Science and the evaluation of habitat improvement projects
in Columbia River tributaries

Regional Science Review & the Expert Panel Process

BONNEVILLE POWER ADMINISTRATION

BUREAU OF RECLAMATION

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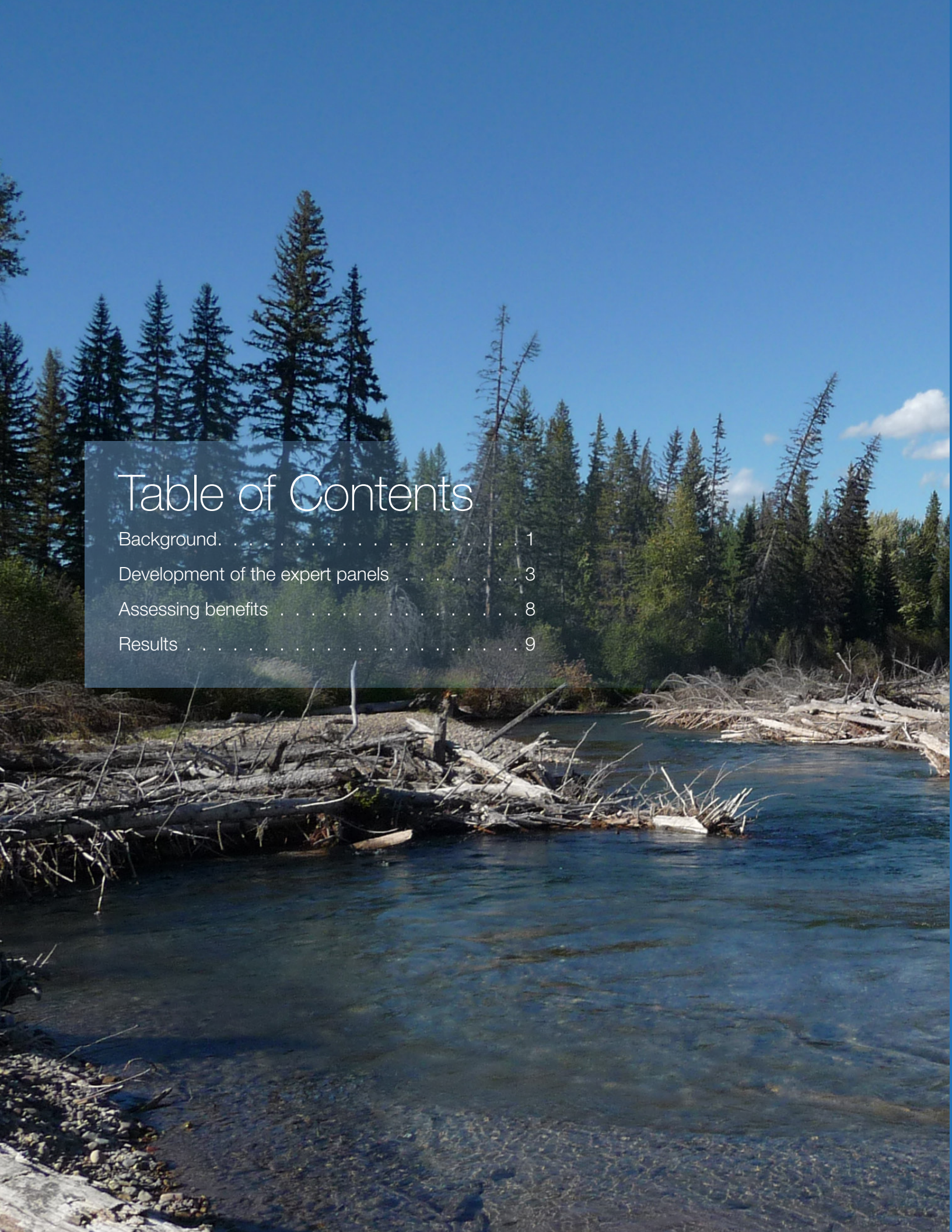

Table of Contents

Background 1

Development of the expert panels 3

Assessing benefits 8

Results 9

Summary

This paper outlines the science-based process that informs the evaluation and guides the selection of habitat improvement projects in tributaries of the Columbia River, where Northwest salmon and steelhead spawn and rear. This rigorous process begins with thorough assessments of current and potential habitat conditions in river reaches and continues with evaluations by expert panels of local biologists familiar with the reaches. For those fish populations evaluated by the expert panels, the panels combine the best available science with their professional knowledge to estimate how habitat improvement projects would resolve factors limiting salmon and improve their survival. The results help prioritize funding and other resources on habitat projects that provide the greatest benefits for salmon and steelhead.

Why are the Bonneville Power Administration and the Bureau of Reclamation improving habitat in Columbia and Snake River watersheds?

Two federal Action Agencies, the Bonneville Power Administration and Bureau of Reclamation, provide funding and technical assistance to state and tribal partners to implement tributary habitat improvement projects to help mitigate the impacts of federal dams on salmon and steelhead. These actions complement improvements made at the dams to meet performance standards there. This "All H approach" also includes estuary habitat improvements, predator management, hatchery management and improvement, and improvements to or modifications of harvest methods.

How do the Action Agencies decide what projects to undertake?

The Action Agencies work with partners to identify potential habitat improvement projects. For those populations evaluated by expert panels, the Action Agencies then ask expert panels of local scientists to evaluate the projects and estimate their benefits for fish based on the latest science. The Action Agencies use the results to prioritize projects that will benefit fish most.

How do the expert panels incorporate the latest science?

The panels include scientists with knowledge of local watersheds as well as the latest science related to fish habitat conditions. They meet every three years, considering the latest science and the recent results of research and monitoring.

How many Habitat Actions have been taken?

Each year, the agencies fund and support hundreds of actions to improve salmon and steelhead habitat in the Columbia and Snake Rivers, which are implemented on the ground by numerous tribal, state, and local partners and conservation organizations. From 2005 to 2012, the agencies have contributed to:

- Improved access for migrating fish to 2,203 miles of spawning and rearing habitat.
- Improvement or installation of 308 fish screens, keeping fish out of irrigation diversions.
- Protected 294,533 acre-feet of water, keeping it in streams to benefit fish.
- Improving instream conditions of 228 miles of spawning and rearing habitat

Background

Habitat improvement

Habitat conservation has been a keystone of salmon and steelhead and other ecosystem conservation efforts in the Pacific Northwest for decades. Research and monitoring indicates that habitat protection and improvement help increase survival, productivity and abundance of salmon and steelhead, both in the short term and the long term.

They also help address potential future impacts from climate change by providing greater resilience for ecosystems and fish.

Similarly, the Northwest Power and Conservation Council's (Council) Fish and Wildlife Program, designed to address the impacts of federal and non-federal dams in the Columbia River Basin, provides subbasin plans that guide extensive "off site" habitat mitigation to benefit fish and wildlife. This includes actions such as installing screens to protect young salmon and steelhead at irrigation pumps and water diversions, revegetating streamsides in areas where fish spawn and rear, and protecting and improving stream habitat through easements or outright purchase. NOAA Fisheries' salmon recovery plans for the Columbia and Snake Rivers also incorporate protection and improvement of habitat as essential conservation strategies.

Two panels provide independent scientific review of the Council's Fish and Wildlife Program: the Independent Scientific Review Panel (ISRP) and the Independent Scientific Advisory Board (ISAB). The ISRP reviews fish and wildlife projects funded by Bonneville Power Administration (BPA) and makes recommendations on how to proceed. The ISAB works with NOAA Fisheries to review programmatic and scientific issues in the basin.

Biological importance of tributaries

Salmon and steelhead often begin and end their lives in tributaries of the Columbia and Snake Rivers, relying on the creeks, streams and rivers to house their nests (called redds) and where their offspring grow and rear. However, the habitat condition of many tributaries throughout the Columbia Basin has been degraded by human population growth and development, such as urbanization, historic mining, grazing and logging practices with a legacy of erosion. In some places, channelization has removed the natural diversity of streambed conditions fish need to grow and thrive and irrigation diversions have drained streams of water needed for returning adults to spawn, eggs to hatch and young to feed and grow. Consequently improvements to habitat conditions in tributaries that remedy those impacts offer significant potential to improve fish survival.

The FCRPS Biological Opinion and tributary habitat

The Biological Opinion (BiOp) issued by NOAA Fisheries to govern the operation of federal dams on the Columbia and Snake Rivers (the federal Columbia River Hydropower System or FCRPS), focuses first on improvements at dams to improve conditions for migrating fish. For instance, improvements at dams will assure that 96 percent of spring-migrating juvenile fish and 93 percent of summer-migrating fish safely pass each dam. However, the BiOp also recognizes that actions at the dams may not by themselves mitigate all impacts on fish. So it goes beyond the dams to better protect fish throughout their life cycles in what is called an "All H approach" that addresses hydropower impacts, tributary and estuary habitat improvement, hatchery operations, predation and harvest techniques.

Chinook salmon in the Lostine River, Oregon

BPA, Reclamation, and the U.S. Army Corps of Engineers spend significant portions of their budgets for endangered species on salmon and steelhead habitat protection and improvement, collectively totaling more than $100 million annually. Associated with these actions is additional spending on research, monitoring and evaluation (RM&E) to assess the value and potential of habitat improvement for fish, which averages more than $20 million annually.

Tributary priorities for fish

The Action Agencies' tributary habitat objective is to prioritize tributary habitat improvements in watersheds with the greatest need for improvement and that benefit ESA-listed fish populations with the most critical biological needs. The approach hinges on increasing scientific evidence that the growth and survival of fish is linked to the quality of their habitat.

Based on scientific measures of fish health, the FCRPS BiOp identifies 18 Upper Columbia and Snake River chinook salmon and steelhead populations as priorities for protection. The BiOp calls for habitat improvements to address "key limiting factors" that inhibit the capacity of these populations to spawn and rear successfully. Habitat improvements may include:

- Boosting depleted instream flows
- Eliminating passage barriers by replacing outdated diversion dams and culverts.
- Screening irrigation diversions to keep fish in the river and out of canals
- Improving habitat complexity by reestablishing meanders and adding large woody material that provides better spawning and rearing habitat
- Reconnecting historic wetlands and other habitat disconnected by dikes or other obstacles.
- Improving riparian habitat by planting native vegetation or installing fences to exclude livestock
- Reducing excessive erosion by decommissioning roads or securing stream banks.

Each year, the Action Agencies compile the metrics associated with completed habitat improvement projects such as the amount of flows added to streams and miles of spawning and rearing stream habitat improved. This information is available for each of the salmon and steelhead populations identified in the FCRPS BiOp in Annual Progress Reports (see "Project Tables" at *www.salmonrecovery.gov/BiologicalOpinions/FCRPSBiOp/ProgressReports*.)

The expert panels

Development of the expert panels

During the development of the FCRPS BiOp, a Habitat Collaboration Workgroup was charged with developing a methodology for estimating fish survival benefits associated with habitat improvement actions in the tributaries. After several months of discussion and examination of existing scientific data and a variety of biological modeling approaches, the HCW developed a structured approach for estimating habitat quality improvement and freshwater survival benefits in tributaries. The approach considers best available science and relies on the professional judgment of local Expert Panels knowledgeable about local watershed processes, habitat conditions, and fish populations.

The expert panels convene once every three years in the geographic areas of the 18 FCRPS BiOp priority fish populations to estimate the improvements in habitat condition resulting from the implementation of habitat improvement actions. Evaluations by the local Expert Panels provide the Action Agencies with the information they need to estimate overall habitat quality improvements associated with habitat actions for the priority populations and other populations within the same major population group (MPG).

How the expert panels work

The expert panels analyze potential habitat improvement projects in the context of a basin-wide tributary habitat strategy. The basis of the tributary habitat strategy is that habitat protection and improvement will help ameliorate limiting factors hindering survival of salmon and steelhead. In doing so, habitat projects that improve habitat conditions for fish will in turn improve freshwater fish survival both in the short and long term.

Analysis by the expert panels requires strong scientific information and assessment, including:

- Identification and quantification of key limiting factors for each population.

- Assessments of how habitat actions affect the limiting factors that otherwise inhibit fish survival and growth.

The primary responsibility of the expert panels is to evaluate habitat actions and estimate how much they help address habitat limiting factors that affect salmon and steelhead growth and survival in key watersheds. The panels consider new and updated science and apply their local expertise within a structured framework that includes detailed technical documentation. The process involves extensive coordination between the Action Agencies and expert panel members to compile, organize and update technical data and information about hundreds of different actions and limiting factors. The Action Agencies use a sophisticated database to record and track habitat actions and limiting factor changes identified by each expert panel.

Once the expert panels provide this information, the Action Agencies:

Expert Panel locations and representatives

EXPERT PANEL GROUPS	REPRESENTATIVES ON EXPERT PANELS
Upper Columbia	Upper Columbia Salmon Recovery Board (coordinating body), Washington Department of Fish & Wildlife (WDFW), *National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA Fisheries), US Fish & Wildlife Service (USFWS), Yakama Nation, Confederated Tribes of the Colville Indian Reservation, Washington Water Trust, some members of the Regional Technical Team members (including BPA contractors and representatives from agencies/entities), US Forest Service (USFS), and others.
Clearwater	Idaho Office of Species Conservation and Nez Perce Tribe (coordinating bodies), Idaho Department of Fish & Game (IDFG), USFS and NOAA Fisheries.
Lower Snake	Lower Snake Salmon Recovery Board (coordinating body), WDFW, USFS, NOAA Fisheries, Confederated Tribes of the Umatilla Indian Reservation, Nez Perce Tribe, Columbia Soil and Water Conservation District, Asotin County Conservation District, members from the Regional Technical Teams and others.
Upper Grande Ronde/ Catherine Creek/ Wallowa/Imnaha/ Lower Grande Ronde	Grande Ronde Model Watershed (coordinating body), Confederated Tribes of the Umatilla Indian Reservation, Nez Perce Tribe, Oregon Dept. of Fish & Wildlife, USFWS, USFS, NOAA Fisheries, The Freshwater Trust, Union County SWCD, and others.
Lower/Middle Salmon	USFS, Nez Perce Tribe, Idaho's Office of Species Conservation, IDFG and NOAA Fisheries.
Upper Salmon	Idaho's Office of Species Conservation (coordinating body), IDFG, NOAA Fisheries, Bureau of Land Management, Trout Unlimited, US Fish & Wildlife Service, US Forest Service, Custer Soil and Water Conservation District, Shoshone Bannock Tribes, The Nature Conservancy, and others.

- Consolidate habitat limiting factors within and across watersheds to assess the overall habitat quality affecting target populations.
- Translate the consolidated changes into habitat quality improvements, which reflect improved freshwater survival.

The Action Agencies then convert the improved habitat conditions identified by the expert panels into corresponding population level survival improvements using methodologies developed and accepted by the Habitat Collaboration Workgroup.

Installation of a PIT tag antenna in the South Fork of the Salmon River, an element of research, monitoring and evaluation.

The first set of Expert Panel workshops was convened in 2007 and the second in 2009. In early 2011, the Action Agencies began planning the 2012 Expert Panel workshops. They held informational meetings to review results of completed habitat improvement projects and new science and monitoring information, and update any changes in tributary habitat assessment units or limiting factors to represent current conditions. The 2012 sessions evaluated completed projects from 2010 to 2012 and identified proposed projects and benefits of habitat actions through the end of the BiOp period in 2018. The Action Agencies will reconvene the local Expert Panels in 2015 to finalize the benefits of habitat improvement projects completed from 2012 through 2015 and refine the scope and benefits of actions to be completed from 2015 to 2018.

Expert panel participants

The Expert Panels include biologists, hydrologists, engineers and others with direct knowledge of local watershed processes, habitat conditions and fish populations. They are grouped into geographic areas that are home to the FCRPS BiOp priority populations: Upper Columbia, Clearwater, Lower Snake, Upper Grande Ronde/Catherine Creek/Wallowa/Imnaha/Lower Grande Ronde, Lower/Middle Salmon and Upper Salmon.

The importance of Research, Monitoring, and Evaluation

Under the BiOp, the Action Agencies annually support extensive research, monitoring, and evaluation of fish populations and watershed conditions to help demonstrate the benefits that tributary habitat improvement projects have for fish production, growth and survival in the tributaries; establish and model relationships between habitat improvement projects, changes in habitat condition and resulting changes in fish growth and survival; and tailor actions to best benefit fish. The results are refining the region's understanding of these relationships, helping guide planning and selection of habitat improvement projects that provide the greatest benefits for fish. The results also inform the expert panels assessing the benefits of habitat improvements. Ongoing research, monitoring, and evaluation work includes:

- **Tributary and reach assessments** conducted by the Bureau of Reclamation. These are thorough evaluations of watersheds and tributary reaches to document baseline geomorphic, hydrologic, hydraulic and vegetation conditions and provide guidance for habitat protection and improvement. The scientific assessments are conducted in collaboration with local

watershed groups and are designed to provide an optimal implementation and sequencing strategy for projects that is tailored to local conditions. This work provides a science-based foundation for project development and implementation.

- **Fish status and trend monitoring** funded by BPA, NMFS and others
- **Habitat status and trend monitoring**, including several Intensively Monitored Watersheds and similar broad scale efforts such as the Okanogan Basin Monitoring and Evaluation Program.
- **Fish-habitat correlation and modeling**, improving understanding of the positive relationship between changes in habitat condition and fish survival.
- **Habitat project "action effectiveness" research and evaluation**, looking individually and collectively at the fish response to projects such as instream flow improvements, barrier removal and reconnection of wetlands.

The data and other results help actively improve and expand the scientific information available to plan and implement habitat improvement projects through a continuous plan-implement-review-adjust process referred to as adaptive management. The adaptive management process helps watershed partners adjust and tailor their subsequent planned projects by applying or improving upon what worked, and eliminating or adjusting what didn't work based on evaluation of prior completed projects.

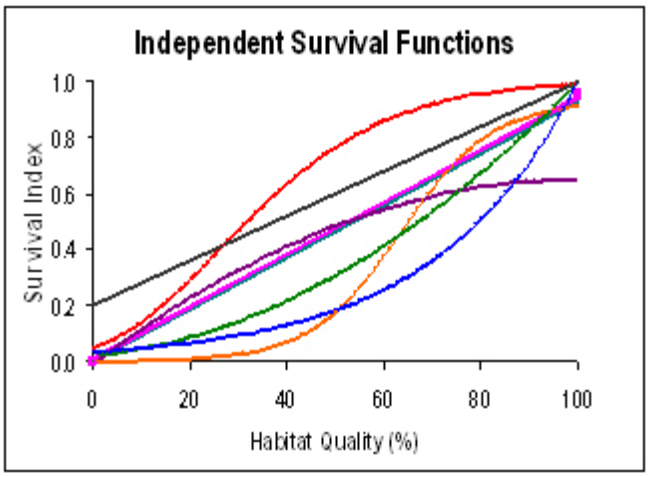

Figure 1. Functional relationships between various habitat factors such as temperature, flows, sediment and fish survival.

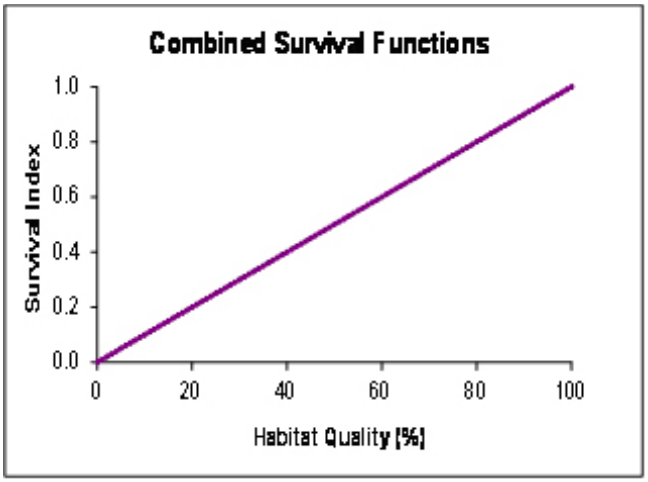

Figure 2. Linear relationship between habitat quality and fish survival based on the median scores of the various functional relations shown in Figure 1.

The Action Agencies also use the results to provide the Expert Panels with updated information as they review habitat actions every three years.

Estimating the benefits of habitat actions

The process of analyzing the benefits provided by habitat improvement projects includes two phases. The first draws on the local knowledge and professional expertise of the expert panels to assess limiting factors that inhibit egg-to-smolt survival and their significance to fish populations and to estimate effects of habitat improvements. The second involves the Action Agencies applying the expert panel findings to connect changes in habitat conditions, habitat quality and fish survival and determine how habitat improvements translate into changes in fish survival.

Expert panels steps:

1. Identify the habitat limiting factors in each geographic assessment unit (areas that share common limiting factors) within each watershed that supports target populations.
2. Estimate the "current" and "potential" habitat condition of each limiting factor in each assessment unit. These "bookends" provide a potential range within which limiting factors can be improved within the term of the FCRPS BiOp.

3. Weigh the significance of each habitat limiting factor within each assessment unit based on the implications for fish, with severely degraded factors weighted most heavily.
4. Weight the significance of each geographic assessment unit based on how much of the total fish population it can support.
5. Evaluate habitat improvement actions that would ameliorate the limiting factors.
6. Estimate the potential improvement in limiting factors if such habitat improvements are carried out.

Action Agency steps:

7. Combine limiting factor estimates into a single score for local habitat conditions across assessment units and then combine those scores into a single score for the affected population.
8. Translate the estimated change in habitat quality attributed to habitat improvements into change in egg-to-smolt survival on a population level, based on established relationships between habitat quality and fish survival.

The translation of habitat quality scores into changes in fish survival is an important step and the Habitat Collaboration Workgroup incorporated the latest science available in 2006 when the process was developed. For example, the Habitat Collaboration Workgroup plotted the habitat-survival relationships (Figure 1) based on established research. Combining these relationships into a central line resulted in a linear relationship between habitat quality and fish survival (Figure 2) indicating that fish survival increases with improvements in habitat quality. This general mathematical relationship connects the chain of effects at the heart of the tributary habitat strategy, which targets habitat limiting factors through habitat improvement projects, improving habitat quality and fish survival.

Restored riparian habitat.

The linear relationship between habitat quality and fish survival is supported by independent results, such as historic redd counts and Ecosystem Diagnostic and Treatment modeling in many parts of the Columbia Basin, underscoring the validity of the relationships. The Habitat Collaboration Workgroup agreed that the linear relationship provided the most realistic way of translating habitat quality improvements into changes in fish survival. This relationship is also supported by more recent published literature that indicates that more intensive and extensive improvement actions result in greater survival benefits (e.g., see Paulsen and Fisher 2005).

Juvenile fish survival in natural tributary environments, no matter how good the habitat, never reaches 100 percent, given disease, predation, competition and other factors. To account for this, the Habitat Collaboration Workgroup capped survival rates based on actual juvenile and adult survivals measured in natural environments. This resulted in the following functions, which relate habitat quality improvements to estimated improvements in fish survival:

Chinook salmon egg-smolt survival = 0.0018*(Habitat Quality)
Steelhead egg-smolt survival = 0.0004*(Habitat Quality)
Adult pre-spawning survival = 1.0*(Habitat Quality)

These functions provide a conservative approach to estimating survival gains.

Limiting Factor maps

(For more detailed information on bar and pie charts see page 11.)

To help the Expert Panels synthesize large amounts of data and information, the Action Agencies have developed standardized maps and graphs to more effectively depict high priority areas and limiting factors for targeted populations. The maps and graphs are designed to provide a rapid visual overview of conditions affecting the populations. The maps were first developed for the 2012

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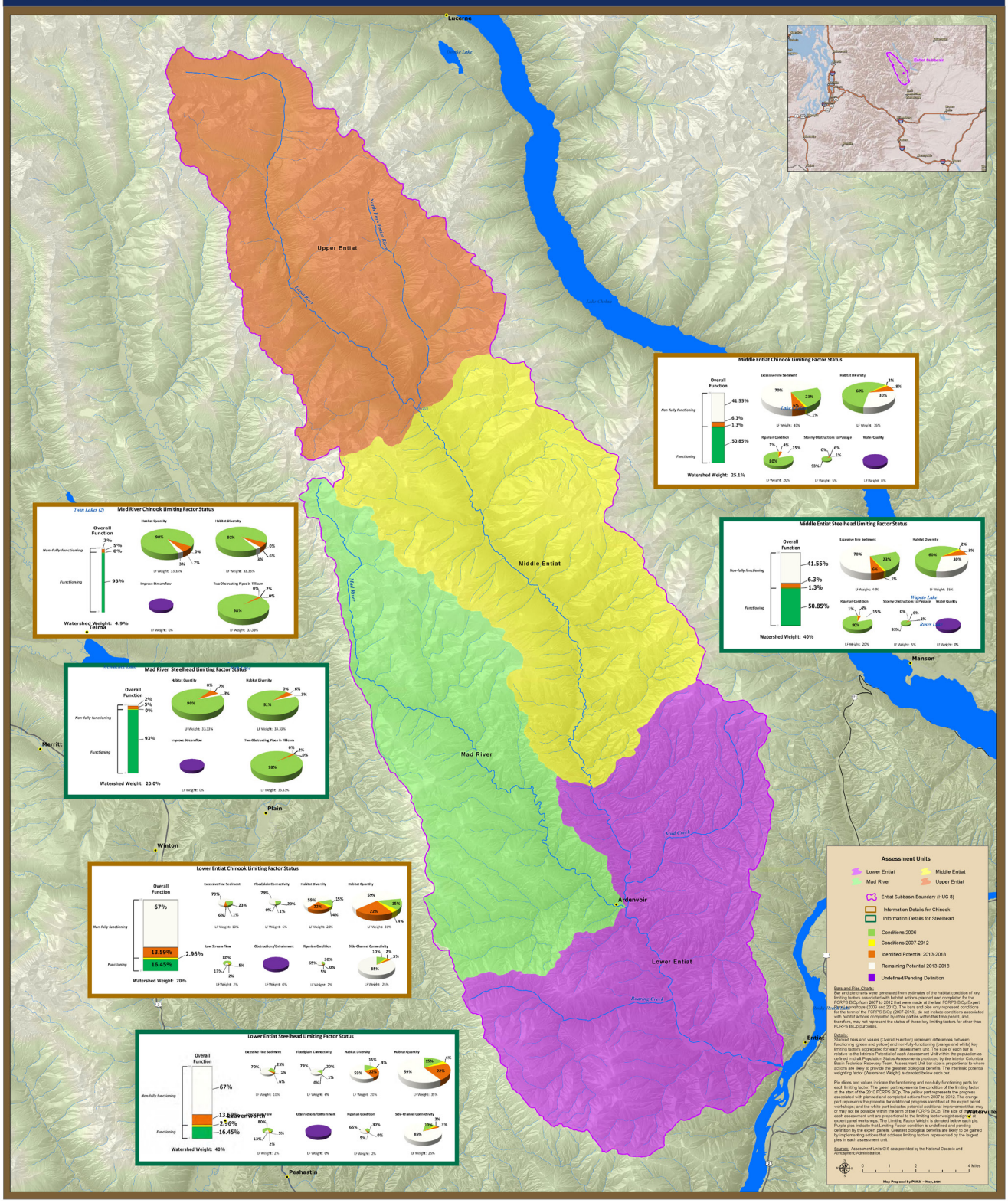
Entiat Subbasin, Washington

Upper Columbia Spring Chinook and Steelhead Population Assessment Units and Limiting Factors



Expert Panel workshops and will be revised and adjusted as new science and knowledge becomes available.

An example of a limiting factor map is on the facing page.

Pie charts displayed on the maps illustrate each limiting factor within an assessment unit, with the size of each pie representing the weight of that limiting factor and the slices representing the current condition of the limiting factor, improvement to date and potential for further improvement through the term of the BiOp. Bar graphs combine the habitat functions illustrated by the pie charts across the entire assessment unit. The width of the bar is proportional to the significance of the assessment unit within the specified population.

For more description of the maps and charts, see the back cover.

Habitat Action results

The Action Agencies committed to specific levels of tributary habitat quality improvement by 2018 for the 56 salmon and steelhead populations listed in the FCRPS BiOp (Table 5 of Reasonable and Prudent Alternative Action 35). While the Expert Panel workshops focus on the eighteen priority populations, the Action Agencies also conduct Expert Panel processes for certain other Snake River and Upper Columbia populations. The implementation of habitat actions since 2005 has resulted in significant accomplishments.

Habitat accomplishments, 2005-2012

Acre-feet of water protected	294,533
Miles of improved stream complexity	228
Acres protected	53,793
Screens installed or addressed	308
Miles of habitat made accessible	2,203

What we have learned

Expert panels currently play an important role every three years for the 2008 FCRPS BiOp in recognizing and defining limiting factors, and evaluating how planned and completed habitat improvement projects improve those limiting factors. Expert panels employ their professional judgment seasoned with a full measure of current research, monitoring, and evaluation results to complete these tasks. Expert panel results processed by the Action Agencies depict the progress that the Action Agencies and their State and Tribal partners are making in reaching the 2008 FCRPS BiOp tributary habitat survival requirements.

For those populations evaluated by Expert Panels, the 2008 FCRPS BiOp initiated a new era for planning and implementing habitat improvement projects by states and tribes who aim to improve Pacific Northwest threatened and endangered salmon and steelhead survival. Habitat improvement projects planned and implemented with funding and technical assistance from the Action Agencies in the decades preceding the 2008 FCRPS BiOp provided a solid foundation for moving forward. Specific 2008 BiOp tributary habitat survival requirements focused attention on the most imperiled salmon and steelhead populations.

Identification of key habitat limiting factors by local experts quantified the status of the problems facing fish growth and survival in the tributaries. Limiting factor pie maps developed by the Action Agencies clearly and concisely portray the limiting factor information compiled by the local experts. Tributary and reach assessments produced by the Action Agencies and other partners characterize physical settings and watershed dynamics as well as potential opportunities to improve river system conditions where fish hatch and grow. Monitoring and evaluation conducted by the Action Agencies, and by state and tribal partners with funding from the Action Agencies, assess the effects of individual or groups of habitat improvement projects on fish response, status and trends of fish populations, and status and trends of habitat conditions. The currently available research, monitoring and evaluation results are employed with an improved understanding of limiting factors, watershed conditions, and potential habitat improvement opportunities by the Expert Panels to evaluate limiting factors and habitat improvement projects and by the Action Agency partners to prioritize and implement habitat improvement projects that address the most important problems in the locations that provide the most benefit for fish.

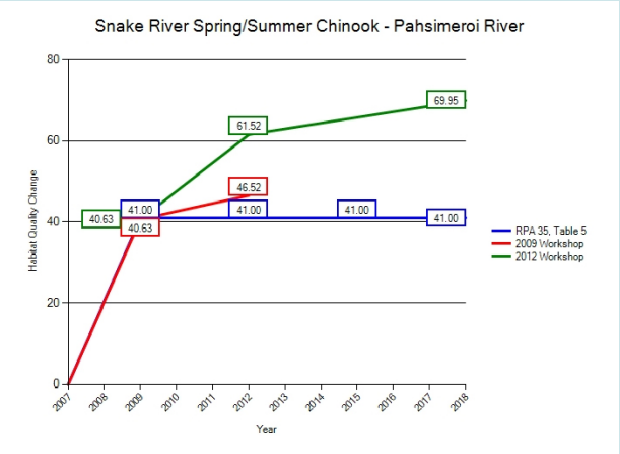
How it works: Pahsimeroi River

The Pahsimeroi River in eastern Idaho provided historic habitat for Snake River spring/summer chinook and steelhead, but became very degraded, with much of its water diverted for irrigation. The result was the elimination of important spawning and rearing habitat for the fish populations. The FCRPS BiOp identified five limiting factors reducing the Pahsimeroi's habitat value:

- Low stream flows
- Water quality degraded by high temperatures and excessive nutrients
- Barriers to fish passage and entrainment into irrigation ditches
- Sediment
- Poor riparian condition and lack of woody material.

The BiOp called for a 41 percent increase in chinook survival and 9 percent increase in steelhead survival by 2018 from habitat improvement actions including habitat acquisition and improvement, removal of barriers, screening of irrigation diversions, reconnecting tributaries and culvert removal and replacement. For instance, consolidating diversions and changing irrigation practices with the cooperation of local landowners and ranchers, allowed reconnection of cool-water springs to the river. The changes boosted instream flows more than 100 percent in the most important spawning and rearing reaches.

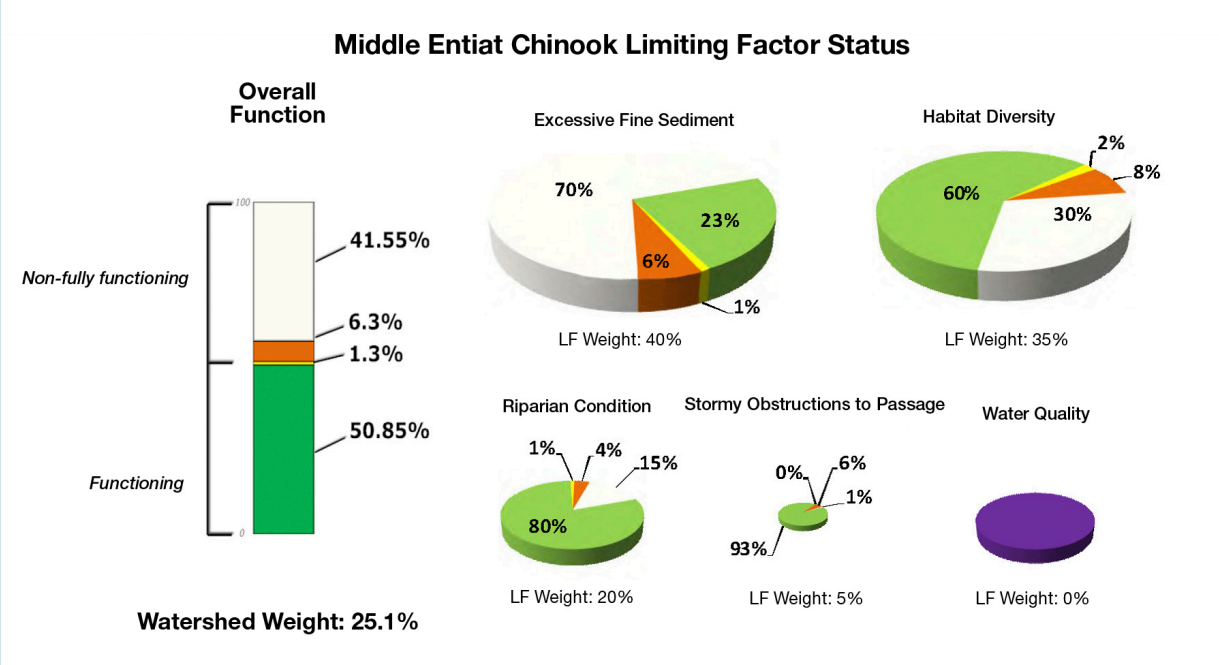
To assess these habitat benefits, an Expert Panel was convened to examine habitat actions in the Upper Salmon. The five limiting factors were weighted equally, each contributing 20 percent to the reduced habitat potential. The Panel then assigned a score to each limiting factor to represent the status of each limiting factor before any proposed habitat improvement actions were implemented. After examining the proposed habitat improvement actions, the Panel then provided a score for the improvement in the condition that could be expected from the improvement actions.



While the BiOp estimated that habitat improvements on the Pahsimeroi River in Idaho would boost chinook survival by 41 percent, the results of Expert Panel workshops found that the improvement would be greater — almost 70 percent improvement by 2018.

The Action Agencies then converted the improvements in limiting factors estimated by the Expert Panel into fish survival improvement, in percent, using the linear relationships and formulas described above. The result was an estimated 62 percent improvement in chinook survival and 21 percent increase in steelhead survival by 2012, climbing even higher — 70 percent for chinook and 37 percent for steelhead — than called for in the BiOp by 2018.

Field surveys following initial habitat work underscored the expected improvements, revealing approximately 69 salmon redds where there had been only two the previous year. While the number of redds in the Pahsimeroi River has not increased by a statistically significant margin within two years of the completion of the projects, the fish now have access to a wider range of quality habitats that increase survival benefits in the short and long term. Access to this habitat is expected to increase growth and survival of young that can now rear in these formerly inaccessible and inhospitable areas.



An example of the pie charts that provide watershed planners and Expert Panels quick overviews of watershed conditions. A set of charts like these is portrayed for each assessment unit in the watershed. The pie charts depict the status of each limiting factor, with the green slice indicating the percent of potential at the start of the 2010 FCRPS BiOp. For example, the pie chart at the top right shows that habitat diversity stood at about 60 percent of its potential. The yellow slices indicate improvements associated with actions from 2007 to 2012 and the orange slice representing potential for additional progress identified by expert panels.

The size of each pie chart reflects the weight assigned by Expert Panels to the limiting factor in relation to its significance for fish. A purple pie chart indicates that the condition of the limiting factor has not been defined. The bar chart on the left summarizes the status of all the pie charts in the assessment unit and shows that the unit is functioning at 50.85 percent of its potential. The greatest biological benefits in any given watershed can be gained through actions that address limiting factors represented by the largest pies in assessment units with the widest bars.

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