful to include structural conditions of wildlife habitats, as well as key environmental correlates, with the analyses.

- For the example subwatershed analyzed in this appendix, here are some sample ecological interpretations of results of such an analysis:

o This subwatershed has gained significant amounts of agricultural (pastureland) area, Pondersoa pine forest, and herbaceous wetland habitats, and has lost most of its shrub-steppe and all of its regenerating forest habitats, from historic to current times.

o Overall, this subwatershed has remained fully functional when averaged across all its habitats, although specific locations have drastically changed in wildlife habitat, associated wildlife species, and their associated ecological functions, within the subwatershed (such as within specific vegetation stands).

o Some of the ecological functions (examples only) of wildlife that have significantly increase since historic times are primary cavity excavation, secondary cavity use, fragmentation of standing wood, impounding of water, and creation of snags. These changes would favor species oriented around snags and tree cavities (e.g., small owls, swallows), down wood (some lizards, snakes), and water and wetlands (some waterfowl, amphibians).

o Some of the ecological functions of wildlife that have significantly declined since historic times are terrestrial burrow and runway excavation, soil turnover and aeration, and grazing alteration of vegetation structure. These changes would disfavor species oriented around terrestrial burrow use (e.g., some small mammals, lizards, others) and early successional shrub vegetation structures (some buntings, sparrows, flycatchers, and others), and may not provide as productive a soil ecosystem as occurred historically.

o It is possible, and easy, to determine which KEF categories have suffered declines, and the associated wildlife species, and thus the wildlife habitats, structural conditions, and key environmental correlates (specific habitat elements and substrates) that would be useful to highlight in a conservation or restoration program, if the objective is to provide for "fully functional" wildlife communities and ecosystems.

- And, finally, it is entirely feasible to integrate habitats and KEFs of fish into such analyses.

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Appendix K-2

Figure Captions

Fig K1. Historic and current distribution of wildlife habitats within an example subwatershed (6-HUC 170601040901) located in the Upper Grande Ronde subbasin, Blue Mountains province, in northeastern Oregon. Note the major change from shrub-steppe to agriculture and Ponderosa pine forest. Such change is typical for much of the interior Columbia Basin.

Fig. K2. Changes in area of wildlife habitats for the example subwatershed shown in Figure K1, from historic to current time periods. Note great decreases in shrub-steppe and increases in agriculture and Ponderosa pine forest types.

Fig. K3. Changes in area, highlighting differences in overall proportion, of wildlife habitats for the example subwatershed shown in Figure K1, from historic to current time periods. Although the information in this figure is redundant with that presented in Figure K2 and Table K1, it helps emphasize the proportional changes in wildlife habitats.

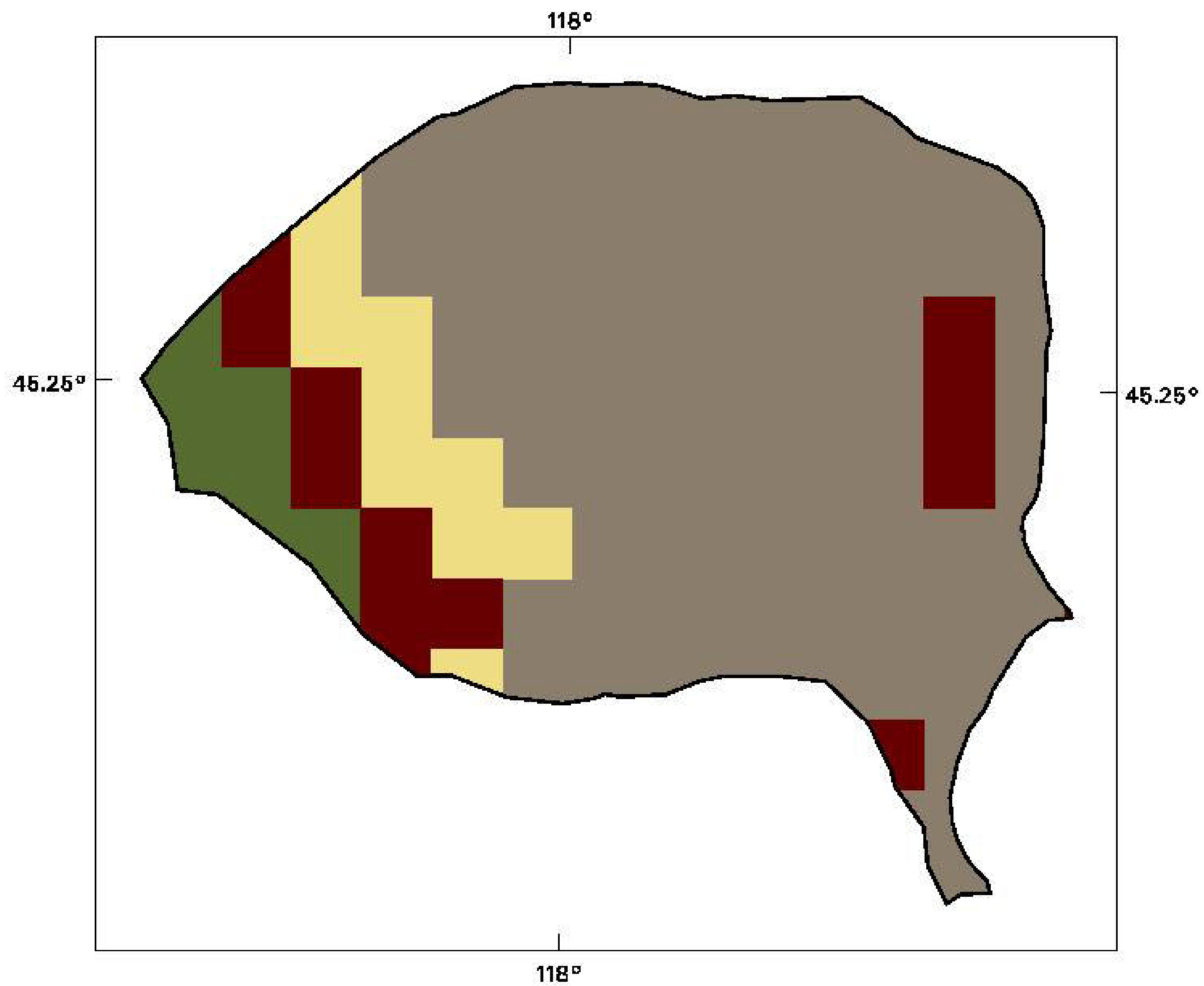
Figs. K4a, K4b. Changes in functional redundancy (summed weighted values as described in the Appendix K text) for selected categories of key ecological functions (KEFs), for the example subwatershed, comparing historic to current time periods. Note the great increase in functional redundancy (mean number of wildlife species across all wildlife habitats) of the KEF categories of primary cavity excavation, secondary cavity use, and creating snags. These increased because of the increase in Ponderosa pine forest within this subwatershed (Figs. K1, K2, K3), with which the wildlife species bearing these KEF categories are associated. Likewise, note the decline in other KEF categories borne by wildlife species associated with the shrub-steppe wildlife habitat, namely burrow excavation, burrow use, and potentially improving soil structure and aeration by digging. These KEFs declined because of the great decline in native shrub-steppe habitat within this subwatershed.

Fig. K5. Levels of functional richness and mean functional redundancy for the example watershed, at historic and current time periods. Note that values of these two parameters remained virtually unchanged, although redundancy levels of the specific categories of key ecological functions changed (Figs. K4a, K4b). This suggests that when these two parameters show little change, attention should still be placed on how redundancy of specific KEFs change.

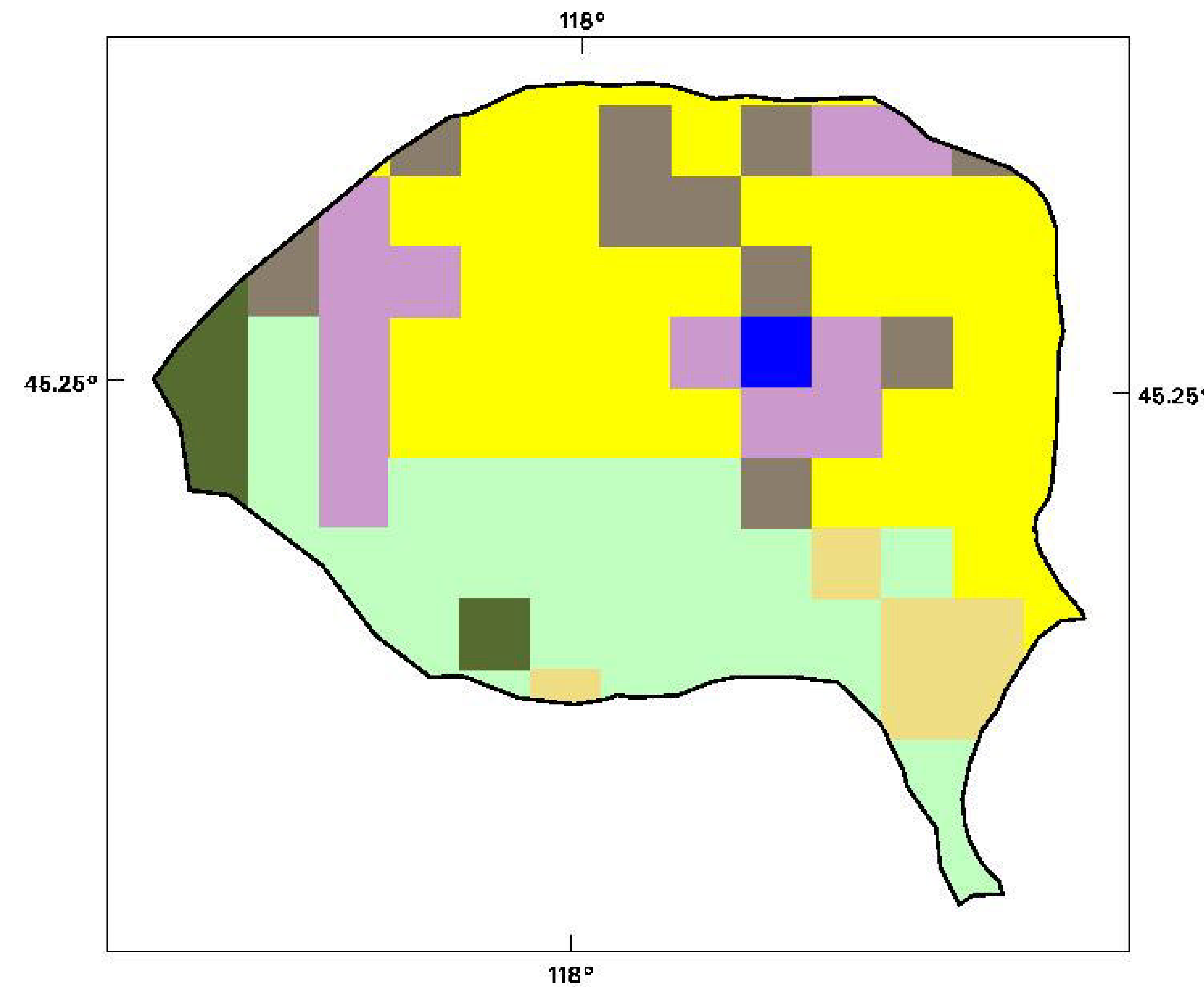
Fig. K6. GIS map showing changes in (summed weighted) functional redundancy of KEF category 5.1, "potentially improving soil structure and aeration by digging," comparing historic to current time periods. The map shows changes for each subwatershed, although it is best interpreted a broader scales, for instance, the major and consistent declines shown in the Willamette Valley, Columbia Basin, and Snake River Basin. Categories of changes are shaded by quartiles of subwatersheds with increases, decreases, or no change. For example, the greatest positive change represents the upper quartile (25% of all subwatersheds) with a positive change in functional redundancy values for this KEF; and this quartile represents an increase of 16.63% or greater in functional redundancy values.

WILDLIFE-HABITAT TYPES
Historic and Current
HUC 170601040901 - Blue Mountain Ecoprovince

HISTORIC



CURRENT



Northwest Power Planning Council www.nwppc.org

ACRES	HABITAT TYPE
1330	Interior Mixed Conifer
2193	Interior Grasslands
16750	Shrub-steppe
2547	Mountain Shrub and/or Regenerating Forest

ACRES	HABITAT TYPE
919	Interior Mixed Conifer
6214	Ponderosa Pine Dominant
1263	Interior Grasslands
2188	Shrub-steppe
9143	Agriculture, Pastures, and Mixed Environs
247	Open Water
2846	Herbaceous Wetlands

Northwest Habitat Institute www.nwhi.org

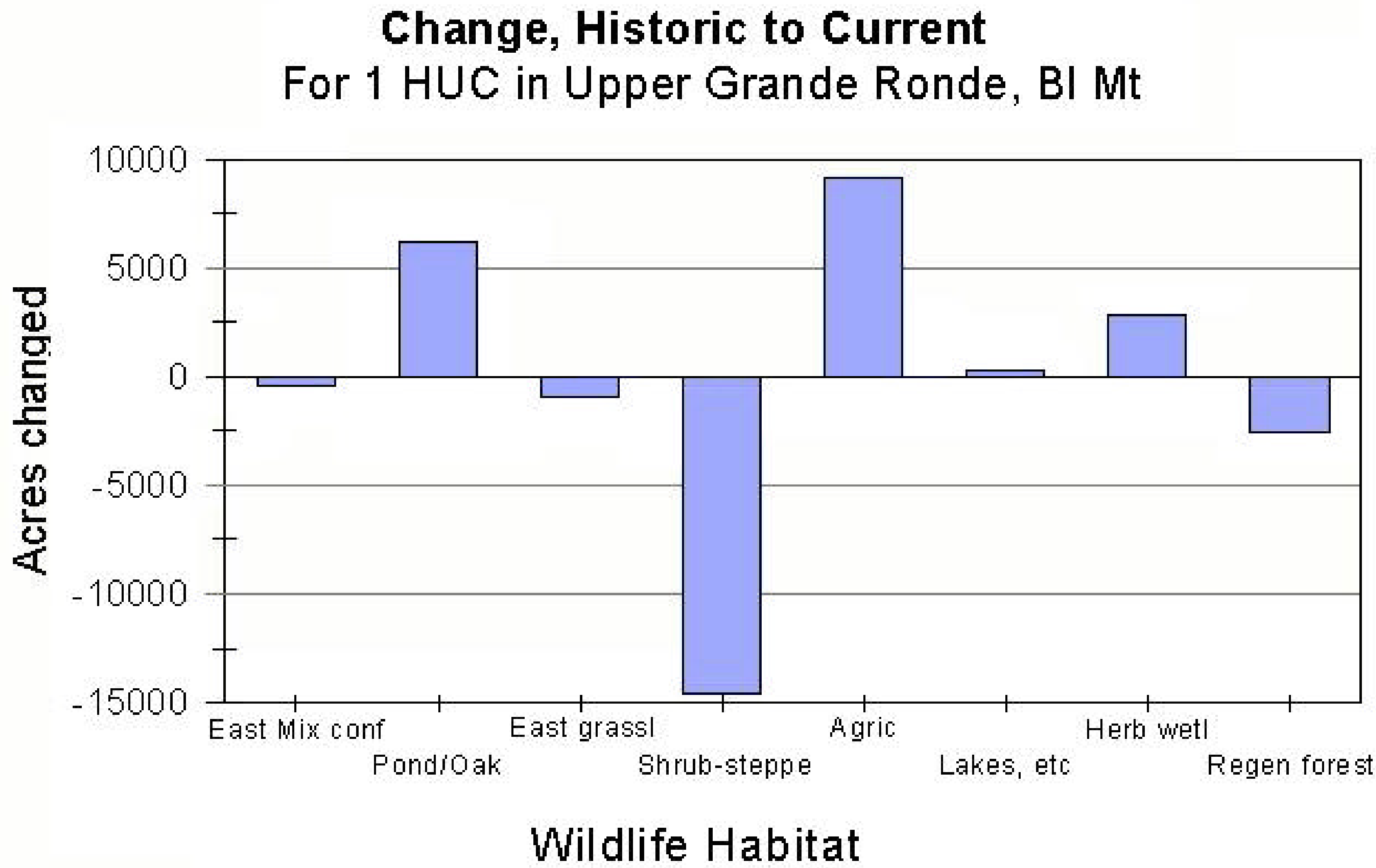
SCALE 1:90,000

1 inch represents 1.42 miles

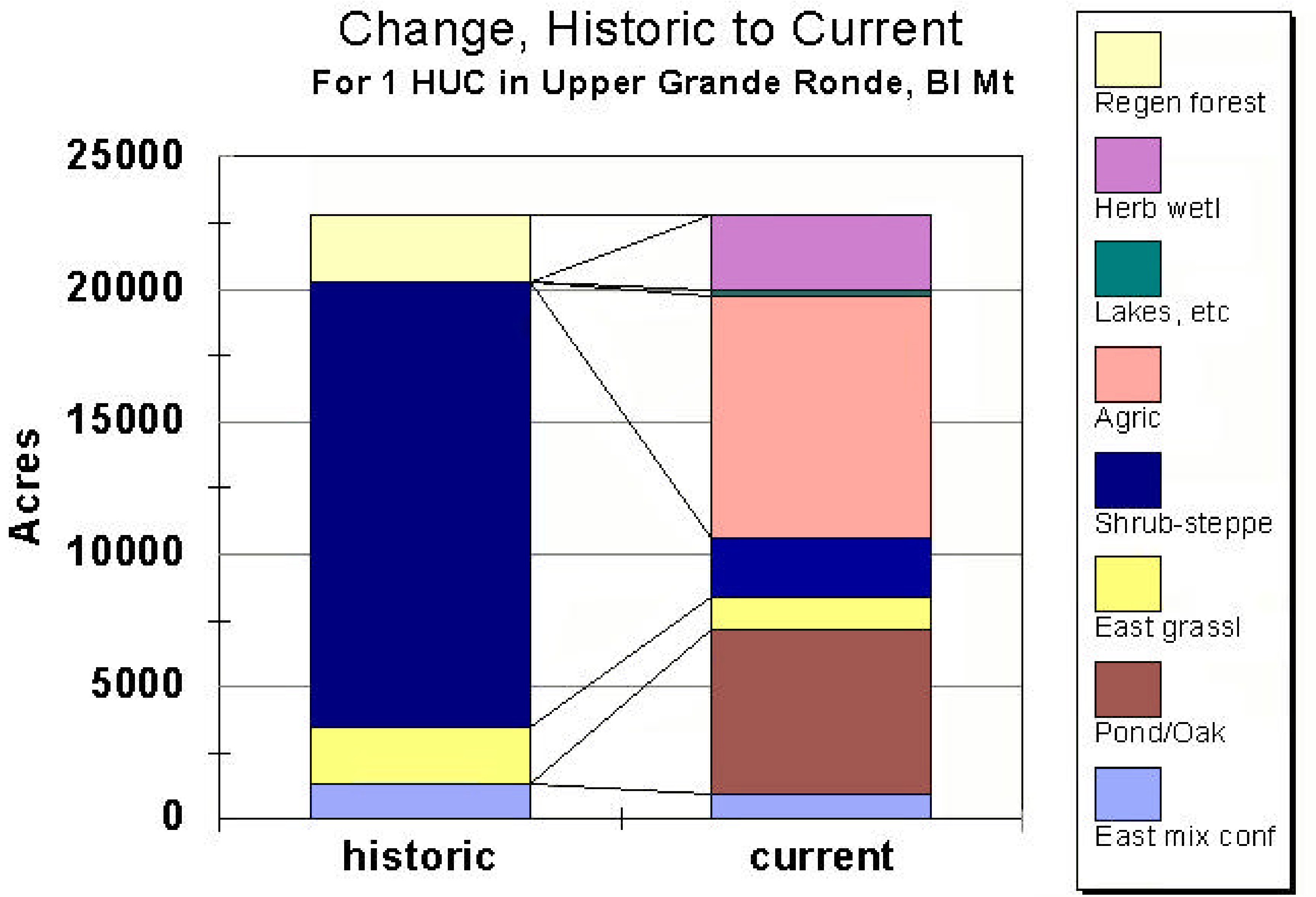
1 0 1 2 3 4 5

Miles

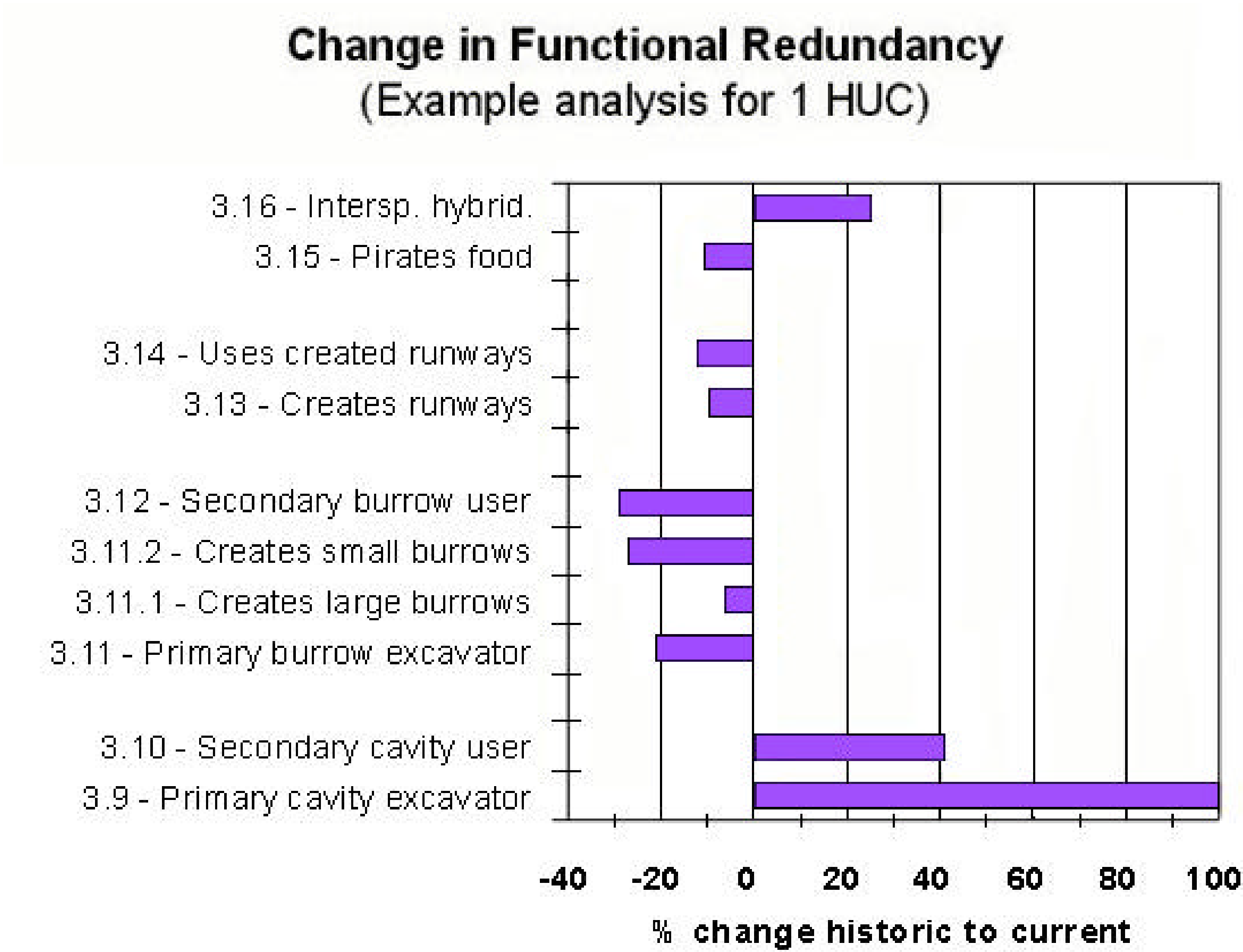
November 1999



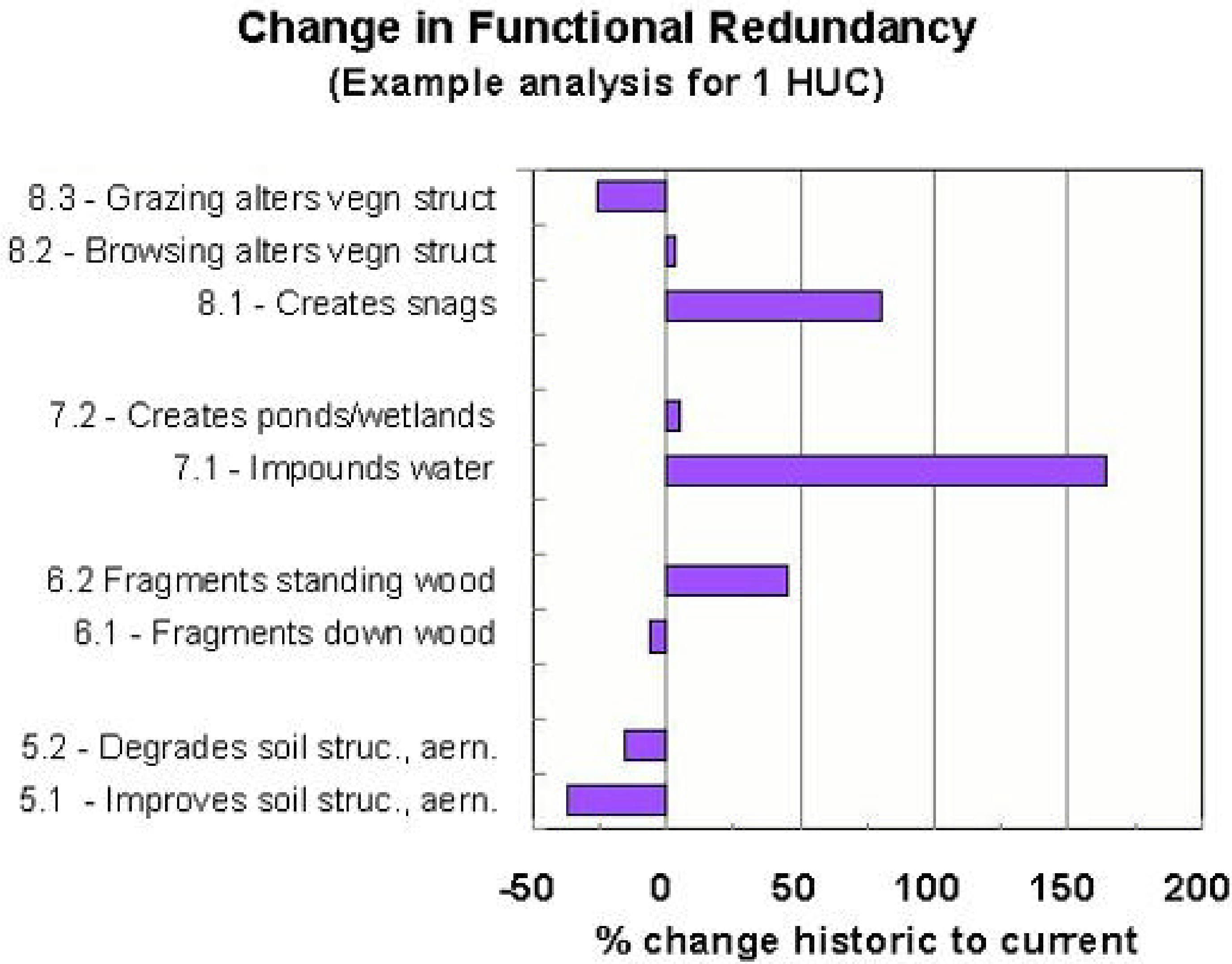
Appendix K - Figure K-2



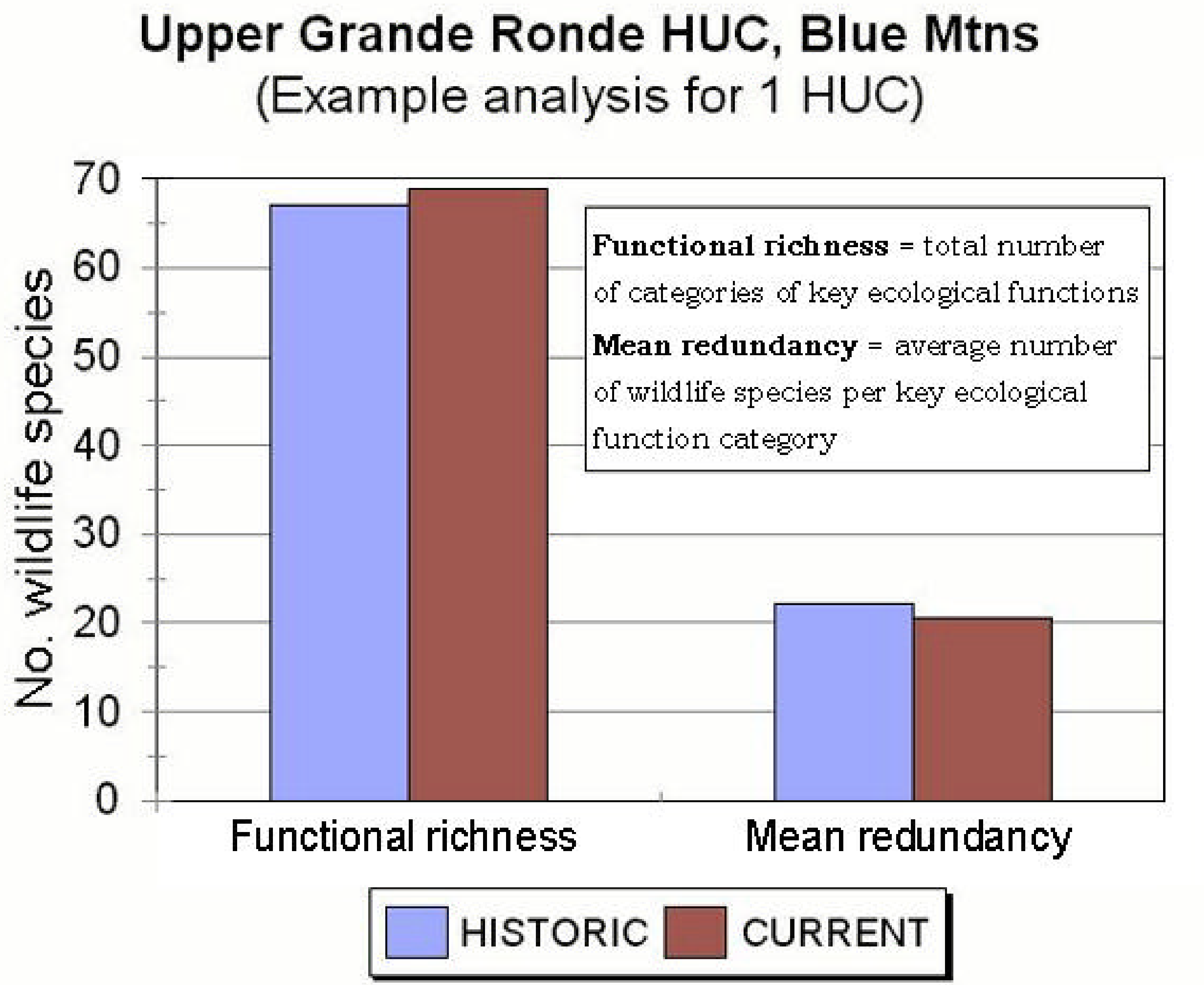
Appendix K - Figure K-3



Appendix K - Figure K-4a



Appendix K - Figure K-4b



Appendix K - Figure K-5

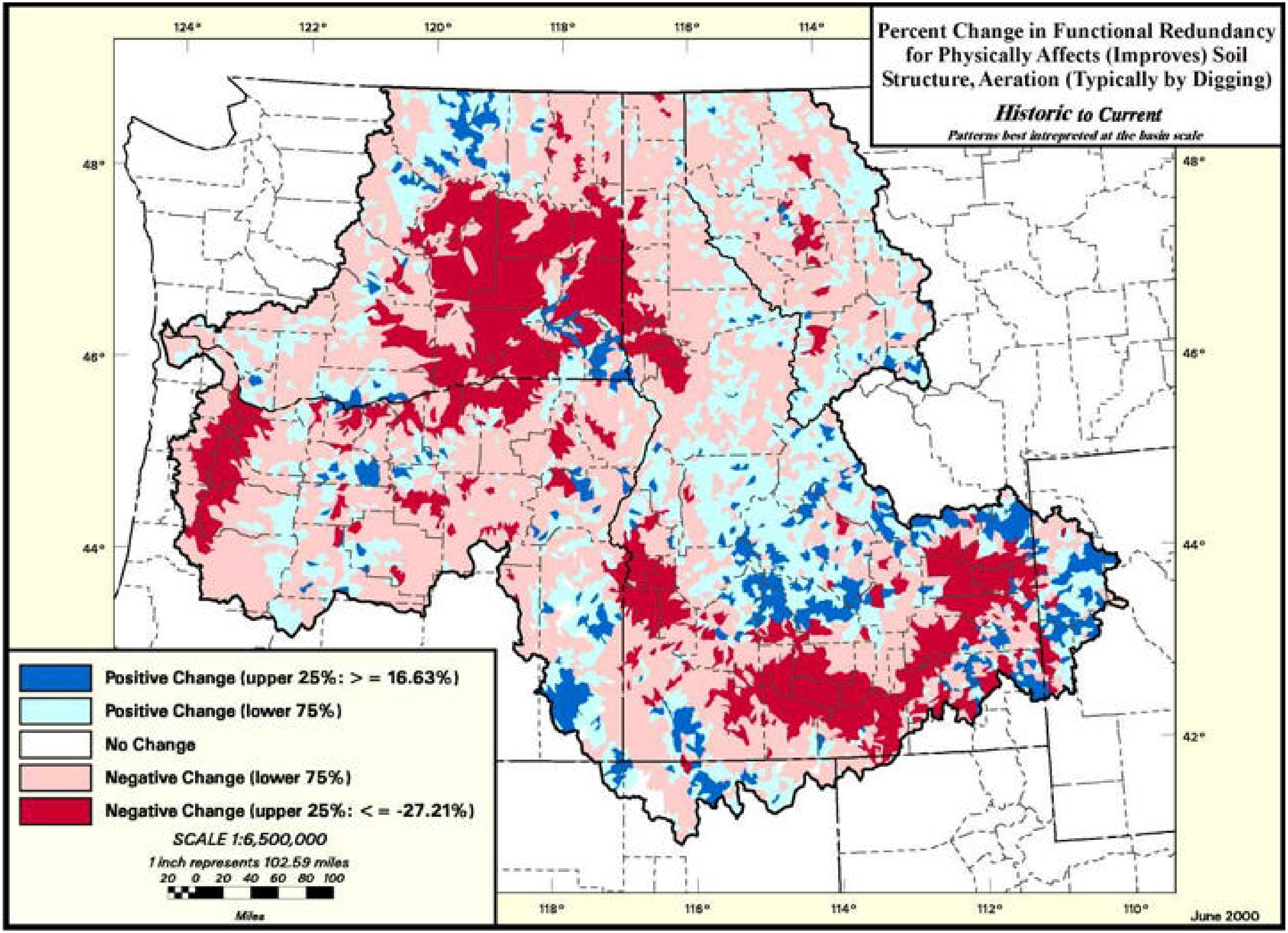

Percent Change in Functional Redundancy
for Physically Affects (Improves) Soil
Structure, Aeration (Typically by Digging)
Historic to Current
Patterns best intrepreted at the basin scale
124°
122°
120°
118°
116°
114°
48°
46°
44°
42°
112°
110°
Positive Change (upper 25%: > = 16.63%)
Positive Change (lower 75%)
No Change
Negative Change (lower 75%)
Negative Change (upper 25%: < = -27.21%)
SCALE 1:6,500,000
1 inch represents 102.59 miles
20 0 20 40 60 80 100
Miles
June 2000

Table K-1. Acres of historic and current wildlife habitat in the example subwatershed (6-HUC 170601040901) located in the Upper Grande Ronde subbasin, Blue Mountains province, in northeastern Oregon.

WILDLIFE HABITAT	Current acres	Current proportion	Historic acres	Historic proportion
Eastside Mixed Conifer Forest	919	0.040	1,330	0.058
Ponderosa Pine and Eastside White Oak Forests and Woodlands	6,214	0.272	0	0.000
Eastside Grasslands	1,263	0.055	2,193	0.096
Shrub-steppe	2,188	0.096	16,750	0.734
Agriculture, Pastures, and Mixed Environments	9,143	0.401	0	0.000
Lakes, Ponds, Reservoirs, and Rivers	247	0.011	0	0.000
Herbaceous Wetlands	2,846	0.125	0	0.000
Regenerating Forest	0	0.000	2,547	0.112
TOTAL:	*22,820*	*1.000*	*22,820*	*1.000*

Table K-2. Number of wildlife species (functional redundancy) by categories of key ecological functions (KEFs), found in wildlife habitats occurring within the example subwatershed (6-HUC 170601040901) located in the Upper Grande Ronde subbasin, Blue Mountains province, in northeastern Oregon. Source of species-KEF relations: Washington-Oregon Species-Habitat Relations database (Johnson and O'Neil 2001).

	WILDLIFE HABITAT TYPES \1							
KEY ECOLOGICAL FUNCTION	H5	H7	H15	H16	H19	H21	H22	H33
1.1.1 - Primary consumer	121	128	93	93	77	49	97	148
1.1.1.1 - Foliovore	14	12	25	17	12	26	32	17
1.1.1.2 - Spermivore	57	69	56	53	40	17	41	70
1.1.1.3 - Browser	9	8	7	6	4	3	10	11
1.1.1.4 - Grazer	24	19	21	21	15	9	26	29
1.1.1.5 - Frugivore	54	64	35	30	27	2	25	67
1.1.1.6 - Sap feeder	10	12	1	1	6	0	3	11
1.1.1.7 - Root feeder	3	3	5	4	2	1	2	4
1.1.1.8 - Nectivore	4	4	0	1	2	0	4	4
1.1.1.9 - Fungivore	20	16	7	10	7	0	7	19
1.1.1.10 - Flwr/bud	12	13	6	5	7	0	5	14
1.1.1.11 - Aquatic herbiv.	10	10	19	11	10	39	37	13
1.1.1.12 - Benthic substr.	7	6	7	7	3	10	10	8
1.1.1.13 - Bark/camb./bole	5	4	1	1	2	1	5	5
1.1.2 - Secondary consumer	189	206	148	152	114	169	201	227
1.1.2.1 - Invertebrate eater	162	180	128	133	101	162	183	200
1.1.2.1.1 - Terrest. inverts	159	177	121	130	94	116	148	195
1.1.2.1.2 - Aquatic macroinv.	15	15	32	26	17	117	94	23
1.1.2.1.3 - Zooplankton	4	4	2	3	2	6	4	5
1.1.2.2 - Vertebrate eater	62	65	60	61	36	72	89	70
1.1.2.2.1 - Piscivorous	8	9	10	12	6	52	44	10
1.1.2.3 - Ovivorous	24	23	13	12	13	16	16	23
1.1.3 - Tertiary consumer	7	7	6	5	2	2	6	7
1.1.4 - Carrion feeder	18	18	17	16	8	10	17	21
1.1.5 - Cannibalistic	4	2	3	2	1	4	2	4
1.1.6 - Coprophagous	2	1	3	4	2	0	0	3
1.1.7 - Human garbage/refuse	0	0	0	0	0	1	0	0

1.1.7.1 - Offal, bycatch	0	0	0	0	0	1	0	0
1.2.1 prey for 2,3 consumers	153	158	122	132	94	107	146	181
2 - Nutrient cycling	21	22	20	21	9	43	37	26
3.1 - Control insect pops	41	43	23	25	24	28	33	45
3.2 - Contol vert pops	25	25	21	22	6	6	21	24
3.3 - Pollination vector	4	4	1	2	2	1	3	4
3.4 - Disperses seeds, etc.	69	71	55	53	36	53	79	77
3.4.1 - Disperses fungi	9	7	2	3	3	0	3	9
3.4.2 - Disperses lichens	8	4	0	0	1	0	3	6
3.4.4 - Disperses inverts	3	2	15	10	3	48	50	2
3.4.5 - Disperses seeds/fruits	61	66	40	45	33	4	24	69
3.4.6 - Disperses vasc. plants	4	3	12	6	3	47	49	3
3.5.1 - Creates feed. opportn.	7	6	2	1	2	1	2	7
3.5.1.1 - Creates sapwells	3	3	0	0	1	0	0	3
3.5.2 - Creates roost/den/nest	1	1	0	0	0	1	1	1
3.6.1 - Creates aer. struct.	13	14	9	12	3	10	17	11
3.6.2 - Creates grnd. struct.	4	4	0	2	2	2	4	3
3.6.3 - Creates aquat. struct.	1	1	0	0	2	13	13	1
3.7.1 - Uses aer. struct.	9	8	3	3	2	1	4	8
3.7.2 - Uses grnd. struct.	4	5	4	3	4	0	2	6
3.7.3 - Uses aquat. struct.	2	2	1	1	3	5	5	1
3.8.1 - Intersp. nest parasite	1	1	1	1	0	1	2	1
3.8.2 - Intersp. host	26	33	7	11	18	2	11	32
3.9 - Primary cavity excavator	12	14	1	2	8	0	1	15
3.10 - Secondary cavity user	26	26	8	9	12	10	17	25
3.11 - Primary burrow excavator	39	29	28	33	24	6	20	38
3.11.1 - Creates large burrows	12	9	9	9	9	4	8	12
3.11.2 - Creates small burrows	27	20	19	24	15	2	12	26

3.12 - Secondary burrow user	42	35	37	44	25	10	25	45
3.13 - Creates runways	22	16	14	16	14	4	19	26
3.14 - Uses created runways	28	25	20	20	13	4	21	29
3.15 - Pirates food	3	3	2	3	0	12	9	3
3.16 - Intersp. hybrid.	17	16	5	5	5	3	9	18
5.1 - Improves soil struc., aern.	25	30	29	42	20	9	12	34
5.2 - Degrades soil struc., aern.	0	0	0	1	1	0	1	0
6.1 - Fragments down wood	10	8	6	7	5	0	11	10
6.2 - Fragments standing wood	2	2	1	1	2	0	1	2
7.1 - Impounds water	1	1	0	0	0	1	1	1
7.2 - Creates ponds/wetlands	3	3	2	3	3	1	5	4
8.1 - Creates snags	3	3	1	1	2	2	4	3
8.2 - Browsing alters vegn struct	7	6	4	4	4	1	6	9
8.3 - Grazing alters vegn struct	5	4	5	6	3	1	8	6

\1 Wildlife habitat types:
H5 = Eastside Mixed Conifer Forest
H7 = Ponderosa Pine and Eastside White Oak Forests and Woodlands
H15 = Eastside Grasslands
H16 = Shrub-steppe
H19 = Agriculture, Pastures, and Mixed Environments
H21 = Lakes, Ponds, Reservoirs, and Rivers
H22 = Herbaceous Wetlands
H33 = Regenerating Forest

Appendix L

Screening Procedure for Estimating the Wildlife-Habitat Types for each Alternative.

A screening procedure was developed to estimate the acres of wildlife-habitat types resulting from seven alternatives considered by the Multi-Species Framework Project. This procedure estimated the degree that current wildlife-habitat types would shift back towards the historic wildlife-habitat types for a specific alternative. Each alternative was composed of a set of strategies. The effectiveness and intensity of each strategy, as defined in the section on Methods-Fish, were considered in combination with the land use and land ownership for each 6-HUC. Changes in the aquatic habitat were estimated in a similar but independent procedure.

The Multi-Species Framework Alternatives working group specified the intensity (expressed in fuzzy terms as low, medium, high) of a specific strategy (e.g. remove logging roads) for a specific land use and land ownership (e.g. Federal forest lands). Intensities were allowed to vary between provinces. This resulted in 11,536 rules combined.

The Northwest Habitat Institute provided the fraction of wildlife-habitat types in each 6-HUC composed of each of 27 (non-marine) different wildlife-habitat types for current and historic (circa 1850) conditions (see Methods-Wildlife). Each of the wildlife-habitat types was associated with one of six land use groupings (forest, range, wetland, water, agricultural, or urban). StreamNet provided, for each 6-HUC, the fraction of area in each land use/land ownership (federal, state, city/county, tribal, or private) group.

Spatial information was not considered at a spatial scale finer than the 6-HUC . This approach was consistent with other elements of the Multi-Species Framework Project. It implies that no information about adjacency of habitat types and land ownership is known. For instance, we don't know if forest represents riparian or non-riparian regions. Such information was beyond the initial basin and province levels of assessment of the Multi-Species Framework Project.

Each of the strategies considered was assumed to result in some shift of the current wildlife-habitat type back to the historic wildlife-habitat type. Continued shifting of habitat away from historical conditions was not considered. Each of the 98 strategies available results in either no or some positive shift in habitat towards historic conditions. The shift from various strategies within an alternative was assumed to superimpose. The shifts associated with each strategy are estimated independently for each alternative, each 6-HUC, and each land use group. The impacts of the three largest shifts were considered to superimpose onto the residual fraction only. Therefore, if the largest three shifts were 50%, 40%, and 30% the combined shift would be 0.5 + (1-0.5)*0.4 +{1 – (0.5 + (1-

0.5)*0.4)}*0.3 = 79%. This procedure ensures that the shift will never exceed 100% and is consistent with a diminishing return on similar strategies.

The magnitude of an individual shift, before superimposing it into an aggregate shift for an alternative, is estimated from the effectiveness and intensity specified for the strategy. The intensity values were specified by the Multi-Species Framework Alternatives working group for each land ownership and land use group for each strategy and each alternative and each province using values of 0, 1, 2, and 3. The effectiveness values were also developed by Multi-Species Framework Alternatives working group and were expressed using values of 0, 1, 2, 3, and 4. In both cases, the larger values signified a greater impact. Effectiveness and intensity values were combined into shift values as shown in Table 1. The intensity values for various land use and land ownership groups were area weighted for each 6-HUC by the fraction of the total acreage in the respective land use group. The resulting area-weighted aggregate intensity values were combined with the effectiveness values designated for the strategy and the result shift for each land use group was interpolated from Table 1 using a 2-dimensional linear interpolation scheme.

The resultant shifts were applied to remap the current wildlife-habitat type towards the historic habitat-wildlife type. A shift value of 1 would reproduce the historic pattern of wildlife-habitat type and a shift value of 0 would maintain the pattern of current wildlife-habitat type.

The procedure was implemented in Microsoft™Excel™ using macros, and this model can be obtained from the senior author of this Appendix. The procedure was implemented in Excel™ because the initial rule database was implemented in Excel™ and it was a common method for communicating information within the Multi-Species Framework Project team. Several macros were used to automate the computational process. The file is 30 MB in size and requires Microsoft™ Excel™ 2000 to run. Microsoft™ Excel™ while common to many users is not a very efficient way to perform the computations, so the computations can take several hours to complete.

The acres of wildlife-habitat types estimated using the screening procedure are used to assess wildlife species-specific performance and terrestrial ecosystem function. The results of this screening procedure are contained in a very large spreadsheet (30 megabytes) that is available from the Power Planning Council upon request. Data in this spreadsheet are summarized and analyzed in the wildlife sections of the report for the Multi-Species Framework Project. Analyses include changes of selected wildlife-habitat types, habitat condition for selected species, and ecosystem function. The screen procedure presented in this report may be useful for subbasin managers to assess the consequences of proposed management actions on fish and wildlife.

Effectiveness	Intensity			
	0	1	2	3
0	0	0	0	0
1	0	0.56	0.63	0.7
2	0	0.64	0.72	0.8
3	0	0.72	0.81	0.9
4	0	0.8	0.9	1

Table 1. Tabular Function of Shifts. Intensity and effectiveness were integrated for each strategy (i.e., cell).