UPPER COLUMBIA SALMON RECOVERY BOARD

HABITAT

BACKGROUND SUMMARY

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The mission of the Upper Columbia Salmon Recovery Board is to restore viable and sustainable populations of salmon, steelhead, and other at-risk species through the collaborative, economically sensitive efforts, combined resources, and wise resource management of the Upper Columbia region.

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September 1, 2014

Dear Reader,

The Upper Columbia Salmon Recovery Board (UCSRB) formed in 1999 as a local response to the federal listing of salmon and steelhead. It since developed and now implements the *Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan* (Plan; UCSRB 2007). The purpose of the UCSRB was, and still is, to develop solutions that work for the people and communities of North Central Washington, and to move the species away from a high risk of extinction. Science has been at the heart of decision-making for our 15 years of existence. Consistent with its goal of transparency and accountability in how the region is addressing the listings, the Board of Directors tasked staff with developing a series of technical reports that describe progress within each management sector of salmon and steelhead – habitat, harvest, hatcheries and hydropower (referred to as "All-H"). With this information, the UCSRB intends to convene decision-makers from each management sector to develop collaborative solutions that accelerate the push towards recovery. Despite the wealth of information in reports and technical documents, none of it exists in one place for someone to understand the progress toward goals in each management sector. Therefore, the UCSRB is meeting this need by producing this and subsequent technical reports for each H-sector.

The Habitat Report is part of a series of Integrated Recovery reports summarizing the major management programs and their reported outcomes related to listed Upper Columbia salmon and steelhead management and recovery. These reports are intended to help support "All- H" collaboration and can be used a) to improve integrated decision making; b) as a communication and outreach tool; c) as a means for identifying key uncertainties and gaps in knowledge and understanding; and d) as a means for better understanding progress toward integrated recovery. These reports are based on unbiased, scientific information and data compiled from a variety of sources. The reports are not intended to be a decision document, but instead guide decision-making by partners working across the different management sectors that affect recovery in the Upper Columbia.

While not all programs are directly aimed at recovery of listed species, many must be consistent with goals and objectives of the Endangered Species Act, and as such should aid in the recovery of listed fish. *Appendix I* of the Recovery Plan indicates that implementation of actions across all sectors may still not be enough to meet increases in survival needed to achieve recovery. Through periodic updates, the UCSRB can help answer the question: "how much is enough," and can facilitate how limited resources should be invested for the greatest impact on species recovery.

Although the UCSRB has no authority to select the suite of actions required across all the H's, it does need commitments that those other decision-makers are working in concert with the Recovery Plan; and, the UCSRB is in a position to make recommendations and requests of the decision-makers to consider the recovery goals of the Upper Columbia. The Plan envisions an "All-H" approach for success and suggests it will take anywhere from 30-50 years to see progress. While habitat investments will continue, the UCSRB is increasingly turning its attention to how it can similarly facilitate collaborative solutions across all of the management sectors simultaneously.

The intention of this report was to provide answers to the following questions:

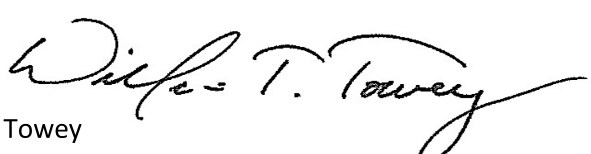
- What is the status of habitat in the region?
- What have we accomplished in terms of habitat protection and restoration?
- How have habitat actions benefitted listed species?
- How do habitat actions contribute to recovery?
- Are our habitat programs integrated with other management programs?
- What are the current data and information gaps, and key uncertainties related to habitat?

In short, the region has made substantial progress in improving the habitat that all life stages of salmon and steelhead depend upon to increase abundance and productivity. **We estimate that the region has moved the needle between 4-6% from the time of listing toward an estimated restoration potential of 15% in improved habitat.** Improvements have been substantial; we are on the right trajectory, and yet have a long way to go to reach delisting.

As one strategy for addressing the need for coordination and integration of efforts across management sectors, the UCSRB created an Integrated Recovery Program. This program is guided by the step-wise process the Board established in 2008 to 1) create a network of people across the H-sectors that can provide information to the UCSRB; 2) gain a common understanding of how the system works and how the Plan is affecting recovery objectives; 3) agree on common goals and short-term outcomes that describe what will be achieved related to the goals in measurable terms – across the H's; 4) implement the Plan, monitor the effects, analyze results, report them, and adapt the Plan as necessary; 5) document the rationale, implementation steps, expected outcomes, and benchmarks; and lastly 6) build and implement a verification, effectiveness and accountability system.

Integrated management of salmon and steelhead means coordinated decision-making to meet various recovery and legal objectives. The Plan recommends objectives for each of the H-sectors. Decisions about programs tend to be made at higher levels, according to discipline, and in isolation from one another. The challenge is to work together to achieve recovery while honoring treaty agreements and meeting legal and regulatory requirements. The UCSRB remains committed to doing this in a voluntary way, rather than through regulatory enforcement. Better alignment between program goals and decision-making processes will improve our chances of meeting recovery goals and objectives while also redeveloping sustainable fisheries. Through this integrated approach, we are confident that recovery is possible. The UCSRB stands ready to facilitate greater coordination among the sectors, and these reports provide a stepping stone toward realizing even more effectiveness.

Sincerely,



Bill Towey
Chair
Upper Columbia Salmon Recovery Board

Contents

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Bonneville Power Administration

Glossary

Action Agencies -	Bureau of Reclamation, Bonneville Power Administration, and Army Corps of Engineers
Assessment Unit -	Comprised of either a portion of a primary sub-watershed or the entire sub-watershed, and, if the former, are used to categorize that sub-watershed into smaller units.
Biological Strategy -	The RTT Biological Strategy documents biological considerations for the protection and restoration of habitat in order to provide a technical foundation for setting priorities. The intent of the document is to provide support and guidance on implementing the Recovery Plan.
BiOp -	Biological Opinion
Capital projects -	Restoration and protection projects
Carrying Capacity -	The maximum population size of the species that the environment can sustain indefinitely, given the food, habitat, water and other necessities available in the environment.
CHaMP -	Columbia Habitat Monitoring Program
Ecological concerns -	Specific features of freshwater habitat and ecology that influence the productivity and abundance of salmonids that restoration projects are meant to address.
EDT -	Ecosystem Diagnosis and Treatment model used to assess habitat and fish populations.
ESU -	Evolutionary Significant Unit
Expert Panel -	Expert Panels are used as the mechanism adopted under the Federal Columbia River Power System Biological Opinion to estimate the progress of, and resulting survival improvements from, mandated tributary habitat restoration actions.
FCRSP -	Federal Columbia River Power System
Habitat Project -	Restoration and protection action implemented to improve or protect habitat
HWS -	Washington State Habitat Work Schedule Database
ICTRT -	Interior Columbia Technical Review Team
IMW -	Intensively Monitored Watershed
Integrated Recovery Program	UCSRB program intended to track and report information about the status of actions affecting salmon and steelhead recovery across management and geographic boundaries for the purpose of informing decision-making and management.

Intrinsic Potential (IP) - Modeled potential quality and quantity of spawning/rearing habitat based on geology, geomorphology, valley width, elevation, stream size, gradient, and other factors.

ISAB - Independent Scientific Advisory Board

Life Cycle Model - A model that incorporates multiple production areas, juvenile life-history diversity, hatchery effectiveness, and numerous out-of-basin effects and reports population trajectories, extinction risk, and life-stage-specific survival bottlenecks under various future scenarios for freshwater habitat, ocean conditions, and other factors.

NOAA - National Oceanic and Atmospheric Administration

Non-capital projects - Design and assessment projects

OBMEP - Okanogan Basin Monitoring and Evaluation Program

PSM - Pre-spawn mortality

Reach - Generally composed of geomorphically similar subsections of an assessment unit

Reach Assessment - Assessment of current geo-fluvial processes and habitat conditions at the reach scale. In some cases the assessments describe the degree of impairment of current habitat and identify specific project opportunities.

Recovery Plan - Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan

REI - Reach-based ecosystem indicators. These metrics provide a consistent means of evaluating biological and physical conditions and have been adopted in the regional assessment process.

Restoration Potential - Estimated potential to restore habitat function (by ecological concern) based on Expert Panel results.

RTT - Upper Columbia Regional Technical Team

SAR - smolt to adult survival

SASI - Washington Department of Fish and Wildlife Salmonid Stock Inventory database

SPS - NOAA Salmon Population Summary database

SRFB - Washington State Salmon Recovery Funding Board

Tributary Assessment - Assessment of current geo-fluvial processes and habitat conditions at the tributary scale.

UCSRB - Upper Columbia Salmon Recovery Board is a coalition of three counties (Douglas, Chelan and Okanogan) and two tribes (Yakama Nation and Colville Confederated Tribe).

VSP - Viable Salmonid Population

WDFW - Washington Department of Fish and Wildlife

WRIA - Water Resource Inventory Area

Executive Summary

The Upper Columbia Salmon Recovery Board was formed in 1999 as a local response to the federal listing of salmon and steelhead. The purpose of the board was, and still is, to develop solutions that work for the people and communities of North Central Washington, and move the species away from a high risk of extinction. Science has been at the heart of decision-making for over 15 years. Consistent with its goal of transparency and accountability in how the region is moving forward on addressing the listings, the board wanted to develop a series of technical reports that describe progress within each management sector of salmon and steelhead – habitat, harvest, hatcheries and hydropower, and convene the decision-makers from each management sector to develop collaborative solutions that accelerate the push towards recovery. Despite the wealth of information in reports and technical documents, there is no single place an interested party can go to understand various programs and the progress being made toward goals in each management sector; hence, the purpose of this and subsequent reports. The *Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan* (Recovery Plan) (UCSRB 2007) envisions an "A*ll-H*" approach for success, and projects it will take anywhere from 30-50 years to see real progress. While habitat investments will continue, the Board is increasingly turning its attention to how it can similarly facilitate collaborative solutions across all of the management sectors simultaneously.

The Habitat Report is part of a series of technical reports summarizing outcomes of major cross-disciplinary programs related to Upper Columbia listed salmon and steelhead species management and recovery. We combine various sources of information to assess benefits to listed species habitat actions may have had, and how these benefits may contribute to recovery. The report addresses several key questions about habitat and habitat actions in the Upper Columbia:

- What is the status of habitat in the region?
- What have we accomplished in terms of habitat protection and restoration?
- How have habitat actions benefitted listed species?
- How do habitat actions contribute to recovery?
- Are our habitat programs integrated with other management programs?
- What are the current data and information gaps and key uncertainties related to habitat?

Significant progress has been made over 15 years in alleviating threats and improving habitat quality and quantity for listed species. In this time, a total of $74 million dollars has been invested in the region on habitat protection and enhancement. These investments contributed to the completion of 278 projects to restore 22 miles of stream, 11 miles of off-channel habitat, and 127 acres of riparian forest; removed 93 fish passage barriers that opened up 282 miles of habitat; and protected 3,379 acres of habitat and 47 miles of streambank. Science continues to guide project development as more is learned about the habitat that fish need at specific times in their lives, and as opportunities arise to work with willing landowners to improve fish habitat. The foundation of our success is built on a voluntary, non-regulatory approach to ensure habitat improvements continue to move the region closer toward established recovery goals for listed salmon, steelhead, and bull trout.

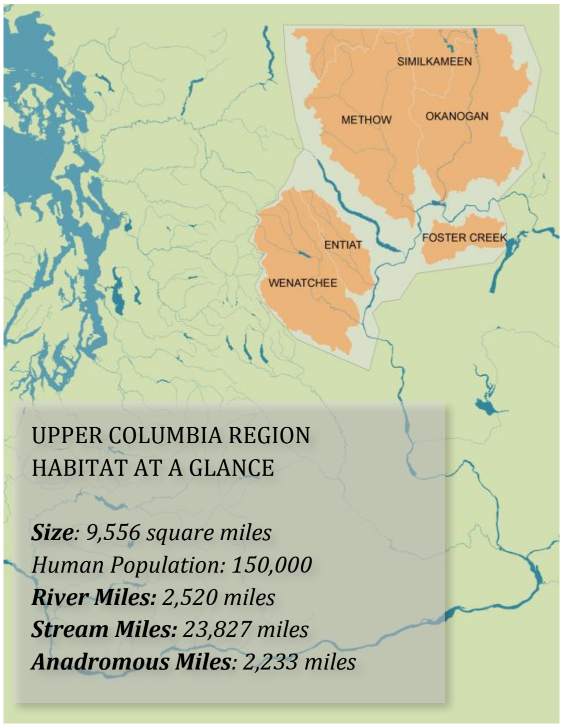
The region's underlying hypothesis is that by using scientific evaluation to identify priority habitat and habitat needs, the collective impact will more quickly and effectively address those factors limiting natural fish production, and move the listed species toward a viable, natural existence. Based on this assumption partners have focused habitat work over the last decade on priority hot spots within those tributaries that have the greatest potential to produce increased numbers of naturally spawning fish. This work has translated into progress toward alleviating key concerns in high priority areas. However, habitat alone cannot get the job done. The Recovery Plan was envisioned to take 30-50 years to fully implement actions in all management sectors. Naturally, there is more work that remains, and a refined alignment with biological priorities will improve habitat benefits. At the scale of recovery, some data exist to decipher the habitat restoration potential that remain and can be filled by future habitat actions. This information supports the original conclusion in the Recovery Plan that meeting this restoration potential will likely not be enough to achieve recovery goals, independent of other actions that affect survival.

The following analyses show that habitat improvements are providing benefits to listed species. However, additional progress in other management sectors is needed to achieve recovery goals for listed Upper Columbia species. It is still unclear how the strategies described in the Recovery Plan, if fully implemented within each of the H-sectors (habitat, harvest, hatcheries, and hydropower), will synergistically contribute to recovery, but the strategies identified are ones that work within the context and confines of what is feasible in the Upper Columbia.

The effect specific habitat actions have on life-stage fish survival rate, and on fish population level responses, remains a critical uncertainty in the implementation of the Recovery Plan. Progress in collecting monitoring information to inform key management questions in the Recovery Plan is an important determinant of success. Although the effects of interacting strategies on population viability remain unknown, the Upper Columbia Salmon Recovery Board intends to summarize information on progress within each sector to better understand the effects of that progress on meeting overall recovery goals.

Introduction

The National Oceanic and Atmospheric Administration (NOAA) formally approved [*The Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan*] (Recovery Plan) in 2007 (UCSRB 2007). The Upper Columbia Salmon Recovery Board (UCSRB) developed the Recovery Plan for Upper Columbia spring Chinook (listed as *endangered* on March 24, 1999), Upper Columbia summer steelhead (listed as *endangered* on August 18, 1997; reclassified as *threatened* on January 5, 2006; and as a result of a legal challenge, reinstated to *endangered* status on June 13, 2007; and finally on appeal by NOAA in the 9th Circuit reinstated in 2009 as *threatened*, where it stands today), and bull trout (the coterminous U.S. population was listed as *threatened* on November 1, 1999). Although the Recovery Plan includes strategies for bull trout, it is not the official recovery plan for bull trout, which is still being drafted by the U.S. Fish and Wildlife Service. The Recovery Plan was the culmination of six years of collaboration among local governments, tribes, citizens, interest groups, and state and federal agencies facilitated by the UCSRB. Through this work, the UCSRB defined recovery of viable and sustainable populations of salmon, steelhead, and other at-risk species through collaborative, economically sensitive efforts, combined resources, and wise resource management of the Upper Columbia region.



UPPER COLUMBIA REGION
HABITAT AT A GLANCE

***Size**: 9,556 square miles*
Human Population: 150,000
***River Miles:** 2,520 miles*
***Stream Miles:** 23,827 miles*
***Anadromous Miles**: 2,233 miles*

Geographically, the Upper Columbia region includes the Columbia River and its tributaries upstream of the confluence with the Yakima River to the base of Chief Joseph Dam. Currently, there are three independent spring Chinook populations (Wenatchee, Entiat, and Methow) and four steelhead populations (Wenatchee, Entiat, Methow, and Okanogan). Spring Chinook in the Okanogan subbasin were extirpated, although the National Oceanic and Atmospheric Administration (NOAA) recently approved a rule to reintroduce Spring Chinook as an experimental population (Section 10j of the Endangered Species Act).

The UCSRB facilitates a regional collaborative process to implement a non-regulatory, voluntary approach to recovery, to track progress, and to understand the effects of implementation on meeting overall recovery goals. Immediately following the listings in the late 1990s, the UCSRB formed as a coalition of three counties (Douglas, Chelan and Okanogan) and two tribes (Yakama Nation and Colville Confederated Tribe). The effect of that fifteen year partnership can be directly measured on the ground, and indirectly observed through the inter-governmental relationships that have developed over that time. The alternative to this approach 15 years ago, and still today, was a top-down, regulatory and enforcement approach to implementing the Endangered Species Act across all Pacific Northwest salmon and steelhead habitat.

Inherent in the creation of the Recovery Plan was the reliance on integration of actions across all sectors affecting salmon and steelhead (harvest, hatcheries, hydropower, and habitat), as well as integration of actions beyond the boundaries of the Upper Columbia region (e.g. lower Columbia, estuary, and ocean). While the Recovery Plan included specific actions for habitat as an attachment referred to as an "implementation schedule", it also acknowledges that actions in freshwater tributary habitat are not likely to be enough to achieve recovery on their own and should not be the sole focus of recovery efforts. The range of improvements needed to achieve viable salmonid populations will require continued recovery actions across all H-sectors (Figure 1).

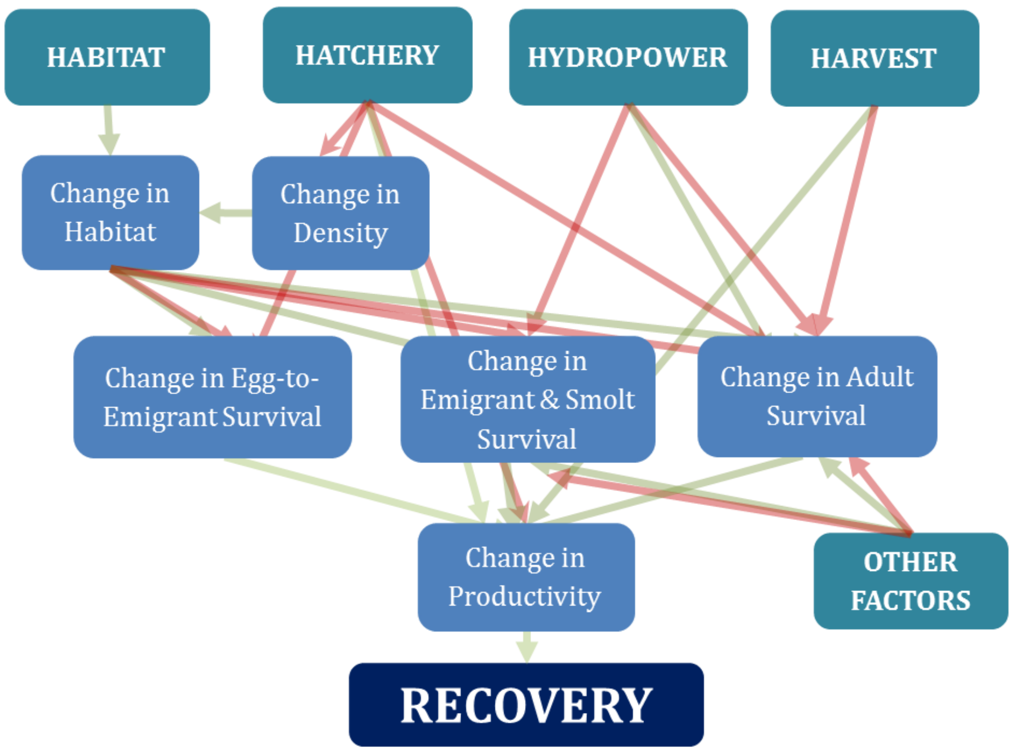


Figure 1. Conceptual drawing of the overall effect of different factors on different life stages, which together contribute to the overall health and recovery of Upper Columbia salmon and steelhead.

Integrated management of salmon and steelhead means coordinating decision-making to meet various recovery and legal objectives. Decisions about management programs tend to be made at higher levels, according to discipline, and in isolation from one another. The challenge is to work together to achieve recovery while honoring treaty and reserved rights, and meeting legal and regulatory requirements. etter alignment between the entities engaged in recovery goals and decision-making processes will improve our chances of meeting recovery goals and objectives while achieving sustainable, harvestable sport, commercial and cultural fisheries. T

As one strategy for addressing the need for coordination and integration of efforts across management sectors, the UCSRB created an Integrated Recovery Program. The purpose of this program is to track and report information about the status of actions affecting salmon and steelhead recovery across management and geographic boundaries for the purpose of informing decision-making and management. This Habitat Report is part of a series of Integrated Recovery reports summarizing the major management programs and their reported outcomes related to listed Upper Columbia salmon and steelhead management and recovery. These reports are intended to help support "All- H" collaboration and can be used to a) to improve integrated decision-making; b) as a communication and outreach tool; c) as a means for identifying key uncertainties and gaps in knowledge and understanding; and d) as a means for better understanding progress toward integrated recovery. These reports are based on unbiased, scientific information and data compiled from a variety of sources working within each sector.

Upper Wenatchee Watershed

Background

Upper Columbia Spring Chinook and Steelhead Life History

Salmon and steelhead use different habitats during different phases of their life. Monitoring programs help develop a better understanding of habitat use within stream reaches as well as in the Columbia River mainstem, estuary, and plume habitat, and in the nearshore and open Pacific Ocean. Although the use of these habitats during the life cycle can vary by individuals and population according to its life history, some general trends exist in how salmon and steelhead use freshwater, estuarine, and ocean habitat. We summarize the most recent information available on Upper Columbia life histories below.

Spring Chinook (Oncorhynchus tshawytscha): Spring Chinook or "stream-type" Chinook are differentiated from summer/fall Chinook or "ocean-type" Chinook by their return to freshwater several months in advance of spawning. Spring Chinook return in the spring before the late summer spawning season, returning to the Upper Columbia between May and August with a peak in May and June at Priest Rapids Dam (Columbia DART 2013). Adults hold in the tributaries for several months during the summer before spawning in rivers and streams from August to September. Incubation takes place over several months in the fall/winter and fry emerge in early spring. The majority of juveniles spend a full year in tributaries and emigrate as yearling to the Columbia River in the spring and out to sea. A varying percentage (15–60%) move downstream through the first summer or autumn and over-winter in the mainstem Wenatchee, before out-migrating to the ocean in the second spring along with those that over-wintered in the tributaries (Peven 2003). A small proportion (<1%) migrate directly to the mainstem Columbia as subyearling after their first summer in freshwater although the rate varies by year and by subbasin. The Entiat subbasin in particular seems to have a high rate of subyearling emigration to the mainstem Columbia (~50%) (ISEMP 2013). Some juveniles may also spend an additional year (2 years total) in freshwater before migrating to sea. To reach the ocean, juveniles swim roughly 500 miles down the Columbia River and pass through 7-9 dams and reservoirs of the Columbia River. In the ocean, Chinook feed in offshore and coastal waters for 1-5 (typically 2-4) years. Some males never migrate to the ocean and mature as parr or "mini-jacks", spawning the season after their second summer in freshwater, although this is rare (Murdoch et al. 2006).

Table 1. Summary of Spring Chinook life history timing in the Upper Columbia region.

Species	Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Spring Chinook	UC In-Migration												
	Tributary In-Migration												
	Spawning												
	Egg Incubation												
	Fry Rearing												
	Juvenile Rearing												
	Juvenile Out-Migration												

Summer Steelhead (Oncorhynchus mykiss): Stream-maturing (summer) steelhead are differentiated by their return to freshwater during the summer months, entering the Upper Columbia between June and November with a peak from August to September at Priest Rapids Dam (Columbia DART 2013). Adults hold for several months over the fall and winter before spawning, with some holding in their natal tributaries and others holding in the mainstem Columbia or other tributaries in the system (WDFW, unpublished data). Spawning typically occurs between March and June the following spring in rivers and creeks. Steelhead can spawn more than once, either after residence instream or migration to and from the ocean. A proportion of adult steelhead emigrate from the tributaries after spawning and are known as *kelt*. Kelt can make several trips to the ocean and back to the spawning grounds in their lifetime (Groot and Margolis 1991; Quinn 2005). Although Upper Columbia populations exhibit this life history, the incidence of successful iteroparity in Columbia Basin steelhead populations appears to be negatively correlated with distance from the ocean and therefore repeat spawning success is likely very low for the

Upper Columbia (WDFW unpublished data). After about a month in the gravel redd, fry emerge in the spring and early summer and juveniles initially reside in their natal streams. Life history strategies and freshwater residence time of juvenile steelhead are highly variable. Steelhead typically spend 1-3 years (average of 2-3 years) in freshwater before migrating downstream to the ocean in the spring. There they spend another 1-4 years (average of 2-3 years) although size and age at maturity varies greatly, depending on habitat and life-history.

Table 2. Summary of steelhead life history timing in the Upper Columbia region.

Species	Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Steelhead	UC In-Migration												
	Tributary In-Migration												
	Spawning												
	Egg Incubation												
	Fry Rearing												
	Juvenile Rearing												
	Out-Migration												

Species Status and Trends

Abundance of Upper Columbia spring Chinook and steelhead populations declined to extremely low levels in the mid-1990's and stayed low until the time of listings in the late 1990's. Numbers increased to levels above (Wenatchee and Methow) or near (Entiat) the recovery abundance thresholds in the early 2000's, and are now at levels intermediate to those of the mid-1990's and early 2000's (Figure 2). Overall trends in productivity indicate swings within the Upper Columbia populations between times of high productivity and low productivity. NOAA periodically reviews the status of what are termed the "viable salmonid population (VSP)" parameters to assess viability of listed species. These parameters are defined as: *abundance, productivity (population growth rate), spatial structure, and diversity*. A viable evolutionary significant unit (ESU) is **naturally** self-sustaining, with a high probability of persistence over a 100-year time period. Definitions for each VSP parameter are provided below.

Abundance is the number of fish produced by natural processes that have spent their entire life cycle in nature (i.e., natural-origin fish). This is often referred to as gravel-to-gravel survival or fish originating from naturally spawning parents that hatch in a stream's gravel and that survive to spawn naturally themselves years later.

Productivity is a measure of reproductive effectiveness at the population level. Typically it is stated as the number of adult offspring (recruits; which adds the number of adults harvested or taken for broodstock to the number actually arriving on the spawning grounds) produced per parent (spawner). In its most basic form it is calculated by dividing the total number of spawners in any year into the number of adult recruits that are subsequently produced by these spawners.

Spatial structure is the range or distribution of wild fish (adult spawners) within a population's habitat range. Populations with restricted distributions (or ranges) and few spawning and rearing areas are at a higher risk of extinction due to natural events than those populations with a wide distribution and access to multiple spawning and rearing ares.

Diversity refers to the distribution of traits within and among populations of salmon and steelhead. These traits include anadromy, morphology, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, physiology and molecular genetic characteristics. A combination of genetic and environmental factors largely causes phenotypic diversity. Habitat, harvest, and hatchery factors can all affect diversity.

Viability criteria for Upper Columbia populations were developed in the Recovery Plan based on recommendations by the Interior Columbia Technical Review Team (ICTRT). The ICTRT (2007) established four categories for populations based on *intrinsic potential*: Basic, Intermediate, Large, and Very Large. The ICTRT then assigned species-specific minimum abundance and productivity thresholds associated with the categorizations. In the Upper Columbia, the population-viability criteria for each population of spring Chinook salmon and steelhead are shown in Table 1. Populations within the ESU must all meet these thresholds to achieve the delisting criteria.

Table 3. Recovery thresholds (UCSRB 2007) and current status of Upper Columbia spring Chinook salmon and steelhead based on NOAA's VSP parameters (see above).

ESU	Independent Population	Minimum Adult Abundance Threshold[a]	Current Adult Abundance[a,b]	Productivity Threshold	Current Productivity[c]	Spatial Structure/ Diversity (SS/D) Risk Threshold	Current SS/D Risk[c]
Upper Columbia Summer Steelhead DPS	Wenatchee	1,000	1,104	1.1	0.87	Moderate	High
	Entiat	500	166	1.2	0.55	Moderate	High
	Methow	1,000	610	1.1	0.32	Moderate	High
	Okanogan[d]	500	181	1.2	0.15	Moderate	High
Upper Columbia Spring Chinook ESU	Wenatchee	2,000	562	1.2	0.61	Moderate	High
	Entiat	500	183	1.4	1.08	Moderate	High
	Methow	2,000	413	1.2	0.45	Moderate	High
	Okanogan	Not defined (extinct)					

[a] *12-year geometric mean of natural-origin adult returns in each subbasin*
[b] *12-year geometric mean of natural-origin adult returns based on information from NOAA Salmon Population Summary (SPS) database (SPS 2013) for data up to 2010, Washington Department of Fish and Wildlife Salmonid Stock Inventory database (SASI 2013) for data 2011-2012, and WDFW (personal communication) for 2013 data.*
[c] *From Ford, M. (2013).*
[d] *The viability criteria for Okanogan steelhead are for the U.S. portion of the population only.*

In its last *5- Year Status Review* for Upper Columbia spring Chinook and steelhead, NOAA noted an increase in the mean abundance of adult natural-origin adults. However, it concluded that both species are still at high risk for extinction, and that none of the Upper Columbia populations meet the recovery criteria established in the Recovery Plan. Spring Chinook have experienced decreases in productivity and although there has been an increase in the abundance and productivity of UC steelhead, the improvement has been minor. Hatchery-origin spawners constitute a high fraction of total spawners in the region for both steelhead and spring Chinook.

The observed abundances of natural-origin spring Chinook are well below those documented in the 1960's and estimated historically. Comparing 2004-2008 retuns to 1997-2001, however, there has been an average increase of 72% in natural adult returns. The trend in total spawners since 1995 has been positive for all three populations of spring Chinook. Steelhead abudance shows similar overall patterns to spring Chinook. Across the region steelhead natural adult returns increased 171% from 2003-2008 compared with returns from 1997-2001 (Figure 2).

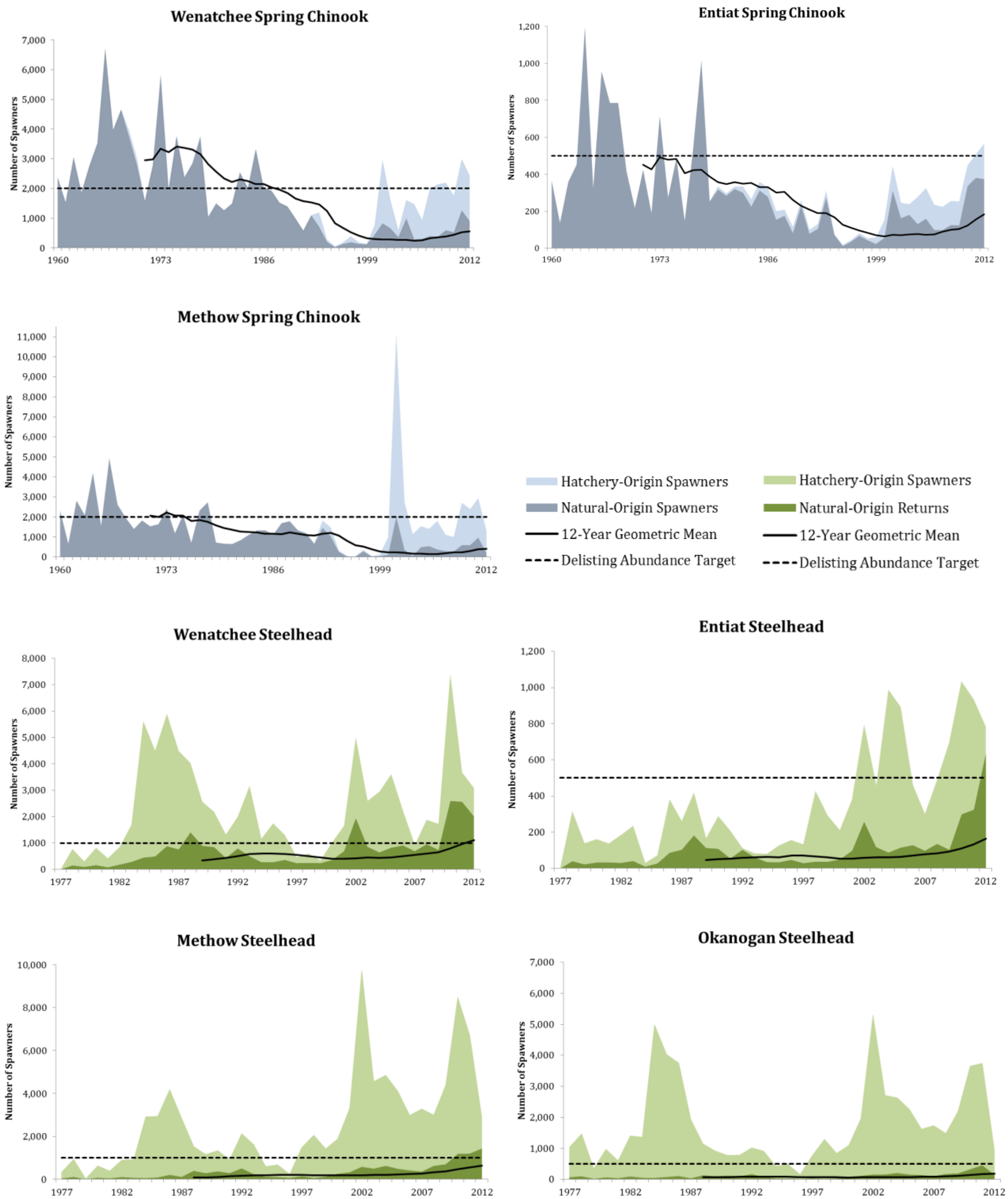


Figure 2. Returns of spring Chinook and steelhead to Upper Columbia tributaries with 12-year geometric means of abundance and delisting abundance targets indicated for each population. Source: NOAA Salmon Population Summary (SPS) database (https://www.webapps.nwfsc.noaa.gov/apex/f?p=261:home:0) and 2010-2012 from Washington Department of Fish and Wildlife Salmonid Stock Inventory database (http://wdfw.wa.gov/conservation/fisheries/sasi/) and WDFW (personal communication) for 2012 steelhead returns. Note: Estimates of returns prior to 2012 were done using radio telemetry data to assign appropriation for each subbasin whereas the 2012 steelhead returns were calculated using PIT tag data from each subbasin.

Despite recent upward trends in abundance, productivity for populations of spring Chinook and steelhead has changed very little and population growth rates are well below replacement. Long-term trends in productivity indicate swings within the Upper Columbia populations between times of high productivity and low productivity. On average, however, spring Chinook productivity has been lower or remained stable in recent years (1999-2008) compared with previous years (1994-2003). Steelhead productivity has remained neutral or been slightly higher in recent years (2000-2009) compared with previous years (1994-2003) in all four subbasins (Ford 2011). Productivity is influenced by both freshwater tributary egg to emigrant survival, out of basin smolt to adult survival (SAR), as well as adult pre-spawn mortality. These measures are summarized below (Table 4).

Current estimates from fish monitoring efforts indicate an average egg-to-emigrant survival rate of 4% (100-500 emigrants/redd) for spring Chinook in the Upper Columbia although suvival has ranged from lows of under 1% to over 15% depending on the population and year. The highest egg-to-emigrant survival rates for spring Chinook are in the Wenatchee River followed by the Twisp River (a tributary to the Methow) and the Methow River. Egg-to-emigrant survival for steelhead is on average 1.1% (118 emigrants per redd) with ranges between <0.1% and >3%. The Methow has the lowest juvenile survival rates and the Wenatchee has the highest (Hillman et al. 2013; Snow et al. 2013; and Jeremy Cram, pers. comm., December, 2013). Although little data have been summarized on egg to emigrant suvival across the Columbia, the Upper Columbia steelhead egg-to-emigrant surival rate is similar to steelhead in the Umatilla River (0.9%) (Hanson et al. 2010); spring Chinook in the Tucannon River (5.5%) (Gallinat and Ross 2013); and other small tributaries in the basin (353 emigrants/redd average for 17 sampled tributaries) (Charlie Paulsen, pers. comm., October 2013). Current estimates of egg-to-emigrant rates for the Upper Columbia are summarized in Table 4.

Smolt to adult return rates (SAR) represents a significant component of survival and can illustrate changes in the Columbia River mainstem and estuary/ocean survival versus changes in tributary spawning and rearing survival. SAR has been shown to be highly correlated to ocean conditions and seaward migration conditions through the Federal Columbia River Power System (FCRPS) (Schaller et al. 2007; Petrosky and Schaller 2010; Haeseker et al. 2012; Hall and Marmorek 2013). SAR for wild fish from Upper Columbia populations is tracked by the Columbia Fish Passage Center as part of its Comparitive Suvival Study. Overall SARs have been calculated as the proportion of PIT tagged Upper Columbia smolts detected at Rocky Reach Dam that return as adults to Bonneville Dam. According to this study Upper Columbia Spring Chinook SAR ranged from lows less than 0.5% to highs near 2% (avg. 0.98%) between 2007-2011. Steelhead typically have a slightly higher SAR than spring Chinook and SARs from the Upper Columbia ranged from lows <2% to highs near 5% (avg. 2.76%) between 2008 and 2010 (Fish Passage Center 2013). The Tucannon River has an estimated SAR of 2% (1985-2008) for natural-origin fish and an SAR of 0.2% for hatchery-origin fish (Gallinat and Ross 2013). Current estimates of SAR rates for the Upper Columbia are summarized in Table 4.

The proportion of adults that enter their natal tributary and survive to spawn (pre-spawn mortality) is another important survival indicator. Several factors have been found to contribute to the loss of returning adults in freshwater including high densities of adults, environmental factors, and poor fish condition (e.g. Quinn et al. 2006; Keefer et al. 2010; Belchick et al. 2004). Steelhead counted at Tumwater dam in the Upper Wenatchee show that on average about half of the fish that pass Tumwater Dam survive and spawn in the upper watershed (Andrew Murdoch, WDFW, pers. comm. December 2013). Similar data from the Methow and Twisp River indicate a pre-spawn mortality rate of 50-70% for those areas (Charles Frady, pers. comm. December 2013). As a comparison, Yakima River adult survival averages close to 66% (Andrew Murdoch, pers. comm. December 2013). Current estimates of pre-spawn mortality rates for the Upper Columbia are summarized in Table 4.

Table 4. Summary of average survival rates for different life stages in tributaries where estimates are available.

Species	Subbasin	Productivity[a] (Spawner-to-Spawner)	Egg-to-Emigrant Survival[b] (%)	Smolt-to-Adult Survival[c] (%)	Pre-Spawn Mortality[d] (%)
Spring Chinook	Wenatchee	0.61	4.48	0.85	46
	Entiat	1.08	4.2		
	Methow	0.45	1.29		43
	Twisp		4.54		
Steelhead	Wenatchee	0.87	1.72	0.78	49
	Entiat	0.55	1.5		
	Methow	0.32	0.38	0.71	62
	Twisp		0.75	1.36	
	Okanogan	0.15			

[a] *1999-2009 from Ford (2011)*

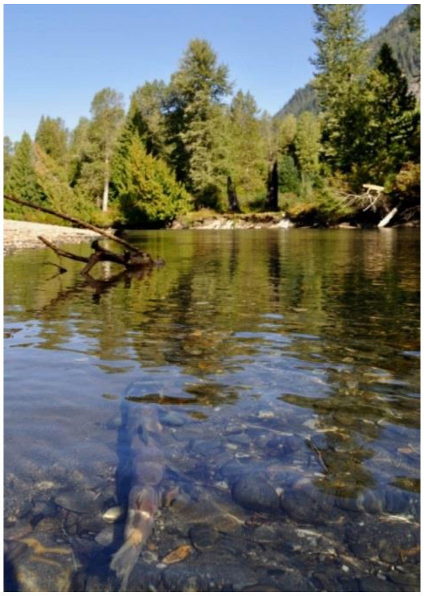
[b] *2001-2010 from Snow et al. (2013) and Jeremy Cram, pers. comm. (December, 2013)*

[c] *2006-2010 from Snow et al. (2013) (MET-WELLS) and 2007-2010 Tuomikoski et al. (2013) and Fish Passage Center (2013) BOA-RRE*

[d] *Based on wild female escapement and redd counts; Steelhead – Wenatchee (2000-2009) from Andrew Murdoch, pers. comm (December 2013) and Methow (2006-2012) Charles Frady, pers. comm (December 2013); Spring Chinook- Wenatchee (2000-2009) and Methow (2006-2009) from Jeremy Cram, WDFW, pers. comm (May 2014)*

In the 2010 5-year Status Review, NOAA gave the three Upper Columbia spring Chinook populations and the four Upper Columbia steelhead popualtions a rating of high risk for diversity. The main factor influencing the diversity of Upper Columbia populations is the chronically high number of hatchery spawners in natural spawning areas and lack of genetic diversity among natural-origin spawners (ICTRT 2008; ICTRT 2011). The Entiat subbasin is currently the only subbasin without hatchery supplementation and is still influenced by high numbers of stray hatchery fish. The proportion of hatchery spawners in natural spawning areas of spring Chinook over the past 10 years has been 61% on average (64% Wenatchee; 42% Entiat; 76% Methow). For steelhead the average has been 75% (55% Wenatchee; 68% Entiat; 86% Methow; 92% Okanogan) (NOAA SPS database 2013; WDFW SASI database 2013). In addition to a change in genetic diversity, populations in the Upper Columbia have undergone a loss of life history diversity due to the loss of habitat.

In terms of the spatial structure of Upper Columbia populations, most habitat is currently accessible and many fish passage issues have been resolved. Remaining barriers are primarily related to flow issues, small road-stream crossings, and diversions. Chief Joseph and Grand Coulee dams on the mainstem Columbia prevent access into Canadian portions of Columbia Basin, and dams on the Okanogan and Similkameen basins prevent access into Canadian portions of those watersheds.


Adult Chinook in the Upper Wenatchee

Based on the current status of Upper Columbia populations, productivity and diversity may require the most improvement to achieve delisting criteria (Ford 2013). Most populations will require a significant improvement in productivity (between 30-100% increase for spring Chinook and between 26-700% increase for steelhead). All population also rated as having a high risk for diversity (Ford 2013) in the last NOAA Status Review and that must be reduced to moderate across all populations.

Upper Columbia Salmon and Steelhead Recovery Strategy- Habitat

Habitat loss is most often cited as the primary reason for the decline of salmon populations in the Northwest (Bisson et al. 2009). This is true for the Upper Columbia where past land use and conversions related to agriculture, timber harvest, floodplain development, and channel modifications has reduced the availability and function of habitats. The Recovery Plan recognizes the importance of functional, intact habitat that can sustain healthy salmon populations over the long-term. An effort to protect and restore high quality habitat is at the core of the recovery strategy.

The list of recommended actions identified in the Recovery Plan represents coalescence in recovery implementation. Habitat actions were selected from other plans (e.g., Power Council subbasin plans, watershed plans, *Wy-Kan-Ush-Mi Wa-Kish-Wit* [Spirit of the Salmon], The Tribal Fish Recovery Plan and the USFWS Bull Trout Draft Recovery Plan), modeling, public input, and the best available science. Habitat actions are refined based on input from local landowners and land managers and additional sources. These actions are believed to represent a sound scientific approach based on available information and tools, address the range of known threats, and are generally considered feasible within the known constraints of the Upper Columbia. However, the Recovery Plan also recognizes that uncertainty exists for many actions because of insufficient information. The UCSRB developed the Adaptive Management Strategy (Appendix Q in UCSRB 2007) to account for adjustments in direction and effort in the implementation strategy. The adaptive management process recognizes that the key political and biological assumptions of the Recovery Plan need to be tested and adjusted as recovery progresses, and as we learn more in the physical, biological, and social science disciplines. The strategy allows recovery partners to capitalize on new information, new developments, and evolving opportunities. The list of overall recovery goals and objectives for habitat are summarized on the following page.

In the adaptive management framework, recovery actions are intended to address uncertainties in the magnitude of effect of any given action and the effort required to achieve a given improvement. The regional Biological Strategy (Appendix H in UCSRB 2007, updated RTT 2013) complements the Recovery Plan by providing further support and guidance, and serves as the technical foundation to set regional priorities for habitat protection and restoration actions. The Biological Strategy is developed by the Upper Columbia Regional Technical Team (RTT), and is periodically revised. The Recovery Plan, Biological Strategy, and specific program objectives within each H-sector are used to guide decision-making. The RTT worked with various stakeholders within and outside of the region to generate criteria and recommendations on habitat restoration and protection projects.

Tyee Ranch restoration project in the Entiat River.

Upper Columbia Salmon and Steelhead Recovery Plan (UCSRB 2007)

Short and Long-Term Habitat Recovery Objectives:

Short-Term (0-15 years)

- Protect existing areas where high ecological integrity and natural ecosystem processes exist
- Restore connectivity (access) throughout the historic range where feasible and practical for each listed species
- Where appropriate, establish, restore, and protect stream flows (within natural hydrologic regimes and exiting water rights) suitable for spawning, rearing and migration.
- Protect and restore water quality where feasible and practical within natural constraints.
- Increase habitat diversity in the short term by adding instream structures (e.g. large woody debris, rocks, etc.) where appropriate.
- Protect and restore floodplain function and reconnection, off-channel habitat, and channel migration processes where appropriate and identify long-term opportunities for enhancing these conditions.
- Restore natural sediment delivery processes by improving road network, restoring natural floodplain connectivity, riparian health, natural bank erosion, and wood recruitment.
- Replace nutrients in tributaries that formerly were provided by salmon returning from the sea.
- Reduce the abundance and distribution of non-native species that compete and interbreed with or prey on listed species in spawning, rearing, and migration areas.

Long—Term (50-100 years)

- Protect areas with high ecological integrity and natural ecosystem processes.
- Maintain connectivity through the range of the listed species where feasible and practical.
- Maintain suitable stream flows (within natural hydrologic regimes and existing water rights) for spawning, rearing, and migration.
- Protect and restore water quality where feasible and practical within natural constraints.
- Protect and restore off-channel and riparian habitat.
- Increase habitat diversity by rebuilding, maintaining, and adding instream structures (e.g. large woody debris, rocks, etc.) where long-term channel form and function efforts are not feasible.
- Restore natural processes (channel migration, etc.) where feasible.
- Reduce sediment recruitment where feasible and practical within natural constraints.
- Reduce the abundance and distribution of non-native species that compete and interbreed with or prey on listed species in spawning, rearing, and migration areas.

Building on the Biological Strategy, the region uses a river reach-based action approach to ensure priority habitat projects are implemented with a clear understanding of the existing physical processes. This reach-based approach to project development incorporates information from tributary-scale and reach-scale hydro-geomorphic assessments and monitoring, which inform restoration and protection actions based on an assessment of channel processes and habitat impairments. As reach-level degradations and processes are defined, alternatives are produced in order to identify, sequence, and prioritize specific actions to protect and/or restore channel and floodplain connectivity and complexity. In concert with this reach-based approach, the Entiat subbasin is implementing a basin-scale experimental approach, which pairs reach-based actions with effectiveness monitoring at the subbasin scale.

The highest priority in the region for increasing biological productivity in degraded areas is to restore the complexity of the stream channel and floodplain function. The RTT recommends a range of strategies for habitat **restoration** in the Upper Columbia, based on a fundamental emphasis on promoting properly functioning geo-fluvial processes that control habitat diversity, instream flows, and water quality throughout the watershed. The highest priority for **protecting** biological productivity is to allow natural geo-fluvial processes, such as unrestricted stream channel migration and sediment transport, instream complexity, and floodplain function where it exists. In general, the goal for habitat protection is to target the highest functioning habitat at the greatest risk of degradation. Protection of existing stream flows in virtually all subbasins in the region is also important to maintaining biological productivity.

Implementation of habitat actions involves many steps. In short, implementation includes addressing data gaps, establishing schedules, engaging stakeholders and landowners, identifying responsibilities, securing funding, permitting, and designing and carrying out actions. Most of this work is done by individual partners with assistance and coordination through key local and regional partnerships, including the UCSRB. Within the region there are currently 14 project sponsor organizations working to implement habitat actions identified in the Recovery Plan. Project sponsors work together through an established framework facilitated by the UCSRB and that is described in Chapter 8 in the Recovery Plan. The framework includes a regional Implementation Team and local Watershed Action Teams. Habitat recovery efforts are ultimately implemented and sustained through public partnership and involvement.

Recovery Plan Implementation – Habitat

Compared with other Columbia basin systems, habitat in the Upper Columbia region has not been subjected to as significant conversion, and is in relatively good condition. The higher elevation areas of most Upper Columbia subbasins are within public ownership and management and thus remain undeveloped. In many lower elevation areas, human activities acting in concert with natural occurrences (e.g. floods, drought, fires, wind, ocean cycles, etc.) have impacted habitat conditions (habitat diversity and quantity, connectivity, and riparian function), and have compromised ecological processes. Water quality and quantity have also been affected by land-use and management activities. Loss of woody debris and floodplain connectivity have reduced overwinter habitat for salmon, steelhead, and bull trout in the larger rivers. Factors that affect fish habitat historically have been partially addressed through changes in land-use practices (e.g. fish screens at diversions, riparian buffer strips, improved livestock management, etc.).

As noted in the Recovery Plan, the recovery of listed salmon, steelhead, and bull trout populations in the region is dependent upon the implementation of habitat restoration and protection actions. Several planning processes provide detailed assessments that identify the highest priority areas that are the most appropriate for reach-scaled restoration and protection programs and the selection of projects and actions is based on these priority recovery actions and reaches. Within these priority areas, the focus is first on maintaining the best remaining functional habitat that has characteristics of biological integrity, connectivity, and diversity. Restoration efforts are focused on restoring natural processes where feasible, and enhancing habitat when processes cannot be fully restored. Within the past several years, habitat restoration has shifted toward larger scale projects designed to address reach-based ecological concerns.

The core foundation of the Recovery Plan is a non-regulatory, voluntary approach that relies heavily on habitat improvements and protection projects and on willing landowner cooperation to implement habitat actions. For more than 15 years, project sponsors have worked with private landowners and state and federal land managers to implement restoration and protection projects across the region. The region is comprised of 52% federal lands, 6% state lands, and 42% private land; the majority of salmonid habitat is within private land ownership. For this reason, a large proportion of projects have occurred on private lands (58% of projects), with a lesser number occurring on federal lands (37%) and state lands (<5%). This means that at least 150 individual private landowners have willingly agreed to habitat protection or improvement on their property. Without the generous cooperation of these private landowners across the region the habitat benefits for listed species and the general public would not be possible.

Habitat programs are primarily funded through several hydrosystem mitigation and recovery programs. Funding comes through a variety of sources, such as the Washington State Salmon Recovery Funding Board, Pacific Coastal Salmon Recovery Fund, the Mid-Columbia Habitat Conservation Plans and Settlement Agreements, and the Federal Columbia River Power System Biological Opinion (2008). Other funding sources include non-governmental organizations and other local, state, and federal programs. Early in the process of Recovery Plan implementation, the UCSRB asked the Regional Technical Team (RTT) for help in aligning recovery goals and objectives with habitat-related processes and priorities. Working with funding agencies and partners, this joint effort has resulted in a coordinated process for identifying, developing, funding, and implementing high-priority habitat projects throughout the region, regardless of the driver of the funding source (i.e. mitigation or recovery).

Restoration on the Chewuch River

Habitat Status and Trends

The quality and quantity of habitat from freshwater tributaries to the mainstem Columbia, estuary, and ocean has a profound impact on the status of Upper Columbia salmon and steelhead populations. Within freshwater tributary habitat, numerous stream processes can affect the success of spawning and rearing of salmonids. Successful spawning and rearing require a combination and diversity of habitat characteristics, including cool, clean water, appropriate water depth, and velocity, upland and riparian vegetation to stabilize stream banks and provide shade and prey, clean gravel for spawning, incubation, and early rearing, and large woody debris to provide cover and prey habitat. In the mainstem Columbia, habitat is driven largely by the mainstem hydropower operations and primary habitat factors affecting survival include flow, predation, food availability and quality, water quality (e.g. dissolved gas), and temperature and water quality (Ebel et al. 1989). The condition of the Columbia River estuary, plume, and the North Pacific ocean also have a large influence on the growth and survival of salmon and steelhead from the Upper Columbia region and factors such as predation and prey availability can have a large effect on productivity (e.g. Wells et al. 2008; Pearcy and Mckinnell 2007; Tomaro et al. 2012).

Not only is the condition of habitat important to recovery but also the natural function of these habitats. Pacific salmon evolved under dynamic physical and climatic conditions and natural ecological processes create a variety of habitat conditions and combinations over time. Natural disturbances such as wildfire, landslides, and flood events have historically contributed to the development of habitat diversity. Human development over the last two centuries has disrupted natural disturbance regimes however the productive capacity of the ESU depends on the continuation of the natural ecological processes (UCSRB 2007).

Columbia River Mainstem, Estuary, and Ocean Habitat Conditions

Mainstem Columbia River and North Pacific Ocean habitat is important for the growth and survival of salmon and steelhead from the Upper Columbia region. In this section we provide a short synopsis of information about Columbia River mainstem, estuary, plume, and ocean conditions and summarize how they are used by Upper Columbia populations. All 13 ESA-listed species of salmon and steelhead in the Columbia River basin use the mainstem and estuary for migration to and from freshwater natal areas to the Pacific Ocean, where they grow from juveniles to mature adults. Salmon and steelhead from the Upper Columbia region use roughly 500 miles of mainstem Columbia River habitat each way during outmigration and upstream migration. They spend from a few days to a few months or more rearing and migrating in the mainstem, the estuary, and then the Columbia River plume offshore before leaving for nearshore and open ocean habitat. The hydropower system in the Columbia will be covered in a later report in this series, but hydropower systems do influence habitat conditions for juvenile and adult salmon and steelhead. Out-migrating smolts from the Upper Columbia usually spend little time within the mainstem corridor. According to tagging data and travel speeds between Rock Island and Bonneville Dams, it takes a juvenile steelhead approximately 36 days and juvenile Chinook approximately 47 days to get to the estuary once it begins its downstream migration in the Columbia River mainstem (PTGIS database, accessed December 2013). English et al. (2006) found similar travel times for adult Chinook and steelhead when they return upstream.

Estuaries are important for salmon and steelhead in terms of providing rearing habitat for growth, potential refuge from predation and a physiological transition before emigrating to the higher salinity in the marine environment (Thorpe 1994; Quinn 2005). Although subyearling summer Chinook have been found rearing in estuary habitats, and can have extensive residence time in the estuary (2 months or more), relatively few spring Chinook have been caught in the estuary and little is known about the importance of this area to these populations (Bottom et al. 2011). This question will be informed by future research. In general, scientists believe steelhead do not use the estuary for rearing but rather as transitional migratory habitat (Carter et al. 2009).

Columbia River Estuary

An *Estuary Recovery Plan Module* (NOAA 2011) was developed to address issues in the Columbia River estuary and plume for all listed species in the Columbia River basin. Other downstream mainstem reaches that are used by Upper Columbia species are addressed in the draft *Lower Columbia* (Dornbusch and Sihler 2013) and final *Middle Columbia* (Berwick et al. 2009) regional recovery plans as well as in the *Mainstem Columbia River Hydropower Module* (NOAA 2008).

A complete list of threats to Upper Columbia salmon and steelhead related to habitat in the estuary and ocean can be found in Fresh et al. (2005). In this report and other subsequent studies, predation has been found to be a major threat to salmon and steelhead in the estuary, especially stream-type (spring Chinook and steelhead) ESUs. Predation, although a natural process in these ecosystems, has been exacerbated by anthropogenic changes in these environments. The major sources of predation on Upper Columbia spring Chinook and steelhead in the mainstem Columbia River are terns and cormorants, predatory fishes and sea lions. Caspian terns and double-crested cormorants are a threat to juvenile salmonids, consuming 13.8% of pit-tagged Upper Columbia steelhead and 3.4% of PIT-tagged Upper Columbia spring Chinook in the estuary between the years 2007-2010. Consumption of Upper Columbia listed species by terns and cormorants is even greater when including inland nesting colonies located upriver (26.6% UC steelhead and 7.8% total UC spring Chinook) (Evans et al. 2012).

In 2013, sea lions were estimated to have consumed almost 3,000 adult Columbia River spring Chinook and steelhead below Bonneville Dam, approximately 2.4% of the adult run at the dam between January 1 and May 31, 2013 (Stansell et al., 2013). Chinook salmon were the most common prey, comprising 97.5% of the observed catch. Keefer et al. (2012) found the predation risk for Chinook was highest for early migrating spring-run populations (Icicle River hatchery run) and lowest for populations with large summer runs (Okanogan and Wenatchee River populations), due to relative predator density.

Nonindigenous species pose a potentially large effect on habitat for Upper Columbia species, especially in the mainstem Columbia River. Predatory fish, such as pikeminnow, walleye, and bass, are estimated to consume millions of juvenile salmon and steelhead annually in the Columbia and Snake Rivers. A recent literature review by Sanderson et al. (2009) concluded that the cumulative impact of invasive predatory fish on salmonids in the Columbia Basin is potentially substantial. Results from studies show that individual species consumption can range from 0-40% of an outmigrating juvenile salmon run in the basin. The authors concluded that predation by nonnative fishes on outmigrating smolts could be roughly equivalent to the productivity declines attributed to habitat loss and degradation depending on the population (Beechie et al. 1994), to harvest-related morality rates on adults (McClure et al. 2003), or even similar, on a per-run basis, to mortality related to mainstem dam passage. In addition to predation effects, there is the opportunity for other direct (e.g. competition) and indirect (e.g. food-web changes, habitat changes, etc.) effects. The WA Department of Fish and Wildlife maintains an active sport angling reward program that has reduced pikeminnow by 40% in these rivers since 1990, which translates to 4-6 million per year fewer young salmon consumed (*Salmonrecovery.gov*).

Changes in ocean conditions can also have large effects on the number of fish that return to the Upper Columbia. For example, adult returns during the period 1980-1999, which coincide with periods of poor ocean conditions, were much lower than those during better ocean conditions (2000-2004) (Figure 3) (UCSRB 2007). Ocean survival of Upper Columbia stocks has been linked to a number of factors from prey abundance and distribution to physical oceanographic conditions such as sea-surface temperature. The NOAA Northwest Fisheries Science Center has developed a suite of indicators related to ocean conditions important to salmon and steelhead (Ocean Ecosystems Indicators- NOAA Fisheries Service). The graph below shows how ocean conditions (based on these combined indicators) have changed since 1998 based on a range of factors related to salmon and steelhead survival during juvenile migration year (Peterson et al. 2012). Ocean conditions have fluctuated over the past 14 years since data has been collected on the biological, physical, and ecosystem indicators most influential on adult returns. This model shows that ocean conditions the first year of ocean residency can be strongly correlated with adult returns along with smolt body size (Zabel & Williams 2002, Duffy & Beauchamp 2011), and timing of marine entry (Scheuerell et al. 2009).

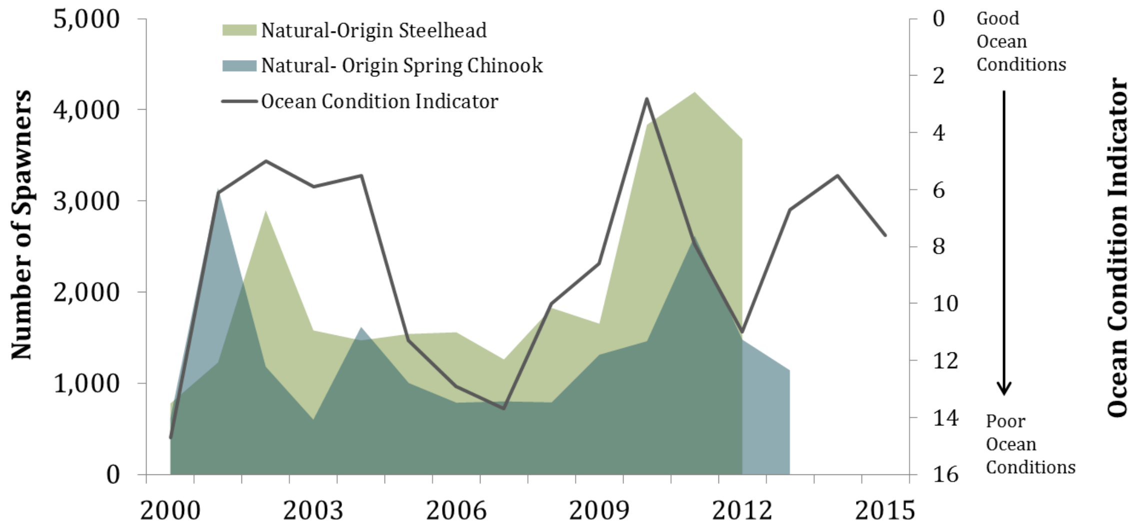


Figure 3. Upper Columbia Spring Chinook and steelhead abundance between 1998 and 2012 (see Figure 2 for data sources) along with rank score for ocean ecosystem indicators (Ocean Ecosystems Indicators- NOAA Fisheries Service; Peterson et al. 2012). Indicator data have been offset by one year to reflect average effect on returns.

Although there is little that can be done to influence ocean conditions, freshwater habitat actions can increase the likelihood that populations can survive varying ocean conditions. Diverse habitats can sustain diverse life histories, and life-history diversity spreads risk across different segments of a population, thereby buffering it from environmental variation over long time periods (Bottom et al. 2005). Given that life history types that are favored by natural selection are likely to change between years, practices that help improve the abundance, productivity, and life history and genetic diversity will help populations persist during periods of poor ocean conditions (Greene et al. 2009). Improvements in growth rates or size of smolts could also lead to improved ocean survival (Zabel and Williams 2002). Tomaro et al. (2012) found that size of upper Columbia River spring Chinook shortly after marine residence (~1 month) was positively correlated to adult returns (i.e. survival). This size characteristic was in itself related to the relationship between emigration timing and ocean conditions.

Upper Columbia Region Freshwater Habitat Condition

Landscape-Scale Habitat Condition

Instream and riparian habitat in most Upper Columbia subbasins is in relatively good condition, especially in high elevation reaches. However, human activities have reduced habitat quantity and quality in many lower elevation stream reaches, particularly within the private lands of the region that are centered near the valley bottoms. Activities within the Upper Columbia that have affected habitat conditions include diversions and dams, water diversion, stream channelization and diking, roads and railways, timber harvest, and urban and rural development (Mullan et al. 1992; Chapman et al. 1994, 1995; RTT 2013; Subbasin Plans 2004, 2005). Some of these factors that affected habitat historically have been partially addressed through changes in land-use practices and/or implementation of BMPs (e.g. fish screens at diversions, riparian buffer strips, improved livestock management, etc.). However, as noted in the Recovery Plan, many of the effects of these practices remain as a result of remnant infrastructure and over a century of previous land conversion/modifications.

Landscape factors such as flooding, drought, land management activities, and recent fire regimes have all been found to be associated with variability in habitat status of Columbia River streams (Al-Chokhachy et al. 2011). As part of Washington State's 2012 *State of the Salmon in Watersheds Report* land use and land cover conversion rates were assessed for the region based on high resolution change detection in a representative watershed (using the Wenatchee Water Resource Inventory Area - WRIA 46). According to the results, from 2009-2011 the Wenatchee watershed had only a small amount of development change (2 acres). The urban growth areas (at 1,557 acres) in the Wenatchee comprises about 0.5% of the land area, but hosts 8% of the change caused by development. The rate of change due to development was 50 times higher within the urban growth areas than outside them but was still generally low (0.03% within urban growth areas compared to 0.0005% outside). Nearly all (98%) of the land cover took place outside the urban growth areas, with the majority of that (83%) caused by natural disturbance. Of the 5 acres of change inside the urban growth areas, 8% was from development (see WA Recreation and Conservation Office 2012 for analysis - http://stateofsalmon.wa.gov/regions/upper-columbia-river/indicators/land-use-land-cover).

This analysis shows that land use and land cover conversion is likely a relatively minor factor in landscape change in the region. Some areas experience higher rates of development and land conversion than the assessed area, but as a whole natural disturbance plays the largest role in large-scale change. A map of the human population in the region shows that in general the human population is low and only a few core population areas exist where development is likely to occur at a significant scale. Those include the lower Wenatchee and the Omak area in the Okanogan. The Wenatchee and Okanogan in general have higher populations than the Entiat and Methow subbasins (Figure 4). Although land use and land conversion rates are low, they can play an important role in affecting fish habitat on a local or tributary scale where fish and human use overlaps, especially in many low elevation, valley segments of rivers, which can be important spawning, migratory, and rearing habitat.

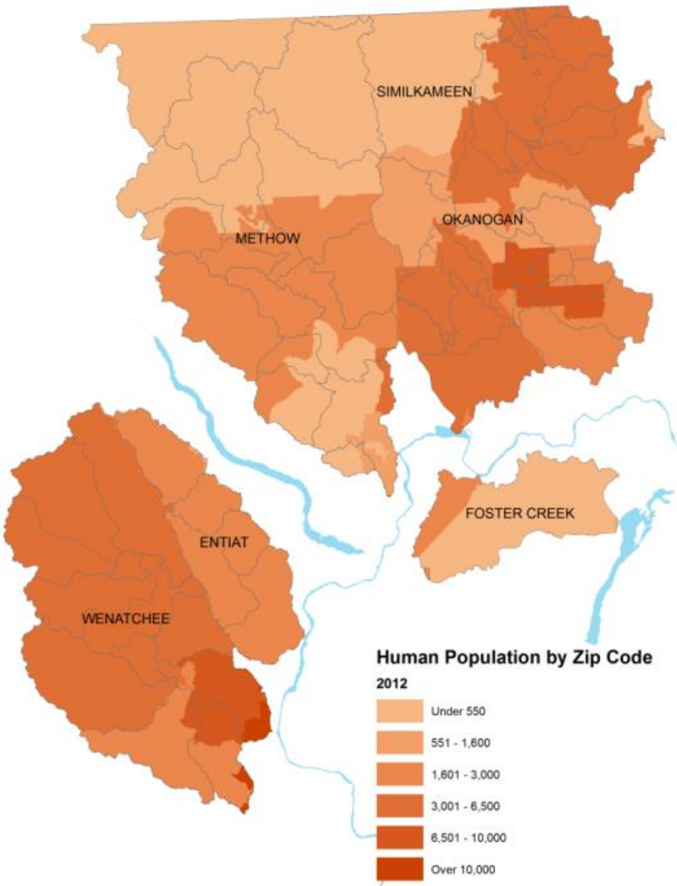


Figure 4. Map showing human population by zip code based on the 2012 projected population from the U.S. Census Bureau's 2010 census (www.census.gov).

Although much of the region remains undeveloped, an extensive forest road network has arisen over the past 100 years. These forest roads have widespread effects on landscape-scale processes and aquatic habitat in the Upper Columbia. Road densities in the region are some of the highest in the state and many of the issues with roads occur in the core areas for salmon and steelhead production. Other important factors that influence watershed health include fire and forest condition.

The U.S. Forest Service classified watersheds in the Okanogan-Wenatchee National Forest using its Watershed Condition Framework and a set of 12 core indicators (http://www.fs.fed.us/publications/watershed/). In addition to the overall *watershed condition classification* that combines all these indicators, several unique indicators can be used to represent aquatic habitat condition: aquatic habitat, riparian condition, roads and trails, fire condition class, and water quality. The *aquatic habitat indicator* represents data on habitat fragmentation, large woody debris, and channel shape and function. *The riparian indicator* represents the function and condition of riparian areas. The *roads and trails indicator* represents changes to the hydrologic and sediment regimes because of the density, location, distribution, and maintenance of the road and trail network. *Fire condition class* represents the potential for altered hydrologic and sediment regimes because of departures from historic range of variability in vegetation, fuel composition, fire frequency, fire severity, and fire pattern. Lastly, the *water quality indicator* highlights impaired waters (303(d)) listed) and other water quality problems. Regional maps of the watershed condition and individual aquatic habitat indicators are provided below in Figure 5.

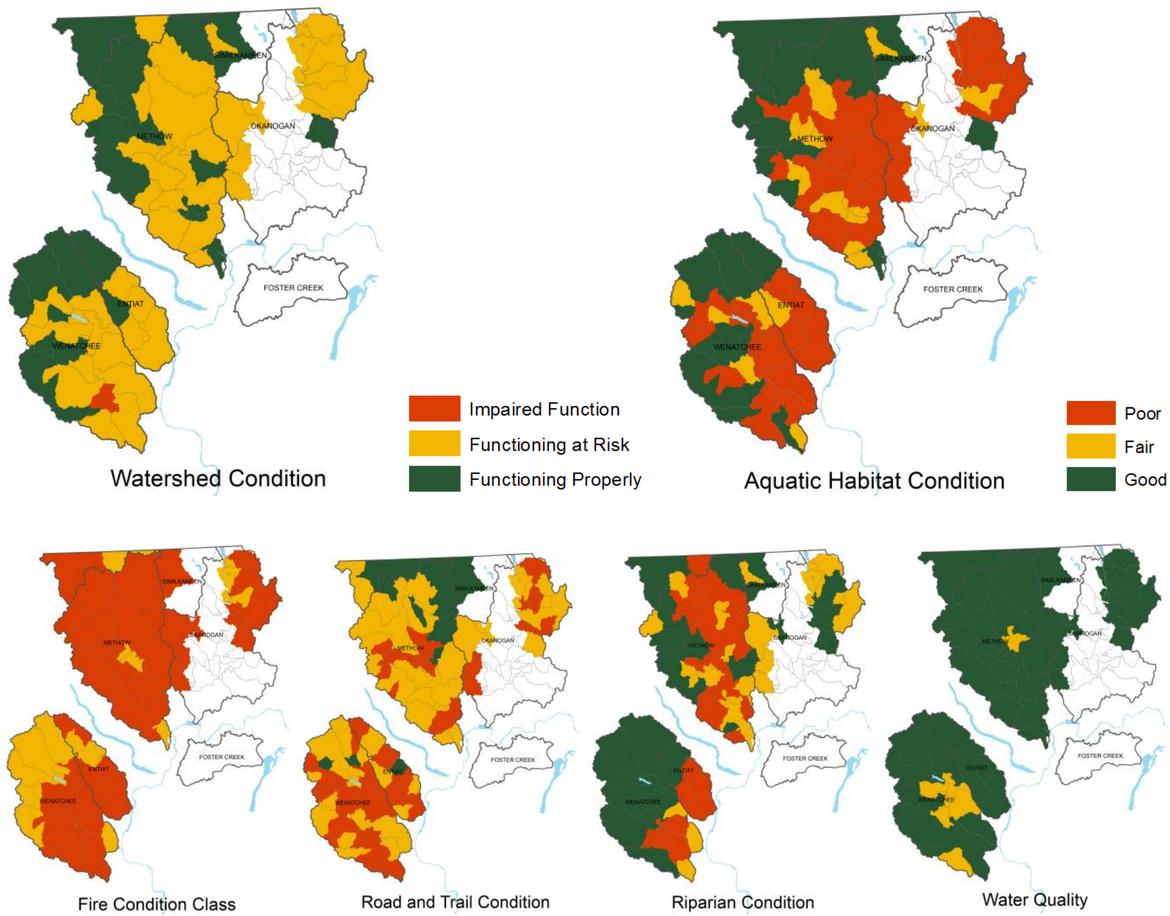


Figure 5. Maps showing USFS Watershed Condition Framework indicator values across the Upper Columbia Region. Assessment units are overlaid for reference.

In addition to human and natural disturbance, changes in precipitation and temperature have influenced trends in habitat over the past decade, particularly flow and water quality. Average annual temperature has increased approximately 1.1° F over the past three decades. This includes an increase of 2° F in the summer and 1.7° F in the winter. This change in temperature has exacerbated temperature issues in some areas during some times of the year. Precipitation has generally decreased approximately 1" per decade annually with changes across all seasons. Changes in temperature and precipitation during the winter have resulted in a decreased snowpack and lower snow-water equivalent in April (WA Office of the Washington State Climatologist 2013) leading to changes in runoff patterns and exacerbated low flow issues in some areas.

Watershed-Scale Habitat Condition

"Ecological concerns" are defined as the ecological conditions essential for maintaining the long-term viability of a given population of salmonids and are linked to abiotic and biotic features of habitat that cause mortality, injury, reduced health, or diminished reproduction (Hamm 2012). Ecological concerns and their assumed causal mechanisms (threats) that affect habitat conditions in each subbasin are summarized in the Regional Technical Team's *Biological Strategy* (RTT 2013) along with a detailed summary of habitat status in each of the 58 assessment units (sub-watersheds or portions of sub-watersheds) in the four major subbasins in the region.

Based on the most current data and information, as described in the Biological Strategy, the highest quality (least disturbed) habitat in the region exists in the upper watersheds of the Wenatchee, Entiat, and Methow subbasins (Figure 6). The most disturbed habitat exists in the Okanogan watershed and in areas of the Wenatchee subbasin.

Figure 6. Habitat quality across the Upper Columbia Region based on priority area designation of assessment units in the 2013 *Biological Strategy* (RTT 2013).

Different factors influence the quality and quantity of available habitat and the distribution of ecological concerns across the region. The type and extent of ecological concerns within watersheds is largely driven by human-caused and natural landscape-scale and reach-scale factors. The distribution of the most commonly cited ecological concerns in the region is mapped below in Figure 7.

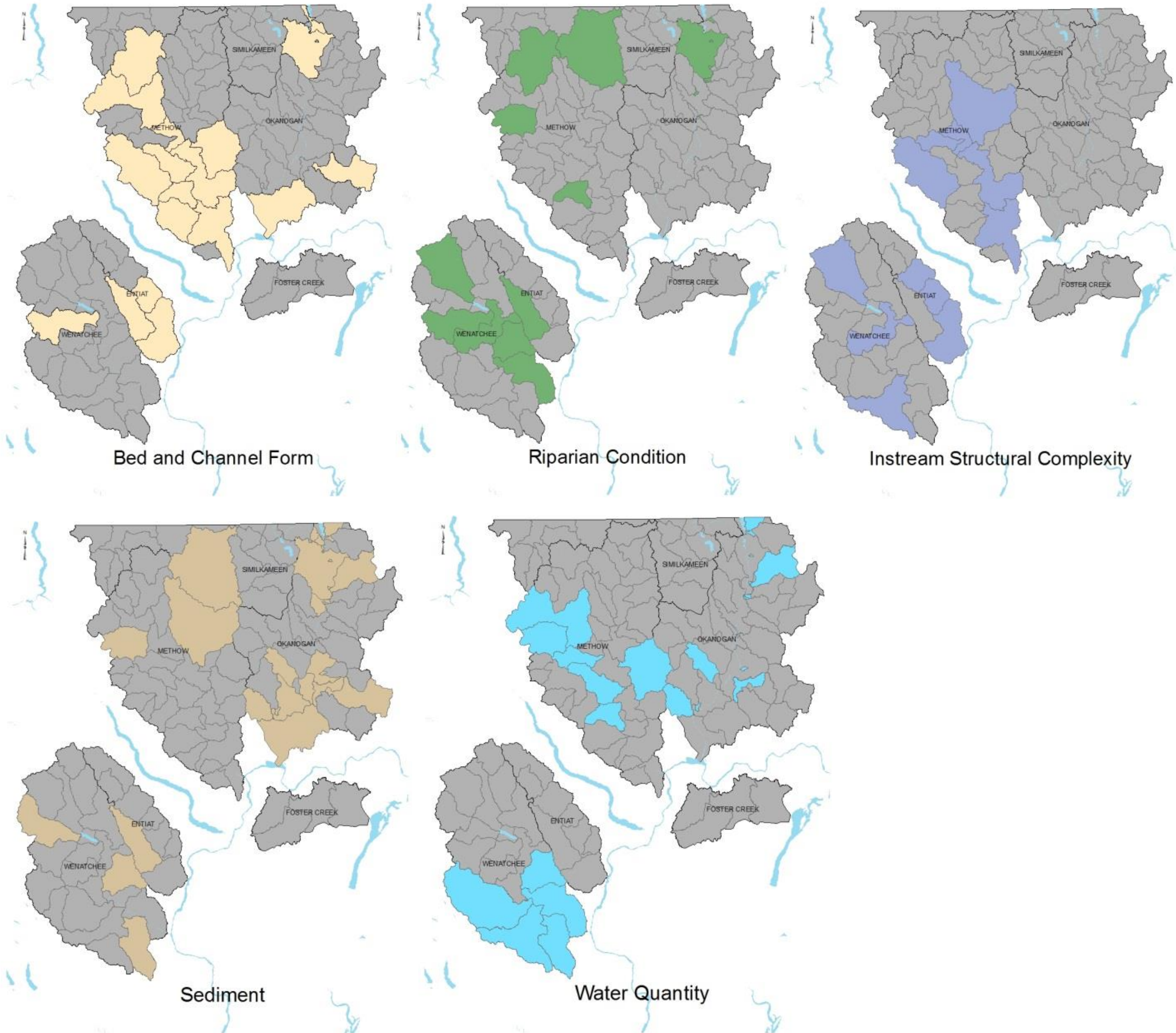


Figure 7. Distribution of primary ecological concerns (Priority 1, 2, or 3) across the Upper Columbia Region (UCTRT 2013).

Another effort to assess habitat conditions is the *Expert Panel* process. Expert Panels are used as the mechanism adopted under the Federal Columbia River Power System Biological Opinion to estimate the progress of, and resulting survival improvements from, mandated tributary habitat restoration actions (FCRPS BiOp, NOAA 2008a). Every three years (2006, 2009, and 2012 so far), the Action Agencies (Bureau of Reclamation, Bonneville Power Administration, and Army Corps of Engineers) convenes local panels of experts in FCRPS BiOp priority areas. Experts use information contained in recovery plans, subbasin plans, watershed plans, limiting factors analyses, monitoring data, and personal knowledge and experience to help assess habitat improvement. The experts determine the current function of each ecological concern (limiting factor prior to 2012) as a percentage of properly functioning condition and assign weights to each ecological concerns and to each assessment unit. The weights reflect their importance to fish survival and recovery.

In order to improve the information used by the 2012 Upper Columbia Expert Panel, a workgroup of Expert Panel members worked for nearly a year to re-examine the list of ecological concerns being used in each watershed, and to adjust the current condition and potential future condition values for each one, using all of the monitoring information available at the time. This effort created information that is useful in summarizing the condition of habitat in the Upper Columbia.

Based on current assessed function of habitat by the 2012 Expert Panel (weighted by assessment unit and ecological concern importance), the highest ecological concerns for the region are instream structural complexity, riparian condition, bed and channel form, and increased sediment (Table 5). The importance of these ecological concerns varies by subbasin with the Okanogan subbasin having the lowest functioning habitat across a number of different ecological concerns. The Entiat currently has the highest functioning habitat across all ecological concerns based on the percent function given to each in that watershed.

Table 5. Rankings of ecological concerns across the region and in each of the major subbasins. Rankings are based on current conditions in each assessment unit as indicated by weighted (based on limiting factor weight and assessment unit weight) and summed scores of individual ecological concerns using Expert Panel results from 2012. Categories from high to minimal are based on a standard binning of scores.

Ecological Concern	Total	Wenatchee	Entiat	Methow	Okanogan
Instream Structural Complexity	HIGH	MODERATE	LOW	HIGH	HIGH
Riparian Condition	HIGH	MODERATE	LOW	HIGH	HIGH
Bed and Channel Form	HIGH	LOW	LOW	MODERATE	HIGH
Increased Sediment Quantity	HIGH	LOW	LOW	MODERATE	HIGH
Anthropogenic Barriers	MODERATE	MODERATE	LOW	MODERATE	MODERATE
Decreased Water Quantity	MODERATE	LOW	LOW	MODERATE	HIGH
Temperature	MODERATE	LOW	MINIMAL	LOW	HIGH
Side Channel and Wetland	LOW	LOW	LOW	MODERATE	LOW
Food-Competition	LOW	MINIMAL	MINIMAL	MINIMAL	HIGH
Altered Primary Productivity	LOW	LOW	LOW	MODERATE	MINIMAL
Mechanical Injury	LOW	LOW	MINIMAL	LOW	MODERATE
Predation	LOW	MINIMAL	MINIMAL	MINIMAL	MINIMAL
Floodplain Condition	LOW	LOW	LOW	LOW	LOW

HIGH
MODERATE
LOW
MINIMAL

Another effort to assess habitat at the watershed scale is the Ecosystem Diagnosis and Treatment model which is being applied for steelhead habitat in the Okanogan subbasin by the Confederated Tribes of the Colville Reservation. The initial model results show that habitats in the U.S. portion of the Okanogan River are operating at 25.72% of historic potential. The current status of habitat capable of supporting all life history diversity has been reduced by 72%. Historic habitat productivity provided for a self-sustaining steelhead population whereas in 2009 the habitat only had the productivity to return 0.1 steelhead for every spawner. Additional runs of the model in the coming years will help improve our understanding of Okanogan habitat status and trends.

Upper Entiat River

Reach-Scale Indicators

At the reach scale, numerous reach assessments completed over the past five years have characterized current geo-fluvial processes and habitat conditions. To date, partners (primarily the Bureau of Reclamation and Yakama Nation) have completed 23 tributary and reach-scale assessments in the highest priority watersheds and reaches (see Table 8). In some cases the assessments describe the degree of impairment of current habitat using reach-based ecosystem indicators, or "REIs". These metrics provide a consistent means of evaluating biological and physical conditions and have been adopted in the regional assessment process. A total of four indicators and fourteen metrics were consistently used in these assessments. A total of 113 miles in priority areas have been geomorphically assessed since 2008 (34 miles in the Wenatchee, 23 miles in the Entiat, and 56 in the Methow) and the table below summarizes the ratings across the region and within each subbasin (Table 6).

Table 6. Reach-based ecosystem indicator (REI) metric outcomes of reach assessments completed in the Upper Columbia region since 2008. Okanogan subbasin not included since not formal reach assessment using REI metrics have been completed there. Values are the percent of reaches within each subbasin exhibiting a particular REI metric condition. Shading indicates the percentage of reaches (darker = greater percentage). Data and references can be found in regional reach assessments in Table 7.

Habitat Indicator	***% Adequate Reaches***	***% At Risk Reaches***	***% Unacceptable Reaches***
Regional Total	**41%**	**38%**	**21%**
Channel Dynamics	42%	35%	23%
Habitat Access	69%	30%	1%
Habitat Quality	37%	40%	23%
Riparian Condition	35%	39%	26%
Water Quality	48%	30%	22%
Entiat	**55%**	**33%**	**11%**
Channel Dynamics	67%	27%	6%
Habitat Access	100%		
Habitat Quality	42%	37%	21%
Riparian Condition	60%	30%	10%
Water Quality	27%	73%	
Methow	**43%**	**37%**	**19%**
Channel Dynamics	76%	64%	34%
Habitat Access	40%	57%	3%
Habitat Quality	45%	39%	16%
Riparian Condition	35%	35%	30%
Water Quality	70%	3%	27%
Wenatchee	**23%**	**43%**	**34%**
Channel Dynamics	20%	38%	42%
Habitat Access	85%	15%	
Habitat Quality	19%	46%	35%
Riparian Condition	13%	52%	35%
Water Quality		67%	33%

In addition to the information being compiled and summarized in the Biological Strategy, Expert Panel process, and reach assessments, current habitat status is being assessed by large-scale, long-term monitoring programs across the region. The Columbia Habitat Monitoring Program (CHaMP) and Okanogan Basin Monitoring and Evaluation Program (OBMEP) track the status and trends in habitat in all four major Upper Columbia subbasins. At this time insufficient data on habitat exists to adequately explain habitat status and trends, although site-scale information shows high site variability in habitat metrics, meaning that habitat is patchy in nature across the landscape.

Habitat Protection and Improvement Actions

The recovery of ESA-listed salmon and steelhead populations in the Upper Columbia region is dependent upon the successful implementation of habitat restoration and protection actions that address threats and habitat impairments limiting survival and productivity. The selection of projects and actions is based on priority recovery actions and reaches. Several planning processes provide detailed plans, assessments, and strategies that identify the highest priority areas that are the most appropriate for large restoration programs. Within these priority areas, the focus is first on protecting and maintaining the best remaining examples of biological integrity, connectivity, and diversity. Restoration efforts are focused on restoring natural processes whenever possible and enhancing habitat when processes cannot be recovered.

Project implementation is tracked through an online Washington State database, referred to as *Habitat Work Schedule* (HWS 2013). For the purpose of this report, all project information in the database was updated and checked for accuracy. Based on the updated information in the HWS database, we were able to summarize efforts to restore and enhance habitat for listed salmon, steelhead and bull trout.

In total, partners have completed nearly 300 projects. Before Recovery Plan approval in 2007, partners implemented an average of seven projects per year. In the past five years, partners implemented an average of 28 projects per year; representing a 300% increase in the implementation rate in the region (Figure 8). Several key events since 1996 have led to increases in the rate of project implementation.

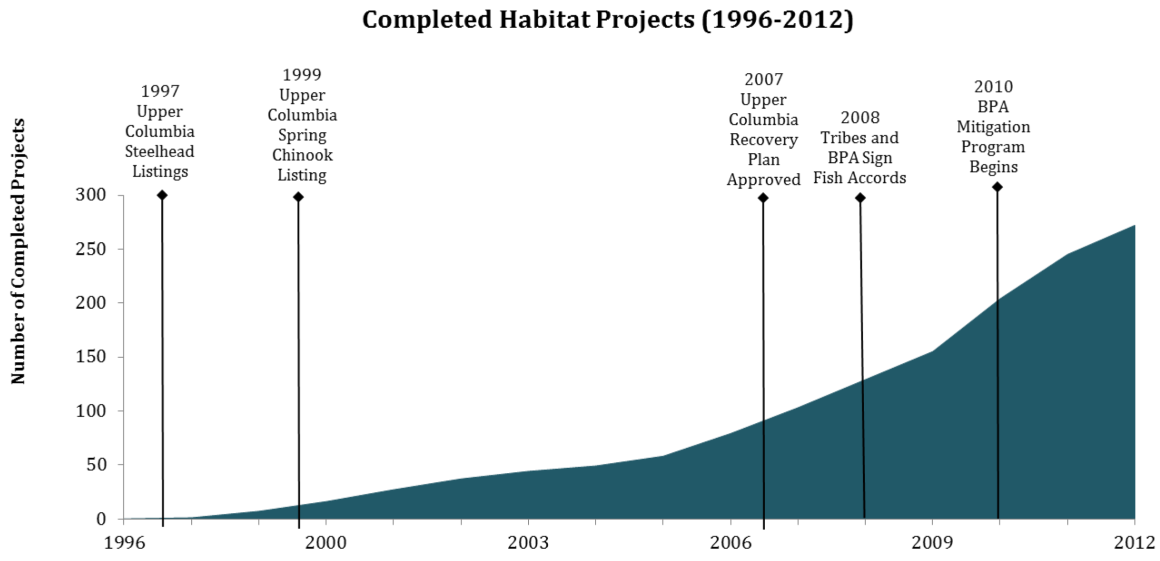


Figure 8. Cumulative number of habitat projects implemented in the Upper Columbia region between 1996 and 2012.

The rate of increase varied by project type with some, like instream and floodplain habitat enhancement, increasing dramatically in the 2008-2012 period (Figure 9). Other project types like riparian enhancement and instream flow have remained relatively constant during this time period.

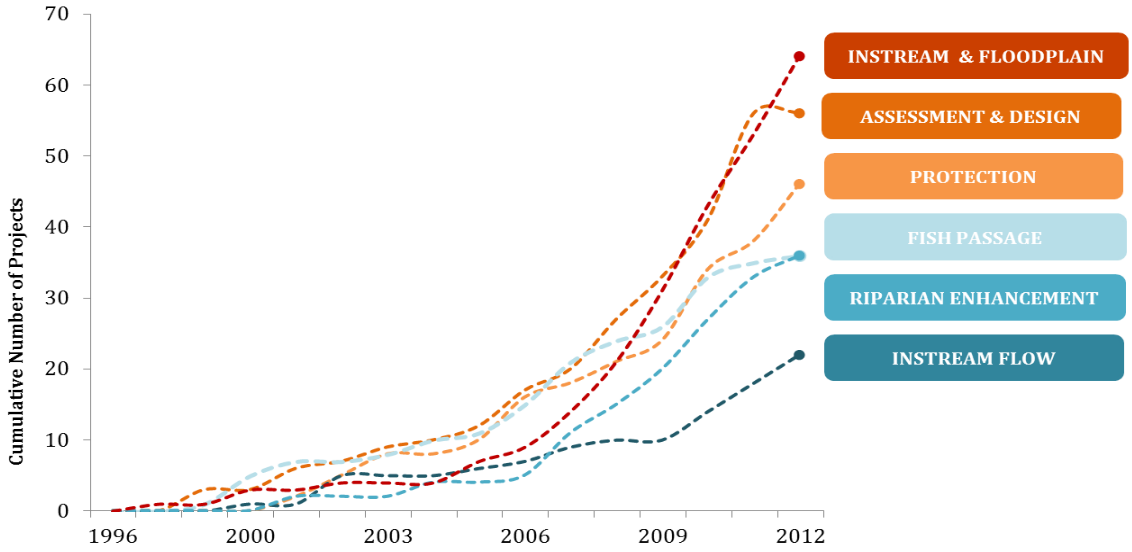
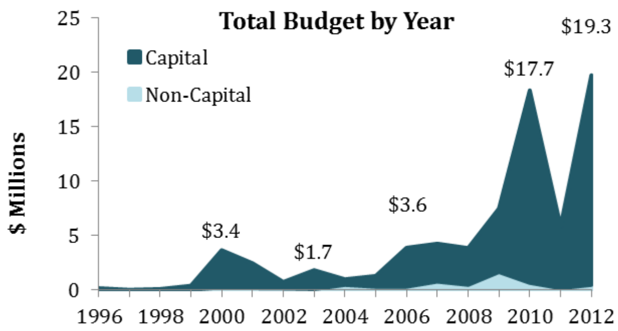


Figure 9. Cumulative number of habitat projects implemented in the Upper Columbia region between 1996-2012 by project type.

A total of $74 million dollars has been invested in the region on habitat projects. Of that total, $69.2 million has been invested in capital projects (restoration and protection), and $5.7 million invested in non-capital assessment and design projects (Figure 10). Peaks in habitat-related funding occurred after listing (1997-1999), the completion of the Recovery Plan (2007), and the start of the BPA mitigation program (2010). On average $4.4 million has been spent per year on habitat projects since 1996, but in the last few years that average has gone up substantially ($11.1 million per year).



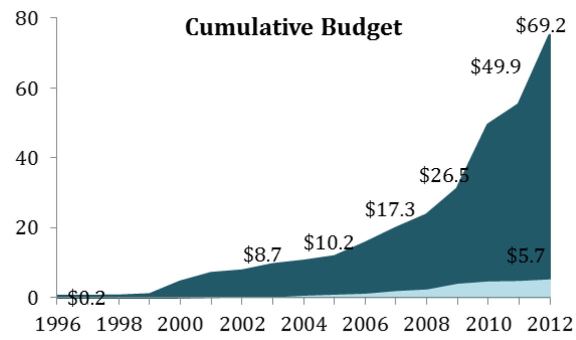


Figure 10. Summary of total funding spent on habitat restoration and protection (capital) and habitat assessment and design (non-capital) projects in the Upper Columbia since 1996 by year (left) and cumulatively (right).

Restoration projects represent over half of the funding for habitat work in the region and account for a majority of the projects (187 projects). Most restoration projects are aimed at improving instream habitat, riparian condition, fish passage, instream flow, and upland habitat and fish screens. Protection projects are also common and account for one third of the funding and almost 15% of the projects (Figure 11). Assessment and design (non-capital projects) represent 17% of the projects but only 8% of the funding. Combination protection/restoration projects are a small proportion of funding and implementation, although these types of projects have grown in importance recently.

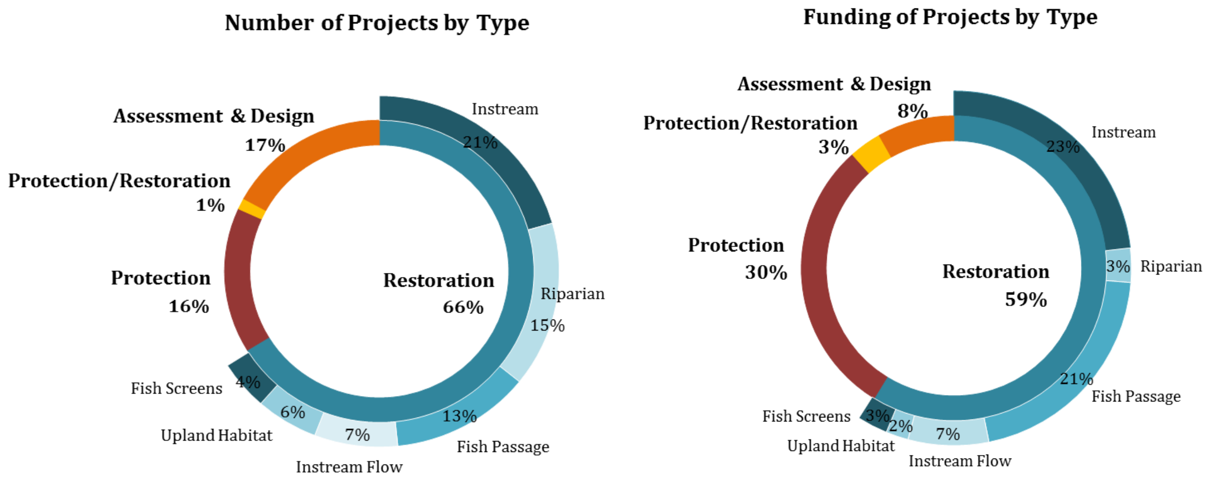


Figure 11. Proportion of different project types implemented in the Upper Columbia region between 1996-2012 by number (left) and by funding (right).

In total, partners restored 22 miles of stream, 11 miles of off-channel habitat, and 127 acres of riparian forest; removed 93 fish passage barriers to open up 282 miles of habitat for fish. In addition, partners protected 3,379 acres of habitat and 47 miles of stream. The pace of these accomplishments has varied over time depending on the metric, however, the pace of accomplishments increased dramatically between 2008-2012 when compared with the pace of accomplishments between 1996-2007 (Figure 12). Some accomplishments, like *riparian acres treated* have increased dramatically in recent years. On average, there has been a four-fold increase in accomplishments between 2008 and 2012.

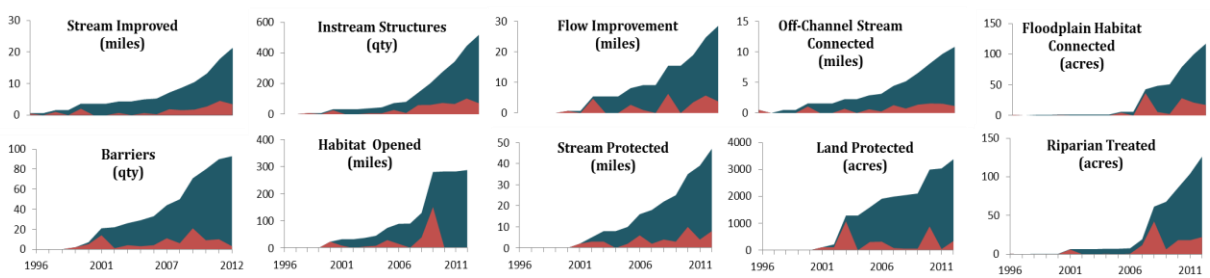


Figure 12. Accomplishments between 1996-2012 by year (red) and cumulatively (blue) across all major reporting metrics.

Completed restoration and protection projects have been spread over the entire Upper Columbia region (Figure 13). The majority of restoration and protection habitat projects (>50%) are concentrated in 10% of the Upper Columbia assessment units: Lower Entiat, Lower Wenatchee, Upper Omak Creek Chumstick Creek, Mission Creek, Lower Chewuch, and Lower Twisp.

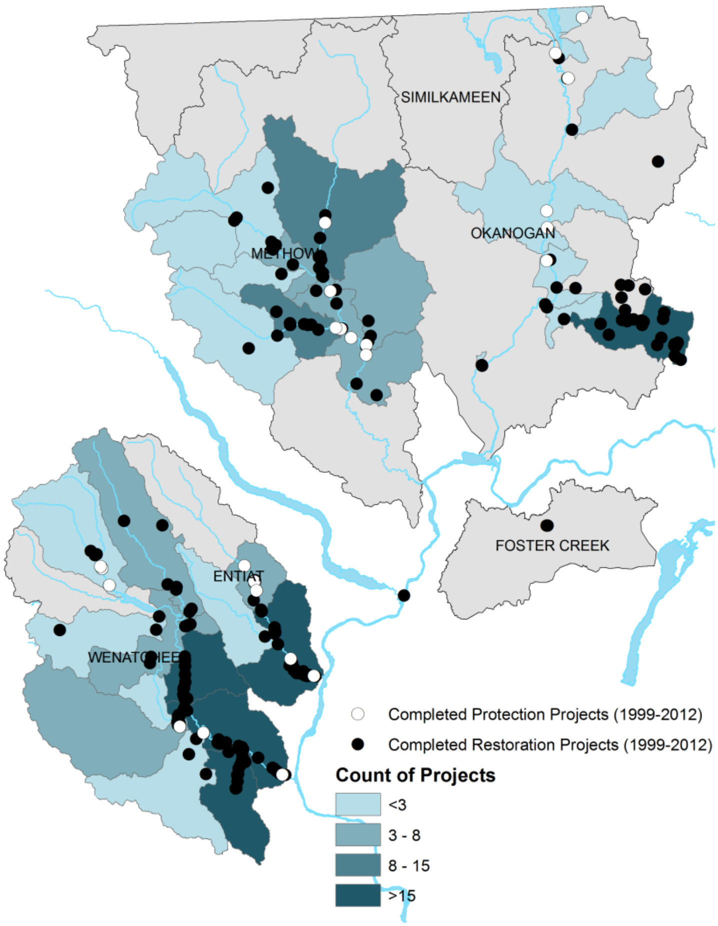


Figure 13. Map showing the location and total number of completed habitat projects across the Upper Columbia by assessment unit.

To date, the primary ecological concerns addressed by habitat projects in the region include water floodplain condition (20% of projects), riparian condition (16%), and anthropogenic barriers (15%). These were followed by side channel and wetland conditions, instream structural complexity, increased sediment quantity, decreased water quantity, and several ecological concerns that were only rarely addressed. The ecological concerns address varied by subbasin as shown in Figure 14.

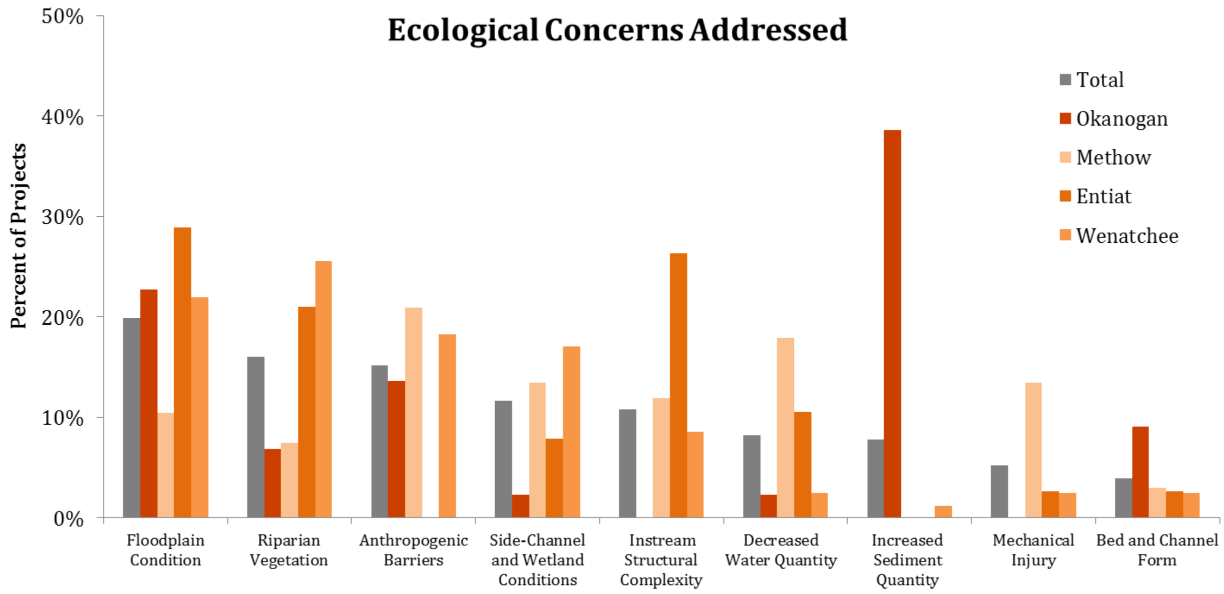


Figure 14. Ecological concerns addressed by habitat projects by subbasin.

Alignment of Habitat Projects with Regional Priorities

Recovery Plan

In addition to specific habitat actions identified in the 2007 Recovery Plan there were also short- and long-term habitat recovery objectives. These objectives are generally aimed at protecting high quality habitat, restoring connectivity, protecting and enhancing instream flow and water quality, increasing habitat diversity and complexity, restoring floodplain and off-channel function, restoring natural sediment delivery process, replacing nutrients, and reducing the impacts of non-native species. In general actions implemented since that time have contributed toward achieving these objectives, but few actions have been taken to restore natural sediment delivery processes, replace nutrients, and reduce non-native species. Table 7 summarizes accomplishments under each of the nine habitat objectives.

Perched culverts on Loup Loup Creek

Table 7. List of Recovery Plan objectives (UCSRB 2007) and related accomplishments and project counts for each (1996-2012). The number of projects was identified based on the primary limiting factors addressed by projects.

Recovery Plan Habitat Objective	Objective Description	Metric Accomplishments	Number of Completed Projects	Associated ecological concerns (number of watersheds (AUs) where cited as a primary concern[b])
Protection	Protect existing areas where high ecological integrity and natural processes exist.	3,379 acres protected (2,728 floodplain acres); 47 miles of stream protected	46	N/A
Connectivity	Restore connectivity (access) throughout the historic range where feasible and practical for each listed species.	93 barriers removed; 282 miles opened	38	Anthropogenic Barriers (10 AUs)
Streamflow	Where appropriate, establish, restore, and protect stream flows (within natural hydrologic regimes and exiting water rights) suitable for spawning, rearing and migration.	28 miles of flow restored; 57 cfs of streamflow restored	20	Decreased Water Quantity (19 AUs) Altered Flow Timing (3 AUs)
Water Quality	Protect and restore water quality where feasible and practical within natural constraints.	127 acres of riparian forest enhanced (temperature);	2	Temperature (8 AUs)
Habitat Diversity	Increase habitat diversity in the short term by adding instream structures (e.g. large woody debris, rocks, etc.) where appropriate.	22 miles of stream enhanced; 518 structures placed instream, 180 pools created	34	Instream Structural Complexity (4 AUs) Bed and Channel Form (13 AUs)
Floodplain and Channel Function	Protect and restore floodplain function and reconnection, off-channel habitat, and channel migration processes where appropriate and identify long-term opportunities for enhancing these conditions.	11 miles of off-channel stream restored; 117 acres of off-channel reconnected	75	Side Channel and Wetland Connections (13 AUs) Floodplain Condition (3 AUs) Bed and Channel Form (13 AUs)
Sediment	Restore natural sediment delivery processes by improving road network, restoring	40 miles of road abandoned or obliterated[a]; 6 acres of slope stabilized; 117 acres of off-	21	Increased Sediment Quantity (21 AUs)

	natural floodplain connectivity, riparian health, natural bank erosion, and wood recruitment.	channel reconnected; 127 acres of riparian enhanced;		
Nutrients	Replace nutrients in tributaries that formerly were provided by salmon returning from the sea.	None	0	Altered Primary Productivity (3 AUs)
Non-Native Species	Reduce the abundance and distribution of non-native species that compete and interbreed with or prey on listed species in spawning, rearing, and migration areas.	None	0	Introduced Competitors and Predators (1 AU)

[a] *Work Schedule database which was used to generate this table is not generally used for reporting road decommissioning projects and therefore this number is under representative of the miles of road decommissioned in the region.*

[b] *Ecological concerns were considered a primary concern if they were ranked between 1-3 in the RTT Biological Strategy (RTT 2013).*

Biological Strategy

Restoring the productivity of salmon and steelhead habitat in the Upper Columbia requires a prioritization of habitat actions to maximize the benefit derived from limited funding. The RTT Biological Strategy (RTT 2013) documents biological considerations for the protection and restoration of habitat in order to provide a technical foundation for setting priorities. The intent of the document is to provide support and guidance on implementing the Recovery Plan. The Biological Strategy provides guidance on habitat actions that are expected to contribute to the improved status of the VSP parameters. As stated above, priority areas and ecological concerns have been identified for each assessment unit within the region. Alignment of restoration and protection actions with the Biological Strategy is important to assess how well regional implementation is aligned with regional strategy.

Over half of the projects implemented between 1996 and 2012 addressed a high (ranked 1-3) or medium (ranked 4-6) ecological concern identified in the current RTT Biological Strategy (Figure 15). Several ecological concerns in select assessment units have been largely alleviated by habitat work over the past decade. This included anthropogenic barriers in the Chumstick watershed of the Wenatchee, flow in Loup Loup Creek, water temperature and fish passage in Omak Creek, and fish passage in Salmon Creek in the Okanogan. Although implementation was generally aligned with priority ecological concerns, a high proportion of projects did not address a ranked ecological concern for the assessment unit in which they occurred. This is likely the result of a refined understanding of ecological concerns over time (e.g. the project occurred at a time when there were not ranked ecological concerns), or due to an opportunity to address an issue that would improve habitat but was maybe not a ranked ecological concern (e.g. a barrier in an area where barriers overall where not an issue).

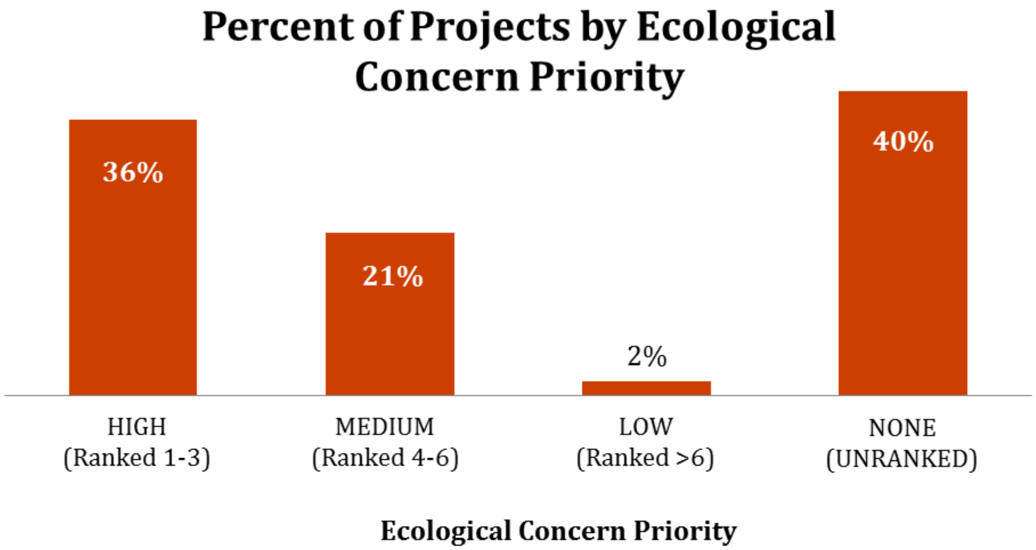


Figure 15. Number of projects that addressed different categories of ecological concern priority.

We found that completed projects (1996-2012) focused on the priority areas currently identified by the RTT (RTT 2013), although roughly 24% of restoration projects did not fall within any Biological Strategy priority area for restoration (Figure 16). All of the completed protection projects were within priority areas for protection. There may be several reasons why projects were implemented in areas not ranked as priority areas for restoration by the RTT. For instance, some projects may have been implemented to address additional priorities for non-listed species or interests; projects may have represented unique opportunities to address habitat issues; some projects may be the product of a "use-it-or-lose-it" funding opportunity; and some projects were the result of the early approach that was more opportunistic and less driven by well-defined priority areas and ecological concerns.

In general, the priority areas that have been identified have not changed and are focused on the core areas of production for both species with the highest habitat impairments (restoration priority areas) and greatest habitat quality (protection). One exception is Chumstick Creek which was initially identified as a priority area for restoration in the Wenatchee, but over the past five years received a fair amount of investment and implementation (21 projects), primarily to address fish passage issues. Practically, all fish passage barriers have now been addressed and the RTT no longer considers Chumstick Creek a priority for restoration (RTT 2013). Taking this into consideration, the percent of restoration projects in unranked areas would actually be much lower (12% versus 24%) if those projects in Chumstick Creek were not considered. There are no other areas where the assessment unit was changed from a ranked priority to an unranked priority.

Some priority areas have been under-represented in regional habitat recovery implementation. Several assessment units that are high priorities for restoration and that have had few restoration projects completed include the Icicle Creek in the Wenatchee, the mainstem Okanogan River (from

Chilwist to Salmon Creek), and Upper Salmon Creek in the Okanogan. These areas are particularly challenging to work in for a variety of reasons but several projects are planned in the near future to address primary ecological concerns within these assessment units. Similar to restoration priorities, the Upper Wenatchee and the Chiwawa River in the Wenatchee subbasin and Upper Salmon Creek in the Okanogan are high priority areas for protection and have had no protection projects completed to date.

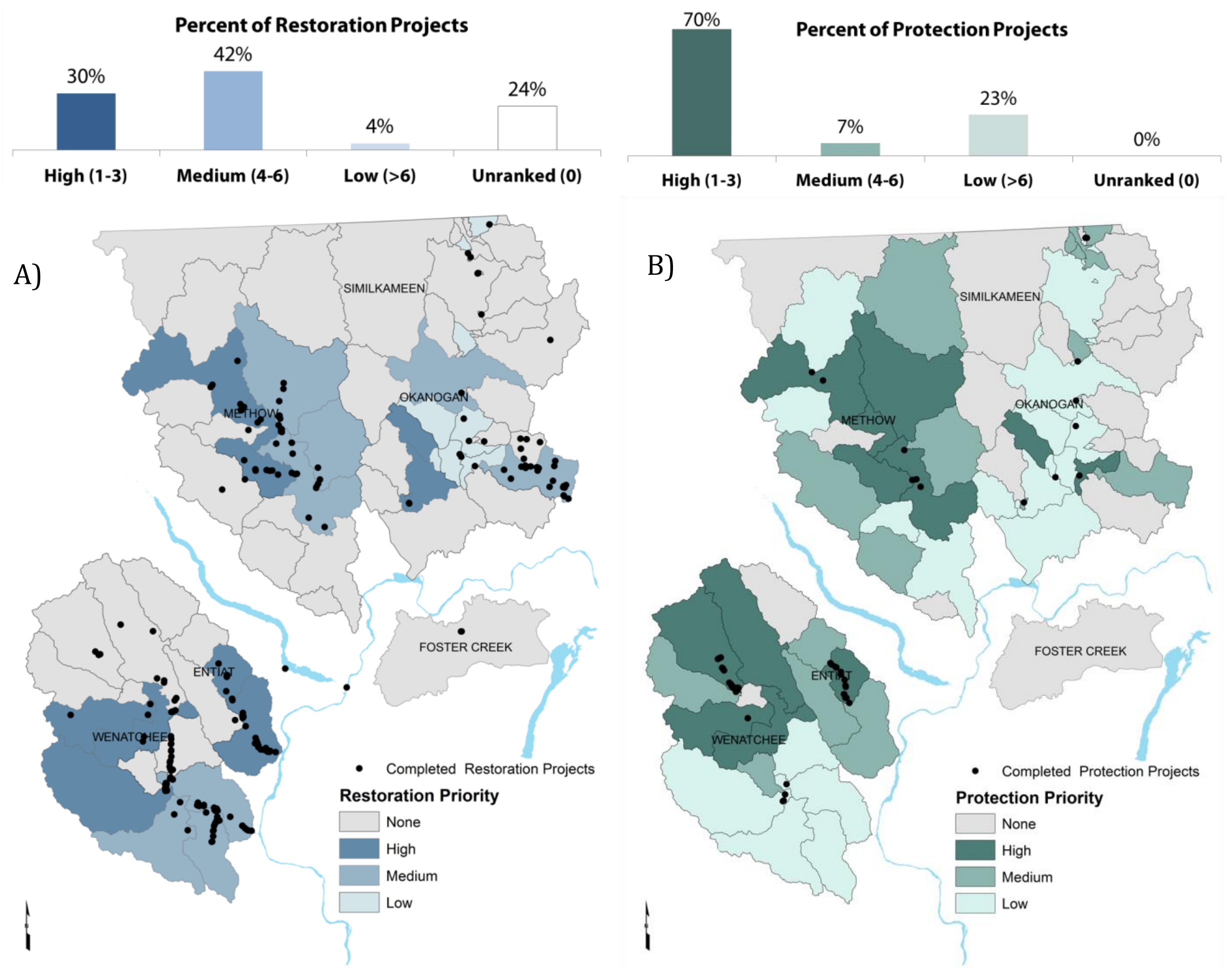


Figure 16. Alignment of A) restoration and B) protection projects with *RTT Biological Strategy* (RTT 2013) priorities (by assessment unit) for restoration and protection.

Combining priority areas and priority ecological concerns, some areas had a higher number of projects that addressed high priority ecological concerns than other areas (Figure 17). The Lower Wenatchee and White River, Lower and Middle Entiat, Upper Methow, and Upper Omak Creek all had more than 10 projects that addressed the highest ranked (ranked 1-3 in RTT Biological Strategy) ecological concerns. Of these the Lower and Middle Entiat and the Upper Methow were the only assessment units that are ranked high as a restoration priority. Besides the lower Twisp, none of the other priority areas for restoration had a high number of completed projects that addressed high priority ecological concerns. On average, the Entiat and Wenatchee had approximately 7-9 projects completed per assessment unit that addressed high ranked ecological concerns. The Methow and Okanogan had between 1-4 projects completed per assessment unit that addressed high ranked ecological concerns.

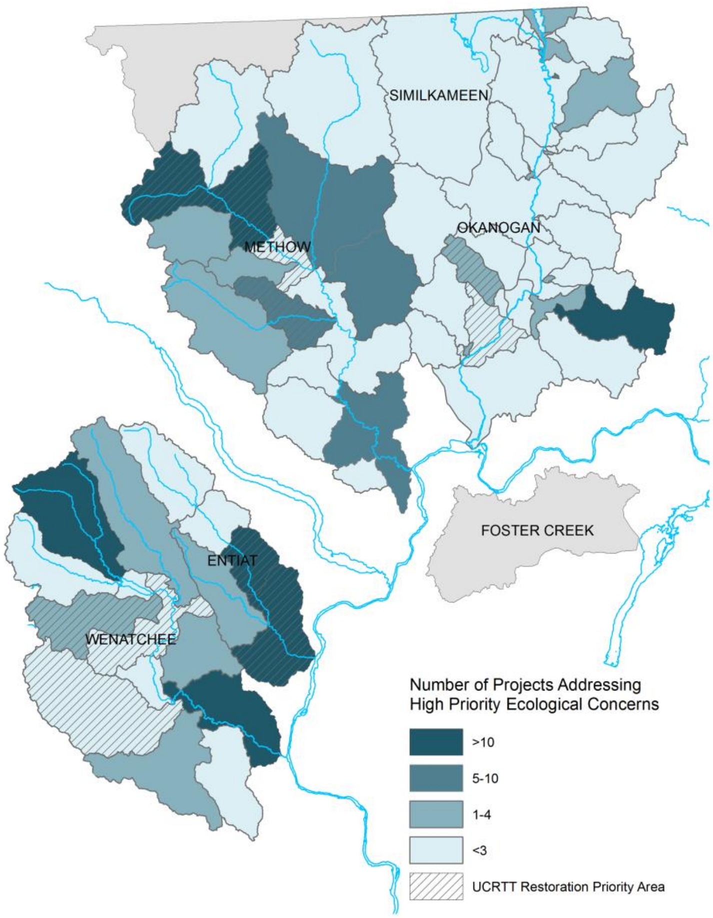


Figure 17. Number of completed projects in each assessment unit that addressed high priority (ranked 1-3 in RTT Biological Strategy) ecological concerns. Shaded areas indicate assessment units that have been designated as high priority areas for restoration (RTT 2013).

Expert Panel

The 2012 Expert Panel process (as described on page 30) resulted in information on current habitat conditions. This included an estimate (in percentage) of current habitat condition for each ecological concern within each assessment unit. Based on weighted averages of these percentages, by assessment unit and ecological concern importance, or weighting, we compared the importance of difference ecological concerns to the magnitude of implementation to address those concerns (based on the percent of projects that addressed that ecological concern).

In general, floodplain condition tended to be overrepresented in habitat work and decreased water quantity, instream structural complexity, and altered primary productivity tended to be under-represented in implementation (Figure 18). This was true when we looked at both the regional and assessment unit scale. As noted previously, instream structural complexity and instream flow (decreased water quantity) projects have increased dramatically in the past 5 years (50-70% since 2007) as funding and opportunities became available. The increase in effort in these areas will help ensure these two important ecological concerns are being adequately addressed.

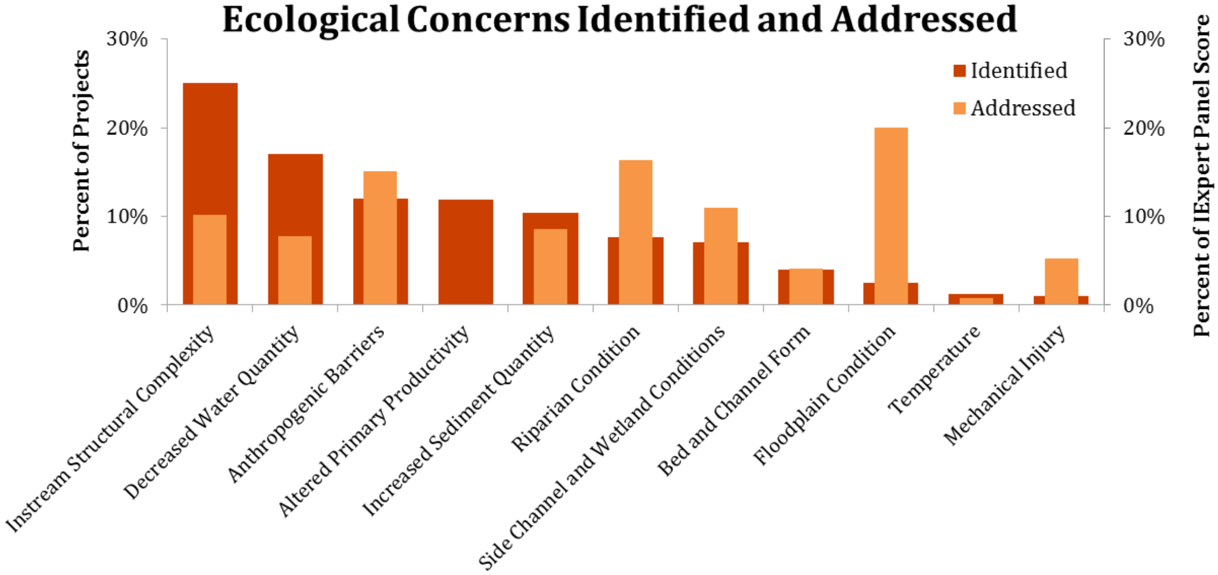


Figure 18. Comparison between the relative importance of ecological concerns identified within the region and the proportion of projects that address those ecological concerns.

Habitat Potential (Intrinsic Potential)

The extent to which habitat projects are located within priority spawning and rearing areas is an important question to answer. Intrinsic potential (IP) is one of the metrics that can be used to assess the quality of spawning and rearing habitat and relative habitat potential. Streams vary in intrinsic potential (i.e., potential quality and quantity of spawning/rearing habitat) because of differences in geology, geomorphology, valley width, elevation, stream size, gradient, and other factors (Cooney and Holzer 2006). Projects that improve habitat quantity and quality within streams of high intrinsic potential, or provide access to such habitat, presumably have a higher biological benefit than those in areas that have low or no intrinsic potential.

A heat map showing an interpolation of IP data for the Upper Columbia shows that there are more areas of high intrinsic potential for steelhead than for Chinook (Figure 19). Steelhead can utilize more of a watershed than can spring Chinook since they can move further up into small, high-gradient tributary streams. By the nature of having more habitat available for restoration, more projects between 1996-2012 benefitted steelhead than did spring Chinook (97% versus 71%). Similarly, more projects were sited within high IP habitat for steelhead compared with the number sited with high IP habitat for spring Chinook. Across the region, almost 34% of projects were within high IP habitat for steelhead compared to 9% of projects within high IP habitat for spring Chinook. Taking the average IP and sum of IP for all projects suggests inconsistency between how well projects addressed steelhead and spring Chinook habitat (270 versus 379 total IP units for all projects and 1 versus 1.5 average IP for all projects). Many of the tributaries that contain high IP habitat for spring Chinook are areas identified as high priority areas for protection and have had numerous protection projects completed in them. The number and percent of projects in high, medium, and low IP habitat within each subbasin is presented in Figure 20.

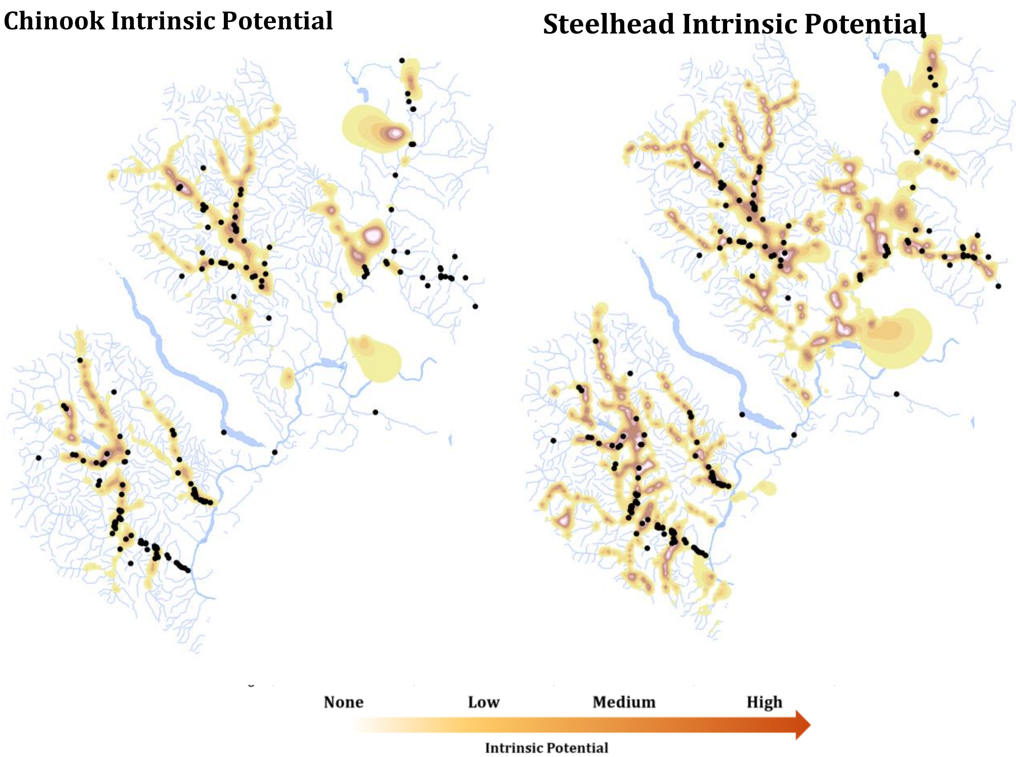


Figure 19. Interpolation of intrinsic potential data from NOAA (2013) for Chinook (left) and steelhead (right). The map is a heat map of IP with darker red areas representing areas of high intrinsic potential (IP) (>2.0) and cooler yellow areas representing lower IP (<1.0). Completed project locations are overlaid.

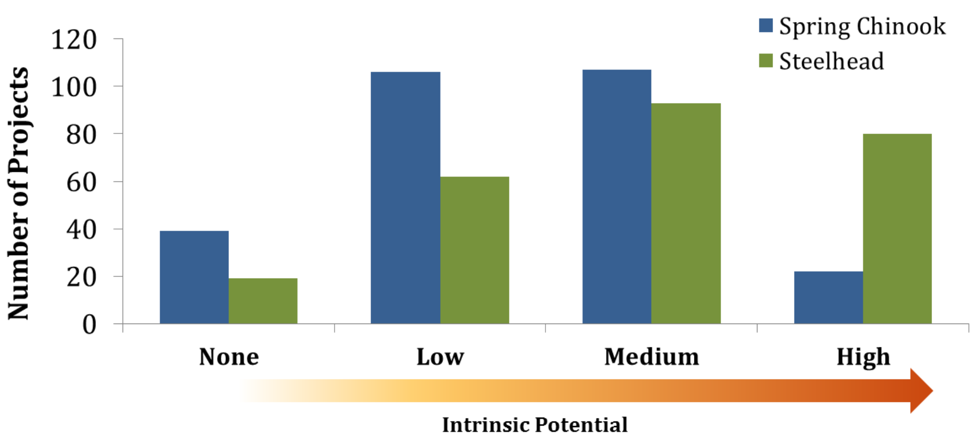


Figure 20. Number of projects associated with high (>2.0), medium (1-2), and low (<1.0) intrinsic potential for both Chinook and steelhead habitat.

Habitat Assessments

Habitat assessments are an important tool in defining habitat improvement actions in the most appropriate locations. Assessments characterize the current geo-fluvial processes and habitat conditions and identify potential strategies and projects to restore and preserve habitat and natural river processes. At the tributary scale, an assessment usually does not identify specific areas for habitat projects. However, reach–scale assessments provide a range of scientific information relevant to habitat improvements for salmon and steelhead over a spatial scale fine enough to identify specific habitat improvement actions and coarse enough to support continuity between those actions. The assessments provide the foundation for reach-scale implementation of restoration projects by a suite of partners. Alignment of habitat actions with habitat assessments is important to ensure a concentration of effort focused in the highest priority areas on the highest priority projects in those areas.

Habitat assessments across the region are aimed at tributary and reach scales in the highest priority assessment units and production areas in the region (Figure 21). Of the 12 high priority assessment units in the region for restoration (three in each subbasin), eight of them have had some kind of assessment completed. In addition, the Icicle assessment unit, a high priority assessment unit in the Wenatchee, is slated as a future priority for assessment. The Okanogan subbasin has had no assessments completed but other types of habitat assessment tools are being used to identify projects (e.g. Ecosystem Diagnosis and Treatment (EDT) modeling).

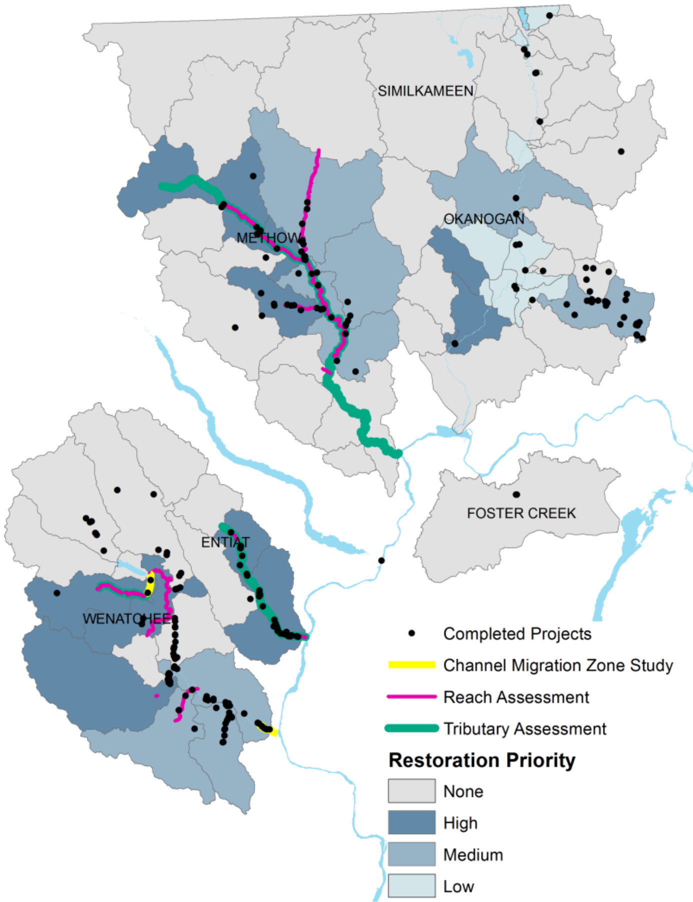


Figure 21. Completed assessments in the Upper Columbia region with completed projects and restoration priority areas overlaid.

To date, partners (primarily the U.S. Bureau of Reclamation and Yakama Nation) have completed 23 tributary and reach-scale assessments (Table 8). In total, 577 "projects" (sometimes named restoration opportunities) have been identified through the habitat assessment process. In total, 46% of the projects completed since 2008 (when most of the assessments began) have been within these assessment areas. The majority of these projects were restoration but many protection projects have also been completed in assessment areas. Some of the largest and most complex reach-scale projects in the region have occurred as a result of reach assessments.

Reach assessments are fairly recent in the region and although many projects have been completed as a result of these assessments, many opportunities remain. Of the 577 restoration opportunities identified, 14% have been completed. Reach-scale implementation has led to targeted restoration efforts in the mainstem Wenatchee, Entiat, and Methow, in Nason Creek, Twisp River, Chewuch River, and Libby Creek. Areas with the most progress toward implementing the full suite of possible restoration actions identified (given social and economic constraints) include Lower White Pine in Nason Creek (29%), the Lower Wenatchee mainstem (40%), the Preston Reach in the Entiat (37%), Big Valley segment of the mainstem Methow (50%), and the W2 (or Winthrop to Wolf Creek) reach of the mainstem Methow (33%). Current efforts are underway in the M2 (Middle Methow) reach of the mainstem Methow (2013), and the Lower mainstem Entiat (2014). As previously stated, the Okanogan subbasin does not have any completed reach or tributary assessments although targeted assessment, restoration, and protection has occurred in areas like Omak Creek, Salmon Creek, and Loup Loup Creek.

Table 8. List of Reach and Tributary Assessments completed and the number of projects identified and the percent completed. A complete list and links to assessment can be found at www.ucsrb.org.

LOCATION	YEAR COMPLETED	# PROJECTS IDENTIFIED	# PROJECTS COMPLETED
WENATCHEE SUBBASIN			
Lower Wenatchee (RM 0-4)	2004	20	8
Nason Creek (0-4)	2004	4	3
Nason Creek (RM 4-14)	2008	N/A	N/A
Upper White Pine (RM 12-14.5)	2009	10	0
Lower White Pine (RM 9.45-11.55)	2009	14	4
Kahler (RM 4.65-8.9)	2009	17	0
Lower Peshastin (RM 0-7)	2009	54	2
Upper Wenatchee (RM 35.5-54.5)	2012	61	0
ENTIAT SUBBASIN			
Entiat (RM 0-26)	2009	N/A	N/A
Stormy (RM 18.02-20.85)	2009	28	4
Stormy (17.9-18.1)	2013	N/A	N/A
Preston (RM 22.7-23.3)	2009	27	10
Upper Stillwaters (RM 23.3-24, 25-33.8)	2013	N/A	N/A
Lower Entiat (RM 0-7)	2012	N/A	N/A
Gray (RM 16.1-17.9)	2013	N/A	N/A
METHOW SUBBASIN			
Methow Subbasin (RM 0-80)	2008	N/A	N/A
Big Valley (RM 55-62)	2008	8	4
Winthrop (W2) (RM 50-55)	2011	3	1
Chewuch (RM 0-20)	2010	124	15
Lower Twisp (RM 0-15)	2010	68	8
Middle Methow (M2) (RM 41.1-50)	2010	113	19
Middle Methow (M2) (RM 41.1-45.5)	2011	3	0
Lower Libby Creek (RM 0-1.4)	2012	23	0

Future Restoration Potential

The Recovery Plan Appendix I includes a gap analysis of survival changes needed to meet abundance and productivity viability criteria for Upper Columbia species. In this analysis, the results of the Ecosystem Diagnosis and Treatment (EDT) output from the Recovery Plan was used to determine which percent increase in productivity could be expected from implementing habitat actions recommended in the Recovery Plan. Since it was not known at the time to what extent the proposed habitat actions would be implemented, two scenarios were modeled: 1) with implementation intensity of 33% and 2) with implementation intensity of 100%. It was noted at the time that these intensities may not be feasible given social and economic limitations.

The results of this analysis showed that productivity of spring Chinook could increase 3-35% under the low (33%) intensity scenario and could increase 3-36% under the high intensity (100%) scenario. Productivity of steelhead could increase 14-47% under the low intensity scenario and 31-64% under the high intensity scenario. The intensity of habitat actions implemented in the future will determine what increase in productivity can be expected from habitat actions, and how much of a gap in productivity will persist.

Large wood in the Methow River.

The FCRPS Expert Panel process described in previous sections sets up estimates of future restoration potential in the context of current (low bookend) and potential (high bookend) percent function of ecological concerns for each assessment unit in the region. Comparing current percent function to potential future percent function (restoration potential), by ecological concern and by assessment unit, we can provide an estimate of the potential for alleviating ecological concerns and habitat function across the entire region. According to this information, the restoration potential (or the gap in estimated habitat function) is estimated to be 15% (Figure 22). This represents the potential to improve habitat status if all potential actions (given known physical, social, and economic considerations) were implemented. Broken out by subbasin there is an 11% gap in the Okanogan, 10% gap in the Methow, 16% gap in the Entiat, and 15% gap in the Wenatchee.

In addition to assessing current and potential future habitat function, the Expert Panel process assesses improvements in habitat condition. Improvements are expressed as the sum of the percentage points of movement between current habitat function and potential future habitat function that would be realized by implementing the suite of proposed mitigation projects. Based on the estimates of habitat improvement that were made by the Expert Panel in 2012 and the expected outcomes (based on reported metrics from projects) we were able to back-calculate our percent progress in terms of habitat function. To do this we used the number of miles improved as a surrogate for progress and calculated a per-metric outcome of 0.0025% per mile. Applying this to the miles we have improved since 1996 we have achieved 4 - 6% progress. The majority of that progress in habitat work was since 2007 with 1% prior to 1996 and 3-5% after 2007 when the Recovery Plan was approved.

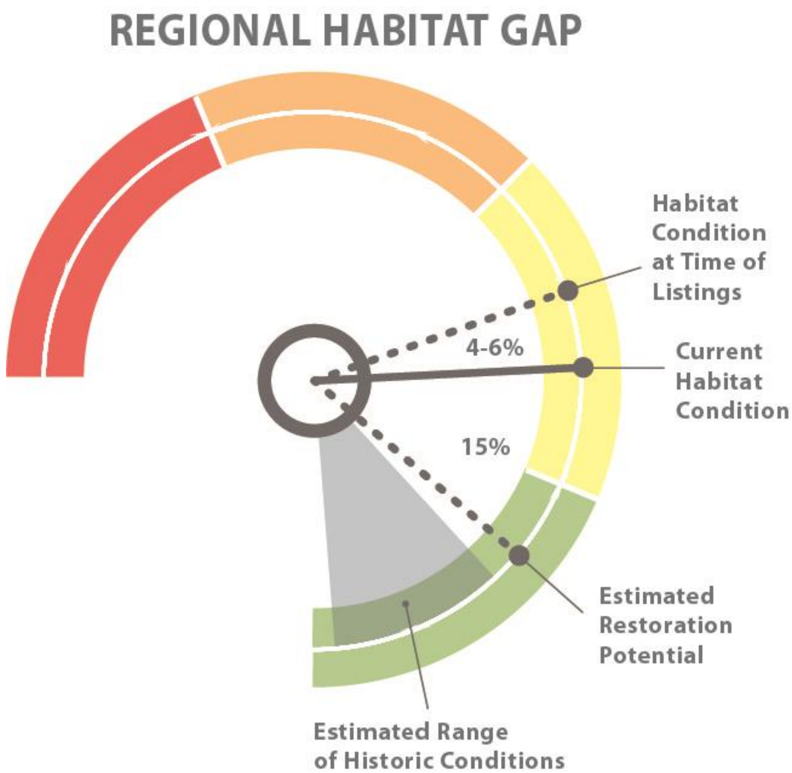
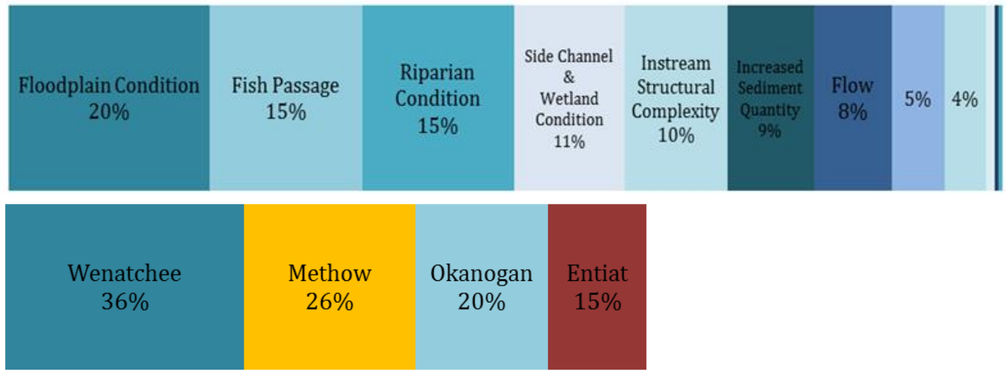


Figure 22. Summary of current and potential future habitat status for the region and for each subbasin based on 2012 Expert Panel estimates.

Based on estimated restoration potential, the biggest remaining opportunities for habitat work address instream structural complexity, decreased water quantity (flow), anthropogenic barriers, and altered primary productivity (Figure 23). Looking more specifically at restoration potential in high priority areas for restoration the largest gaps are slightly different (instream structural complexity and decreased water quantity (flow), anthropogenic barriers, increased sediment quantity, and side channel and wetland conditions). Comparing the ecological concerns that have been addressed in the past with the remaining restoration potential identified above, it would appear that future projects may need to address slightly different ecological concerns (Figure 23).

Increased effort in instream structural complexity, decreased water quantity (flow), and altered primary productivity may be needed. Shifts in geographic focus may also need to occur with more emphasis in the future in the Entiat watershed.

Past Habitat Focus



Future Restoration Potential

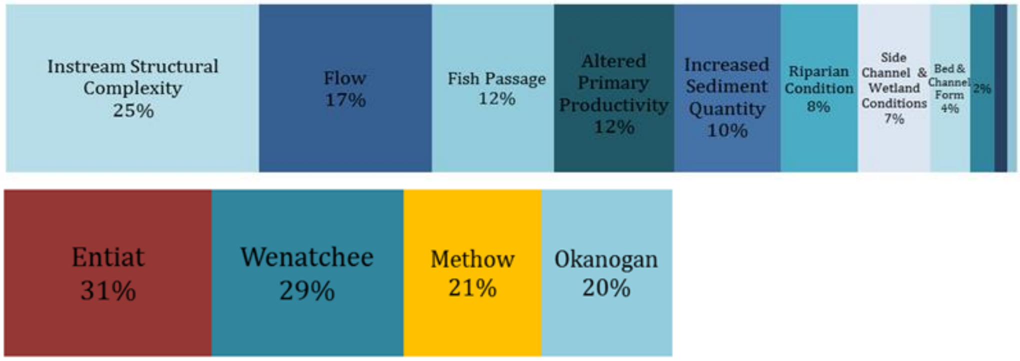


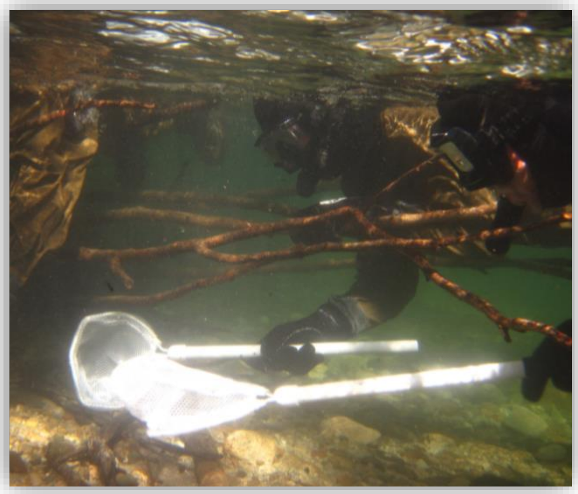
Figure 23. Comparison between ecological concerns and subbasins addressed in past habitat projects with the gaps in habitat that remain to be addressed to meet full habitat potential in the region. Figure is from data from the 2012 FCRPS Expert Panel process which estimated current and future habitat status based on a variety of data and information.

Potential Benefits to Listed Species

When the Recovery Plan was developed partners acknowledged that a critical uncertainty associated with its implementation was the effect of management actions or strategies on the environment, on life-stage specific survival rates, and on population level responses. This uncertainty remains today, but we have gained some insight into these effects. Project specific effectiveness monitoring conducted by a variety of organizations confirms previous knowledge about fish response to habitat restoration. In general, projects have been able to meet their biological objectives (if stated) and to positively influence habitat characteristics at the intended scale. The benefit of these observed small-scale responses to overall tributary or population recovery has not been assessed but we examined several lines of evidence to assess the potential benefit that habitat work in the region has had. Below we summarize the direct and indirect evidence for the potential benefits of habitat work to listed species. Direct evidence comes from actual fish monitoring at habitat projects sites and indirect evidence comes from 1) habitat responses; 2) state-wide effectiveness monitoring of fish and habitat responses; and 3) comparable evidence of fish responses in literature.

Direct evidence of the fish response of habitat work in the region is limited. Most habitat projects are aimed at restoring or enhancing watershed processes and/or habitat conditions. Monitoring of these projects primarily focuses on the habitat response and only rarely focuses on the actual biological response in the target fish species or population. Based on our assessment of projects conducted over the past 5 years, only a small proportion (<10%) of projects have had any level of fish monitoring, or effectiveness monitoring, associated with them. A much greater proportion has had habitat effectiveness or basic implementation monitoring completed.

Habitat monitoring indicates a short-term habitat response and the ability of projects to meet their habitat objectives. Projects have been shown to provide enhanced habitat for fish, at least within the first few years after implementation. The lack of long-term habitat monitoring limits the ability to assess long-term benefits. The lack of established fish-habitat relationships prevents us from drawing major conclusions about the benefits of these habitat improvements to fish or populations although we do have limited evidence that fish do benefit from these improvements in habitat.



Snorkel surveys on the Entiat River.
Photo courtesy of U.S. Fish and Wildlife Service.

It is difficult to draw broad conclusions from site-based fish monitoring efforts since the methods have been inconsistent and the results are mixed in terms of fish response. Monitoring at specific projects and reaches has shown a local and reach-scale fish response. In the Entiat, monitoring at instream structures showed the abundance of juvenile Chinook salmon was consistently higher in habitats with structures, compared to those without, at least in early season (Polivka et al. *in review*). Differences in juvenile steelhead were less clear. In the Middle Methow (M2) reach, juvenile Chinook and steelhead used patches of constructed habitat and carrying capacity increased in the restored reach (BOR 2013). Other post-implementation fish monitoring (via snorkel surveys or electrofishing) in the Methow also indicates a positive fish response as a result of restoration treatments (John Crandall, pers. comm., October 2013).

Looking more specifically at different project types, fish passage projects that have been monitored have shown juvenile and adult fish movement into the newly accessible habitat (e.g. projects in Chumstick Creek, Stormy Creek, Beaver Creek, Chewuch River, and Loup Loup Creek). Side channel and off-channel pond restoration monitoring has shown salmon and steelhead using newly created or re-opened habitat (e.g. Methow Elbow Coulee, mainstem side channels and ponds in the Entiat, Lower Wenatchee, Nason Creek, and Hancock Springs,). Projects that have restored flow in flow-limited creeks and reaches have shown an immediate local fish response (e.g. Loup Loup Creek).

Programmatic, reach–scale effectiveness monitoring has been conducted throughout Washington by the Washington State Salmon Recovery Funding Board (SRFB) since 2004. The program monitors eight different project categories with six of those being commonly implemented in the Upper Columbia region. These categories include: fish passage, instream habitat, riparian planting, floodplain enhancement, diversion screening, and habitat protection. Overall, the results of this study indicate that projects across the state are achieving their desired habitat outcomes. However, some project types are more effective at achieving specific goals (TetraTech 2012; O'Neal 2013). A summary of results from the state-wide monitoring program are presented below in Table 9. Overall, the program has evidence of specific habitat responses tied to specific project types but has not found evidence for specific fish responses to specific project types. A larger sample of projects is expected within each category over the next few years and may enhance our ability to detect significant differences in fish density if they exist.

Table 9. Summary of results from the Salmon Recovery Funding Board and Upper Columbia Salmon Recovery Board state-wide monitoring program conducted by TetraTech since 2004. Any significant results (+) are noted based on a slope method or an average difference method before and after project implementation.

	Project Type			
Indicator	In-Stream Habitat	Floodplain Enhancement	Habitat Protection	Riparian Planting
Pool Area	+	+		
Pool Depth	+			
Bankfull Height				
Bankful Width		+		
Flood Prone Width		+		
Canopy Density				
Volume of Wood	+			
Riparian Vegetation Structure				
Coniferous Basal Area			+	
Deciduous Basal Area				
Non-Native Herbaceous Cover			+	
Percent Fines				
Percent Embedded				
Bank Erosion				
Chinook Juvenile Density				
Steelhead Parr Density				

Looking more broadly at the results of fish monitoring at restoration sites similar to those in the Upper Columbia is informative in assessing the potential benefits of such projects to local populations. Recent reviews of published evaluations of stream rehabilitation techniques (Roni et al. 2008; Smokorowski and Pratt 2007; Roni et al. 2013) and their effectiveness for improving habitat and water quality, and increasing fish and biotic production, have shown varying results. Reconnection of habitat, off-channel and floodplain rehabilitation, and instream habitat improvements have proven effective for improving habitat and increasing local fish abundance, size, and potentially growth over a relatively short time period. Fish rearing in floodplain and off-channel habitats that have been enhanced or reconnected often have higher growth rates than those in the mainstem. The literature has also shown that improvements in instream flow lead to increased prey and fish production, with the greatest response in those reaches that were previously dewatered or too warm to support fish (Roni et al. 2013). Other restoration types such as riparian planting, road improvements, and restoration of natural flood regimes have shown promise for restoring natural processes that create and maintain habitat, but no studies on their long-term success have been published. Few studies have examined the response of instream habitat or fish to these types of projects, largely because of the time period or scale at which change may occur.

There are few data to support changes in survival at the reach scale as a result of habitat improvement and few projects across the northwest have tried to measure benefits in terms of fish survival. Of the 400 studies that Roni et al. (2013) examined, only 19 reported changes in survival rather than fish numbers, density, size, or growth. These studies focused on off-channel or side channel habitat restoration and improvements of instream habitat. Of those 19, the majority (13) suggested that survival improved as a result of restoration, or was at least equivalent to high-quality reference sites. From these studies Roni et al. (2013) concluded that floodplain and off-channel reconnection or creation leads to survival rates for coho and Chinook that are equivalent to those found in natural floodplain and off-channel sites. He also found that improvements in spawning habitat, through improved gravel retention or augmentation, can lead to some improvements in egg-to-fry survival.

Entiat River instream restoration.

Paulsen and Fisher (2005) showed a positive correlation between the number of actions taken to improve habitat and the beneficial effect on parr-to-smolt survival of Chinook salmon. This study found that watersheds with more than 24 actions had 22% greater juvenile survival rates than those with 0-3 actions. In an updated analysis in 2011, Paulsen and Fisher found that the influence of habitat improvements carries through to adulthood and that fish from areas with the most habitat actions survived their downstream migration and years at sea and returned as adults at a higher rate than those from areas with fewer actions (Paulsen and Fisher, unpublished manuscript, 2011, cited in NOAA 2013). Through coordination at the regional level the UCSRB, RTT, and other implementing and funding partners have worked to target projects within priority areas to achieve such a survival increase. The majority of restoration projects (>50%) are concentrated in less than 10% of the Upper Columbia assessment units: Lower Entiat, Lower Wenatchee, Upper Omak Creek, Chumstick Creek, Mission Creek, Lower Chewuch, and Lower Twisp.

Another study by Roni et al. (2010) found that 20% of floodplain and in-channel habitat would have to be restored in a given watershed to detect a 25% increase in steelhead smolt production. Given the large variability in fish response to restoration, 100% of the habitat would need to be restored to be 95% certain of achieving a 25% increase in smolt production for either species. Given this estimate and the expert panel results showing the increases in habitat function for these attributes between 2012-2018 and between 2012-2033, there are 15 assessment units where a 20% increase in floodplain and in-channel habitat is expected by 2018 and four additional assessment units where it is expected by 2033. The remaining 39 assessment units have a small potential for improving these ecological concerns. This means there may be limited opportunity to increase survival in some areas. This is consistent with the findings of this report and with the findings in the Recovery Plan that were derived from EDT modeling results (Appendix F).

Progress Toward Recovery- Habitat Perspective

Although a positive response in project-scale fish abundance or density is informative, it is difficult to link this type of response to improved survival or productivity at larger scales, or to translate this into progress toward recovery. The influence of restoration on survival and growth has not been thoroughly explored in the Upper Columbia region and responses at the reach or population scale has yet to be determined. Efforts in the Methow and Entiat Intensively Monitored Watersheds (IMWs) may provide some evidence of the response at these scales in the future (within 5-10 years). There is an untested assumption that improved conditions will benefit the target species, although the type and extent of benefit varies and is difficult to monitor. Currently, we assume that those actions targeted at the highest priority ecological concerns in the highest priority areas (as identified in the RTT Biological Strategy) will have the greatest benefit to the population and will move the populations and the species toward recovery.

Progress toward recovery can be assessed a variety of different ways. In this report we summarize how habitat actions could contribute toward recovery of listed Upper Columbia species based on the potential contribution of habitat work to viable salmonid population criteria (VSP). The Recovery Plan focuses on the four viable salmonid population (VSP) criteria as the core measures used to gauge progress toward recovery. Status assessments performed during development of the plan indicated that those VSP parameters which are most impaired and which can be influenced by habitat actions are the parameters that must be addressed first by habitat actions. Specifically, habitat actions that increase juvenile survival (e.g., smolts/redd) and growth are the highest priority for improving VSP status in all Upper Columbia populations.

Abundance and Productivity

Abundance and productivity can be directly influenced by tributary habitat projects because of the benefits to life stage-specific survival (specifically egg-to-emigrant and pre-spawn mortality) and therefore overall freshwater productivity. There is no guarantee that improved tributary survival will result in higher spawner abundance, because factors outside the natal rearing tributaries may limit the production of spawners. Although there is little direct evidence of the effect of habitat actions on tributary survival and productivity, projects have improved rearing, holding, and migratory habitat across the region in the primary areas of production and addressed primary ecological concerns in those areas.

Simple scenarios looking at spawner abundance as a function of life-stage specific survival can be informative about how much habitat improvement (egg-to-emigrant survival as a surrogate) would be needed to achieve abundance recovery targets for each species. Using current average abundance (R_c), average eggs per female (e) and recovery abundance targets (R_t) we can model what egg-to-emigrant survival (s) would be needed to reach abundance targets for the region for steelhead and spring Chinook under different smolt to adult return (SAR) and pre-spawn mortality (PSM) scenarios. The equation we used was:

$$\Big(\big((Rc * e)s\big)SAR\Big)PSM = Rt$$

We ran this basic model using the current 12-year geo-mean for abundance as the input for R_c (2,061 for steelhead and 1,158 for spring Chinook), an average number of eggs per female for each species (2,600 for steelhead and 3,500 for spring Chinook; Snow et al. 2013), and the recovery target abundance for each species as R_t (3,000 for steelhead and 4,500 for spring Chinook). Under average conditions (SAR=2%, PSM=50%) we estimated a target egg-to emigrant survival of 6.5% (2 - 12% range based on ranges of pre-spawn mortality and SAR). For spring Chinook the estimated target egg-to-emigrant survival is 12.5% (range of 4.5% - 17%) (Figure 24). With both poor ocean conditions *and* high pre-spawn mortality egg-to-emigrant survival would need to be much higher for both species to achieve target abundances (20% for steelhead and 29% for spring Chinook).

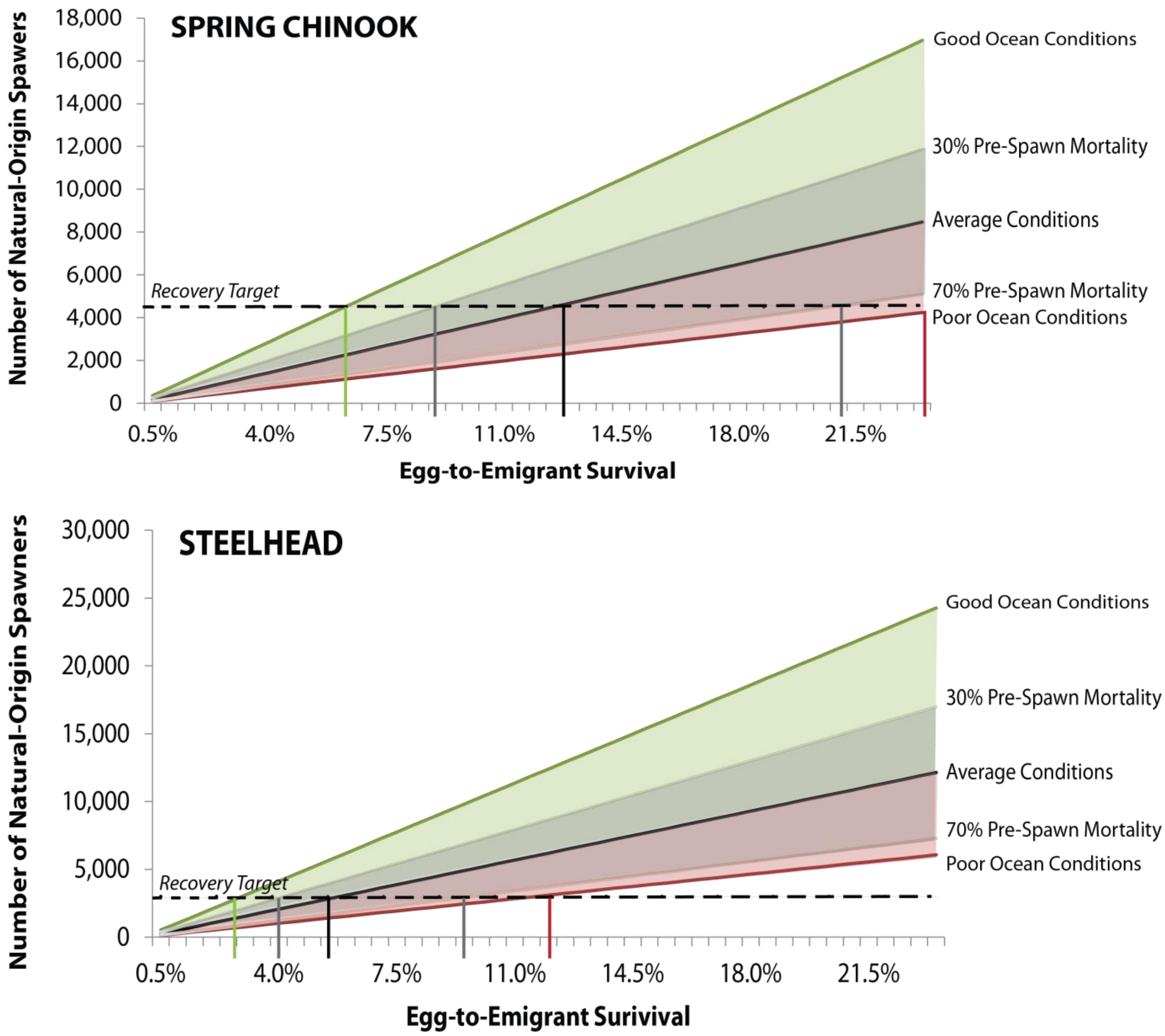


Figure 24. Scenarios of egg-to-emigrant survival necessary to meet recovery abundance targets given different ranges of smolt-to-adult returns (SARs) and pre-spawn mortality (PSM) rates. Current survival rates for each species are given as reference on the axes.

Given a restoration potential of 15% and an assumption that this translates into an equal potential for improvement in survival (a 1:1 relationship as assumed by experts) this would equate to an average egg-to-emigrant survival of 1.3% for steelhead and 4.14% egg-to-emigrant for spring Chinook. These increases would not be enough on their own to achieve the target spawner abundances for each species (Figure 25). Therefore, as pointed out in the Recovery Plan, recovery will likely not be possible without other changes beyond just habitat. If recent returns continue to improve (due to a variety of improvements across the life cycle of regional populations) or the survival improvements from habitat are beyond a 1:1 relationship this scenario would change and the gap in survival would not be as substantial.

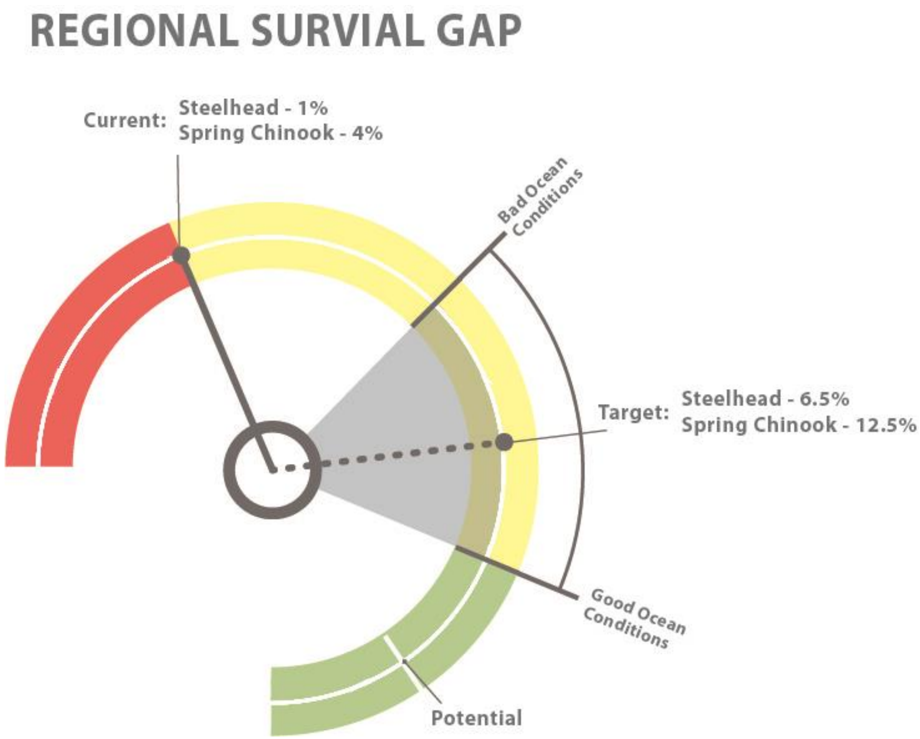


Figure 25. Estimated survival gaps in the egg-to-emigrant (freshwater juvenile) life stage most affected by habitat actions. Target survival estimates were calculated based on current and target spawner abundances fed into a simple life cycle model.

A more complicated life cycle model has been developed in the Wenatchee subbasin for spring Chinook (Honea et al. 2009). The model incorporates more complex in-river and out-of-basin survival modules and future environmental conditions. The results show that there is limited opportunity to improve abundance and productivity of wild spawners under current conditions but that without restoration and protection of habitat we could lose over 50% of the spawners and have 40% lower productivity in the future. The life cycle model is currently being refined and expanded by NOAA, WDFW, and partners to other subbasins and to steelhead to provide better estimates of the effect of life-stage specific survival improvements on overall abundance and productivity. These models are expected to provide more insight into the benefits incurred from improvements in habitat quality and freshwater survival.

Spatial Structure and Diversity

In most cases diversity is not controlled by habitat conditions, but rather is more directly influenced by genetic introgression from hatchery-origin spawners. Habitat projects can influence life history diversity but this generally is not a large contributor to the life history risk rating as used by NOAA-NMFS in the Upper Columbia populations. Spatial structure can be directly influenced by habitat project that result in fish passage to previously blocked habitat. A large proportion of the early habitat work in the Upper Columbia did just this, opening up almost 300 miles of habitat that had previously been blocked. This equates to 13% of total available anadromous habitat in the region (2,233 miles). Despite this achievement a proportion of habitat in the region still remains inaccessible, especially in the Okanogan subbasin. Fish passage has still been noted as one of the largest habitat gaps, although many of the high priority fish passage barriers have been addressed.

Data Gaps and Information Needs

The Recovery Plan is built on a solid foundation of science. A productive, efficient, scientifically-sound monitoring effort in the Upper Columbia is essential for planning and adaptively managing for future implementation, and for evaluating and understanding the benefits of past accomplishments. Updated science and information is critical, not only in identifying, prioritizing, and implementing projects, but to understand our ability to meet habitat goals and objectives at a variety of scales, from the project to the region.

Some of the uncertainties identified in the Recovery Plan remain today as important information gaps that could affect our ability to meet recovery goals. Resolution of these uncertainties will greatly improve our chances of attaining these goals. Specifically related to freshwater tributary habitat, information related to habitat status and trends, habitat actions and their effectiveness, life-stage survival and limiting factors, life history and habitat use, and productivity and carrying capacity are all important, especially at the tributary and reach scale.

Basic, summarized data on habitat status and trends and fish survival are lacking from most major tributaries. Not only does the lack of information impede our ability to track progress, but it impedes the potential to identify the most appropriate habitat actions in the most appropriate places to achieve recovery in an effective way. Recognizing that monitoring programs are designed and funded for a variety of purposes, the following recommendations are intended to identify the data and information that would be most helpful for answering the questions that were outlined in this report. Many of these recommendations are currently being reiterated and expanded upon by the RTT's Monitoring and Data Management Committee.

Electrofishing on the Wenatchee River. Photo courtesy of Yakama Nation Fisheries.

We need a better understanding of habitat status and fish survival at the population scale

Although a wealth of information is being collected on fish and habitat, it is not always informative to project development and implementation. There is very little effort to analyze diverse data to answer a variety of questions related to fish performance and survival and habitat status and trends at the tributary scale. Basic data on freshwater life stages (abundance and survival) is lacking from many major tributaries and is not always reported consistently even where it is being collected. Basic data on egg-to-parr, parr-to-smolt, or egg-to-emigrant survival, along with smolt-to-adult return and pre-spawn mortality at the tributary, or assessment unit scale, would help answer many questions related to freshwater habitat performance and limited life stages.

Although habitat data are being collected at a watershed scale, current information at the assessment unit scale is limited and generally inadequate in the highest priority watersheds. There is a lack of summary metrics for habitat being used by habitat monitoring programs, and no clear connection between the habitat data and the ecological concerns being identifed and targeted. Collecting habitat data that is consistent, summarized, and clearly linked to ecological concerns at the assessment unit and reach scale would benefit future habitat actions.

We need a better understanding of how fish respond to habitat actions

A critical uncertainty associated with the implementation of the Recovery Plan has been the effect of management actions or strategies on the environment, on life-stage specific survival rates, and on population level responses. In particular, a high level of uncertainty exists for the magnitude and response time of habitat actions. Populations will likely respond more quickly to some actions (e.g., diversion screens and barrier removals) than they will to others (e.g., riparian plantings). Similarly, populations will respond more to actions that address primary ecological concerns or life stage limiting factors than they will to those that address lesser threats to productivity. Although significant investments have been made to try and address these uncertainties, they remain key information gaps. It is clear from the available information in this report that there is insufficient information available to adequately assess the benefit of habitat actions to listed species, and to evaluate the extent to which these benefits translate into progress toward recovery. We recommend that there be an increase in project- and reach-scale monitoring of fish response to restoration projects, and that the metrics chosen to monitor fish response are as robust as possible.

We need a better understanding of how habitat actions contribute to recovery

Similar to the need to relate habitat data with ecological concerns, there is a need to relate information about habitat status and fish survival to our progress toward recovery. Models can be used to interpret data at a variety of scales to evaluate fish and habitat change to inform future management. As indicated in this report, several models are under development in the Upper Columbia that show promise in helping to inform many of the management questions related to habitat and recovery plan implementation across management sectors.

A life cycle model is being refined for spring Chinook in the Wenatchee subbasin and is proposed to be developed in the Methow subbasin, but this effort should be expanded across all important tributaries for both species. The model should be able to help inform decisions regarding habitat restoration, hatchery operations, and hydropower operations, as well as other management decisions related to listed species. Results can be useful in evaluating the effects of habitat restoration and hatchery supplementation at the tributary and population scale and can be used in the evaluation of effects of threats throughout the life cycle.

Partners in the Okanogan subbasin are using the newest version of the Ecosystem Diagnosis and Treatment (EDT) model to provide this kind of information. This effort could be expanded to other watersheds to replace existing EDT model runs. The model offers the potential to be able to interpret habitat monitoring data in a meaningful way for recovery practicioners. It can be used to inform habitat priorities and evaluate changes in habitat related to past actions. Results from the Okanogan suggest the model can be very useful in decision-making related to habiat and recovery implementation.

To help address these questions the most important regional information, analyses, and tools are currently:

- Status and trends of habitat in core spawning and rearing areas related to ecological concerns and summarized at the tributary, assessment unit, and reach scale.
- Robust effectiveness monitoring at the reach scale.
- Modeling tools that can incorporate monitoring data to help inform implementation and evaluate recovery scenarios (e.g., EDT and Life Cycle Modeling).
- Status and trends of abundance, survival, and life history of freshwater life stages at the population scale.
- Tributary productivity and carrying capacity for different life stages.

Smolt trap on the Wenatchee River

Emerging Issues

Several emerging issues related to salmon and steelhead habitat have the potential to have a large effect on our ability to achieve recovery. In the review of the 2009 Fish and Wildlife Program, the Independent Scientific Advisory Board (ISAB) summarized several of the most prominent issues affecting listed Columbia basin species, which pertain to the Upper Columbia. These included potential future changes in temperature and precipitation, proliferation of chemicals and contaminants, non-native species and predation, uncertainty about carrying capacity, and artificial production (ISAB 2013). Below we summarize some of their concerns and relate them to the Upper Columbia region.

Future changes in temperature and precipitation could have regional effects on the timing and distribution of water, water quality, ocean conditions, and the susceptibility of areas to expansion and introduction by non-native species. Toxic pollutants throughout the Columbia River are well documented and continue to be a growing concern. The collective impacts of contaminants on Upper Columbia fish that migrate through the lower Columbia are unknown. Non-native species are a major threat to the region and to the Columbia basin as a whole. Non-native species can lead to changes in food webs and genetic diversity and can increase predation rates. They can also affect habitat in other ways through changes to ecosystem function. Many of these potential impacts have not been explored.

Uncertainty about the carrying capacity of freshwater habitats has been identified as a high priority for research, management, and restoration activities. Carrying capacity has rarely been considered within the regional planning context; however, it ultimately could constrain our ability to meet recovery goals. Carrying capacity should be considered across all habitats and life stages. Carrying capacity naturally changes over time and should be tracked to adaptively manage habitat programs in the region so that the appropriate habitat actions are implemented in the appropriate order to achieve increased productivity (e.g. targeting the limited life stage and its associated habitat).

Juvenile Chinook salmon in the Methow River.

Conclusions and Next Steps

Functional habitat is essential to the recovery and long-term sustainability of listed salmon and steelhead in the Upper Columbia. Salmon and steelhead abundance, productivity, diversity, and spatial structure are inherently maintained by complex and resilient habitats. This report indicates that progress has been made across the region to improve habitat, but a large amount of habitat work remains. A refined understanding of the habitat potential that exists and how it is related to life-stage species survival will improve effectiveness at increasing productivity and meeting recovery goals. Comprehensively addressing major data gaps and information needs across the region builds a better understanding of, and improves our ability to, assess and track the benefits of habitat work and its contribution to recovery.

The UCSRB and its partners in salmon recovery intend to continue salmon recovery efforts in a transparent and adaptive process to restore habitat and fish populations. In just a short period of time many of the major restoration opportunities in the region have been addressed. The number of salmon and steelhead returning to the Upper Columbia is higher than it was five years ago, with populations generally trending up or staying the same. While this is very encouraging there is more work to be done. Large improvements in tributary survival are needed to achieve recovery targets along with complimentary improvements in survival of other life stages. Habitat restoration and protection continues to be the sole tool that can contribute to tributary survival improvements and is ultimately the key to the long-term sustainability of salmon populations. This work must continue. Better and more refined information and tools facilitates adaptive management to strategically target habitat work in the future and confirm that habitat improvement actions are having the desired outcomes for both habitat and fish.

Within the next few years we expect that additional monitoring, data analysis, and modeling efforts will refine our collective understanding of habitat restoration, its benefits to populations, and its contribution to recovery. These efforts should continue to be supported, and research and monitoring that helps to better understand these questions should be encouraged. In the future, this effort to summarize habitat actions will be expanded and this information will be integrated into a comprehensive view of recovery. Looking across the four H's will foster progress to track information from all management sectors that influence progress toward recovery.

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