PROTECTING SALMON AND STEELHEAD

Endangered Species Act
Federal Columbia River Power System

2013 Annual Progress Report - Section 1

NOVEMBER 2014

Throughout the Columbia River Basin, Tribal, State, local, and Federal parties are working in partnership to protect and restore stocks of salmon and steelhead. Thirteen species specific evolutionarily significant units (ESUs) or distinct population segments (DPSs) of salmon and steelhead are listed as threatened or endangered under the Endangered Species Act (ESA). Many parties in the region are working together to protect and enhance important habitats, improve hatchery and harvest practices, implement improvements at dams to increase fish survival, manage and reduce predation, and enhance river conditions for migrating fish. This report summarizes the actions implemented by the Action Agencies in 2013 to protect ESA-

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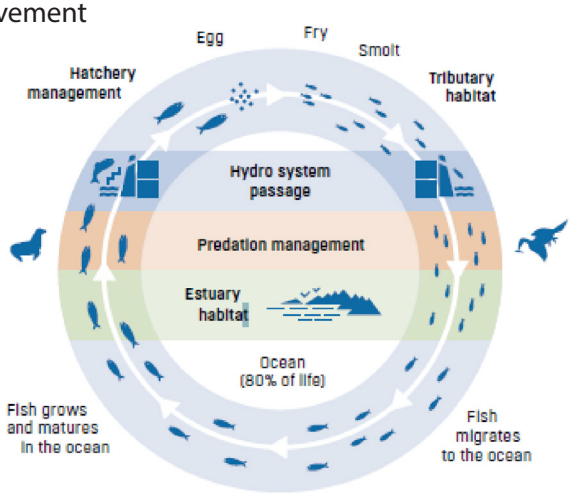
In May 2008, the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (also known as NOAA Fisheries) issued a Biological Opinion on the operation of 14 of the projects that make up the Federal Columbia River Power System (FCRPS). The FCRPS projects are operated for multiple purposes including flood control, fish and wildlife, power generation, navigation, irrigation, and recreation. The FCRPS Biological Oppinion (BiOp) considered a suite of Reasonable and Prudent Alternative (RPA) actions proposed by the Bonneville Power Administration (BPA), Bureau of Reclamation (Reclamation), and U.S. Army Corps of Engineers (Corps), together referred to as the Action Agencies. These actions, developed through a collaborative process with States and Tribes in the Columbia Basin, were designed to protect salmon and steelhead across their life cycle and were supported by a biological analysis that NOAA Fisheries concluded would avoid the likelihood of jeopardizing the fish or adversely modifying their critical habitat. In 2010 and again in 2014, NOAA Fisheries updated the FCRPS BiOp in a Supplemental BiOp, which can be found at

http://www.westcoast.fisheries.noaa.gov/fish_passage/fcrps_opinion/federal_columbia_river_power_system.html

The Action Agencies committed to implementing the RPA actions, including the use of spill and surface passage structures at dams, management of water releases from storage reservoirs, expanded control of predators that prey on young salmon, improvement of tributary and estuary habitat, and implementation of hatchery reforms. To strengthen implementation of the BiOp and promote regional collaboration, the Action Agencies also entered into the Columbia Basin Fish Accords with three States and five Tribes.



All-H Problems: All H-Solutions

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This report is produced by the "Action Agencies"—the U.S. Army Corps of Engineers Northwestern Division, Bureau of Reclamation Pacific Northwest Region, and Bonneville Power Administration.

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listed salmon and steelhead affected by the operation of the FCRPS.[1] It describes the status of RPA actions that were implemented in calendar year 2013 to benefit fish at multiple phases of the life cycle. The actions described in this annual report are focused on achieving biological performance standards, achieving programmatic performance targets, and addressing factors that limit certain life stages for specific listed salmon and steelhead.[2] The Action Agencies in coordination with NOAA Fisheries use adaptive management to make adjustments to actions based on new scientific information to meet biological performance objectives effective and efficiently.

1. The FCRPS includes 14 dams and power plants on the Columbia and Snake rivers. These dams and power plants are operated as a coordinated system (including coordination with Canada) to meet multiple purposes as authorized by Congress.

2. The FCRPS BiOp RPA actions are designed to meet ESA Section 7(a)(2) responsibilities.

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The Action Agencies are responsible for providing annual progress reports detailing the implementation and progress of the RPA actions. This report provides implementation progress by the Action Agencies during the period of January 1 through December 31, 2013.

This report is organized into three sections. Implementation highlights and accomplishments are presented in Section 1, which identifies findings that will inform future RPA action implementation. Section 2 provides 2013 accomplishments on RPA implementation by action. Section 3 lists actions implemented during 2013 and includes habitat metrics completed.

The full FCRPS 2013 Annual Progress Report, which includes the Detailed Description of RPA Action Implementation (Section 2) and Project Tables for RPA Action Implementation (Section 3), is available online at *http://www.salmonrecovery.gov/BiologicalOpinions/FCRPSBiOp/ProgressReports.aspx*. Previous FCRPS progress reports and information on other salmon and steelhead protection efforts are also available at the website.

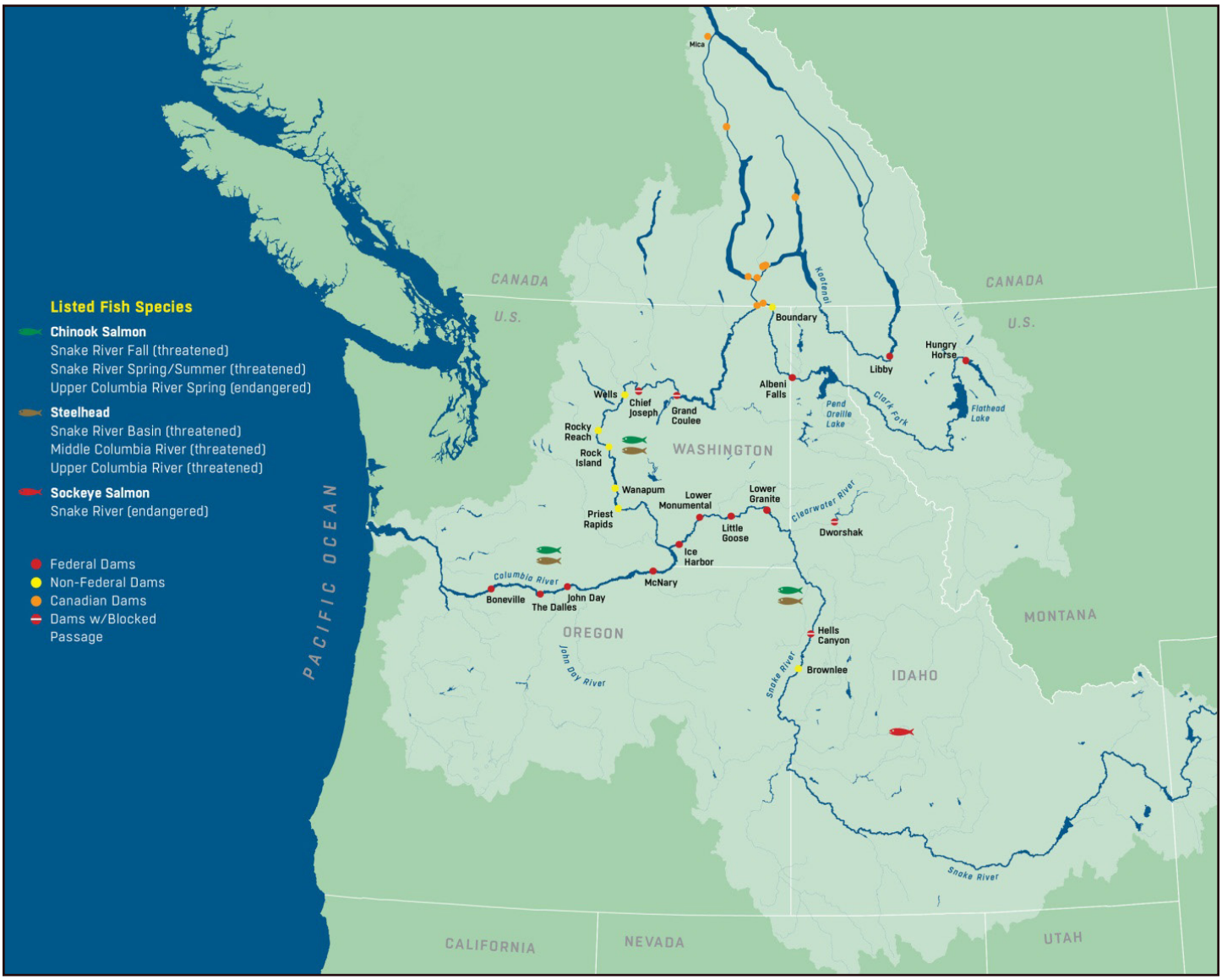


Figure 1. Map of the Columbia River Basin showing action areas, dams, and listed species.

2013 Fish Status and Environmental Conditions

Fish Status

Columbia River Basin salmon and steelhead have been adversely affected for well over a century by a range of human and environmental impacts. These impacts include urbanization, the introduction of non-native species, adverse ocean and climate conditions, overfishing, mining, predation, hatchery practices, toxic pollutants, as well as the impacts from dams and water diversions. Steep declines in salmon and steelhead abundance in the early 1990s led to the first listings under the ESA.

In the Pacific Northwest, salmon and steelhead status is evaluated by tracking the number of fish that return each year to spawn. Many dams have fish counting stations where annual index tallies are made of the various species as they swim up the fish ladders. In 2013, more than 1.75 million adult and jack salmon and steelhead were counted as they passed Bonneville Dam, after ocean and lower river harvest. This number includes hatchery and naturally produced fish as well as listed and unlisted stocks. In a typical year, an estimated 80 percent of all returning adult salmon are of hatchery origin, although the actual percentage varies by species and population; many of these are also part of the listed ESUs/DPSs. In addition, approximately 178,000 of these were jacks, which are young males that mature and return to spawning grounds earlier than others in the age class. The 2013 counts exceed historical averages for 2000 and earlier and also exceed the more recent 10-year average (Figure 2).

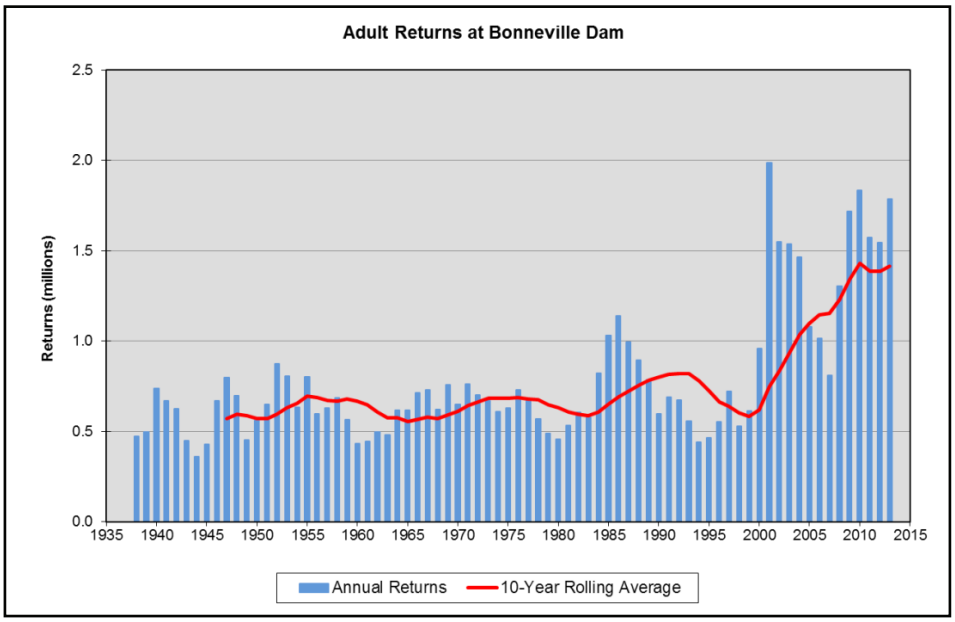


Figure 2. Salmon and steelhead returns at Bonneville Dam, 1938 to 2013. Values shown are for daytime counts, and include both hatchery and natural-origin fish, and both adults and jacks. Harvest levels have varied over time. (Data from ACOE 2014.)

As shown in Table 1, counts in 2013 of adult salmon and steelhead passing Bonneville Dam varied by species. Returns of spring Chinook, coho, and steelhead were considerably below the 10-year average, while returns of summer Chinook and sockeye were about average. The more than 950,000 adult fall Chinook that returned to Bonneville Dam in 2013 (in addition to more than 110,000 jacks) was the largest run since counting began in 1938 and more than twice the 10-year average.

Table 1. Adult Salmon and Steelhead Returns at Bonneville Dam – 2013 and 10-year Average (includes hatchery and natural origin fish). Chinook and coho numbers include jacks.

Species	2013	10-year average
Chinook – Total [1]	1,300,711	747,985
Spring Chinook [2]	117,165	152,244
Summer Chinook	119,283	104,754
Fall Chinook	1,064,263	490,987
Steelhead	234,047	351,191
Sockeye	185,505	192,263
Coho	66,758	120,446
Chum and Pinks	675	567
TOTALS of all species for period	1,787,696	1,412,452

Period of 10-year average 2004-2013. Data are for daytime counts – 0400 to 2000 PST.
All Data are from ACOE 2014, Table 22b, *except:*

[1] Chinook data are from monthly values in Table 23

[2] Assumed Chinook run dates are: Spring = Jan 1–May 31; Summer = June 1–July 31; Fall = Aug 1–Dec 31

Overview by Species

The following summaries describe abundance and abundance trends at the species or ESU/DPS level as of January 2014. Species-level status is determined based on a review of population-level status and includes consideration not just of abundance, but also productivity, spatial structure, and diversity attributes of a viable salmon and steelhead populations.

Species-level abundance is an important indicator under the ESA and the BiOp's contingency plans. The BiOp includes abundance and trend-based indicators intended to signal significant declines at the ESU/DPS level. A significant decline is judged to occur when the running four-year mean of natural-origin adult abundance falls below a 10 percent likelihood of occurrence based on historical data. For this purpose, running four year means are included in Figures 3 through 9 below (with the exception of Figure 7 - Upper Columbia River spring Chinook). Such declines—in the unlikely event they occur—would trigger contingency actions. This contingency process is more thoroughly described in the Action Agencies' Rapid Response and Long Term Contingency Plan (*https://www.salmonrecovery.gov/Files/2011 APR files/2011_RRandLTC_Plan.pdf*).

Figures 3 through 9 display natural-origin spawners only and do not include listed hatchery fish (with the exception of the Snake River sockeye ESU, which is sustained through a captive broodstock program)[3]. It should be noted that natural annual variation in population abundance and productivity can be substantial, so longer term trends are more informative than shorter term indicators. Therefore, 10-year averages are also reported in the narrative for each species.

Snake River Fall Chinook Salmon

The Snake River fall Chinook salmon ESU was listed under the ESA as a threatened species in 1992. This ESU is composed of only one extant population, which spawns and rears in the mainstem Snake River and in the lower reaches of its major tributaries below Hells Canyon Dam. It is estimated that 85 percent of the ESU's historical spawning habitat was lost as a result of construction of the privately owned Hells Canyon Dam complex, which blocks all fish passage.

The most recent 10-year average return of natural-origin fish (through 2013) is estimated to be 7,652 adults. The most recent four-year average return is 12,674 adults (Figure 3). An analysis of adult returns from 1990–2013 indicates that the ESU-level trend in abundance was positive during this period. Neither the early warning indicator nor the significant decline trigger for this ESU were tripped in 2013.

The 2008 FCRPS BiOp considered trends of natural-origin adults based on two time periods with differing management actions and climate: 1977–2004 and 1990–2004. Although abundance trends were positive for both periods, productivity measured as returns-per-spawner was positive only for 1990–2004. These estimates represent average survivals during the periods in question and do not fully reflect survival improvements resulting from more recent hydrosystem improvements and other management changes.

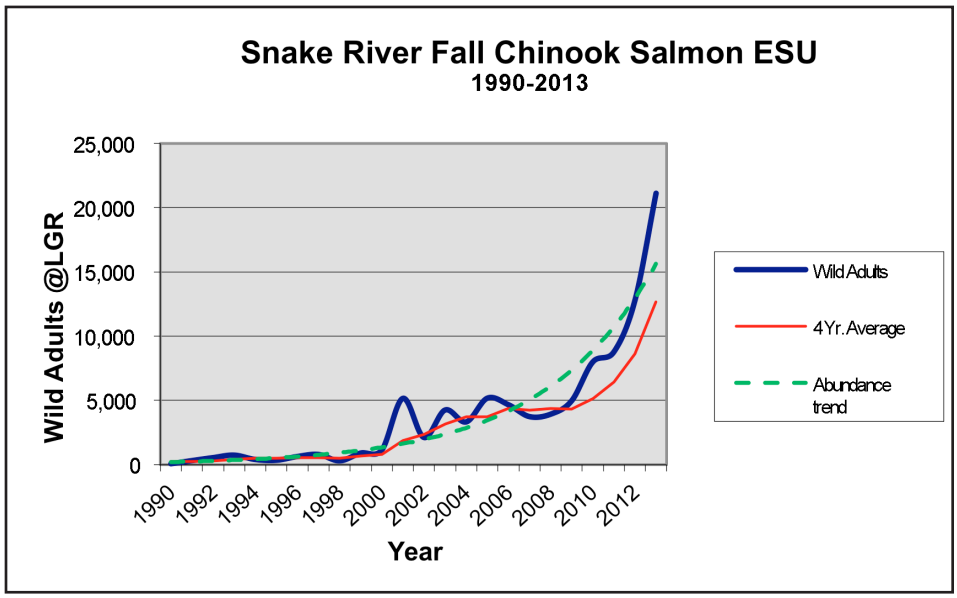


Figure 3. Returns of naturally produced adult Snake River fall Chinook salmon at Lower Granite Dam, 1990–2013. The ESU-level trend in abundance was positive during this period.

3. Abundance charts in this report show ESU-level abundance from 1990 until the most recent available observation, consistent with the 2008 BiOp "short-term" trend estimation period. The exception is the Middle Columbia Steelhead DPS, which is represented by the Yakima River major population group. Estimates are of naturally produced adult returns and are taken from the U.S. v. Oregon Technical Advisory Committee Joint Staff Reports at http://wdfw.wa.gov/fishing/crc/staff_reports.html, with the exception of the Yakima River MPG returns, which are taken from Columbia River Data Access in Real Time at http://www.cbr.washington.edu/dart/, and upper Columbia Steelhead numbers, which were supplied by NOAA Fisheries. Trend lines are shown where the 1990–present trend is statistically significant ($p<0.05$). The trend estimation method is taken from Good et al. (2005).

Snake River Spring/Summer Chinook

The Snake River spring/summer Chinook salmon ESU was listed under the ESA as a threatened species in 1992. The ESU comprises 28 extant populations in five major population groups (MPGs). The populations in this ESU spawn and rear in the tributaries of the Snake River between its confluence with the Columbia River and the Hells Canyon Dam.

The most recent 10-year average return of natural-origin Snake River spring/summer Chinook salmon was 16,633 adults. The most recent four-year average return was 21,950 adults (Figure 4). An analysis of adult returns from 1990-2013 indicates that the ESU-level trend in abundance was positive during this period. Neither the Early Warning Indicator nor the Significant Decline trigger for this ESU were tripped in 2013.

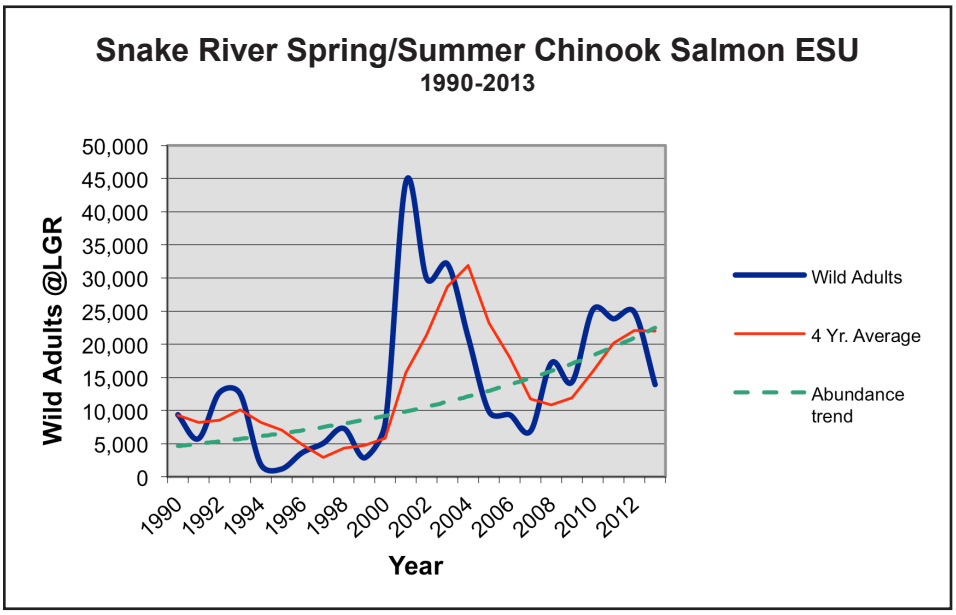


Figure 4. Returns of naturally produced adult Snake River spring/summer Chinook salmon at Lower Granite Dam, 1990–2013. The ESU-level trend in abundance was positive during this period.

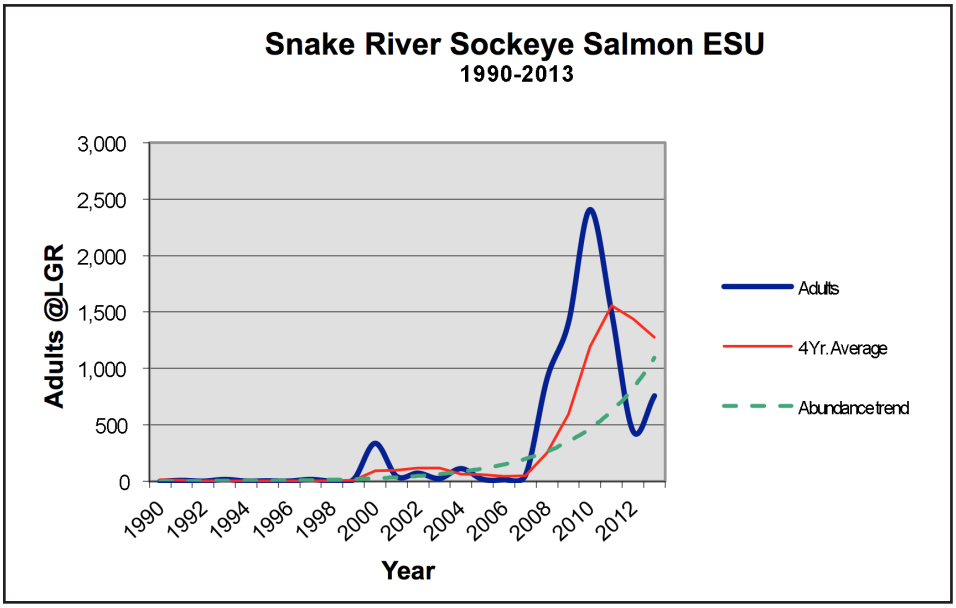


Figure 5. Returns of all Snake River sockeye salmon at Lower Granite Dam, 1990–2013. The ESU-level trend in abundance was positive during this period.

Snake River Sockeye Salmon

The Snake River sockeye salmon ESU was listed under the ESA as endangered in 1991. The ESU includes all anadromous and residual sockeye in the Snake River Basin, as well as the artificially propagated fish from the Redfish Lake Captive Broodstock Program. This species was thought by some to be functionally extinct at the time of its listing. It had suffered from significant long-term harvest pressures, a State-sponsored fish eradication program that eliminated it from three of its natal lakes, private dams with little or no fish passage, construction of the Federal dams on the lower Snake River, and a major detrimental ocean/climate shift in the mid-1970s. An experimental captive broodstock program was initiated at the time of listing in an effort to forestall complete extinction in the near term and to preserve the species' remaining genetic diversity. The program has achieved its original purpose and is now being expanded to help support recovery.

The average annual adult return from the captive broodstock program between 1991 and 1999 was 11 fish. An average of 50 sockeye were counted at Lower Granite Dam from 2004 to 2007. The years 2008–11 saw improved counts of 907, 1,219, 2,406, and 1,502 fish, respectively, at Lower Granite Dam (Figure 5). These were the largest sockeye counts since fish counting began at Lower Granite Dam in 1975. Counts were lower in 2012 and 2013; the most recent 10-year average is 763 adult fish and the most recent four year average return is 1,278 fish.

Snake River Steelhead

The Snake River steelhead DPS was listed as threatened in 1997. The DPS comprises 24 individual populations in five MPGs. Steelhead of the interior Columbia River Basin, and especially the Snake River DPS, are commonly referred to as either A-run or B-run. These designations are based on migration timing, age, and size at return. There is only marginal information regarding the status of most individual populations of Snake River steelhead, but it is believed that B-run steelhead spawn almost entirely in the Clearwater and Salmon rivers, while A-run steelhead occur throughout the Snake River Basin. NOAA Fisheries is currently undertaking an analysis to assess the importance of the distinctions.

The most recent 10-year average return of natural-origin Snake River steelhead was 26,949 adults (2004-2013). The most recent four-year average return was 33,755 adults (Figure 6). An analysis of adult returns from 1990–2013 indicates that the DPS-level trend in abundance was positive during this period. Neither the early warning indicator nor the significant decline trigger for this DPS were tripped in 2013.

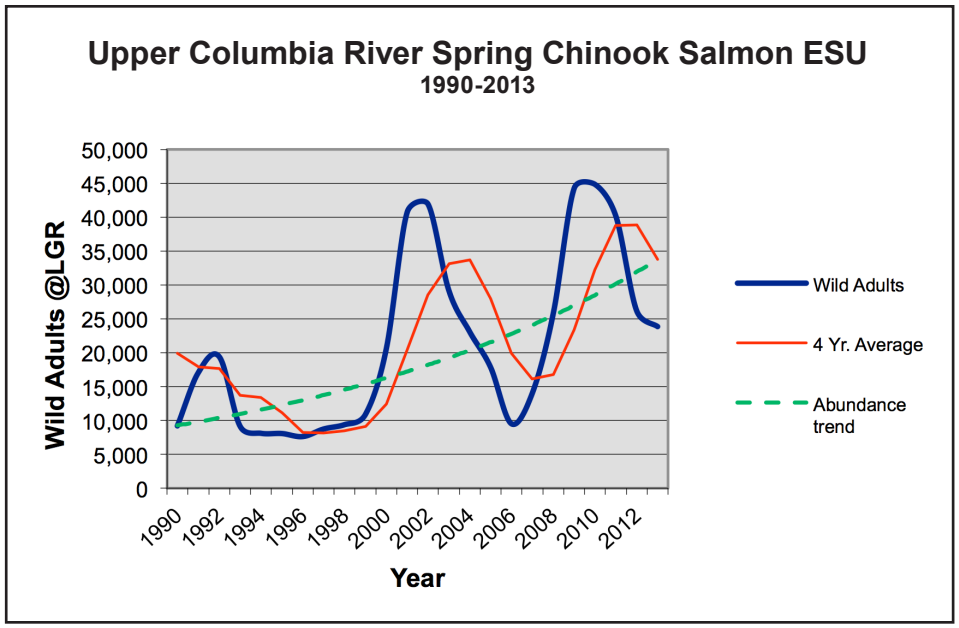


Figure 6. Returns of naturally produced adult Snake River steelhead at Lower Granite Dam, 1990–2013. The DPS-level trend in abundance was positive during this period.

Upper Columbia River Spring Chinook Salmon

The Upper Columbia spring Chinook salmon ESU was listed as endangered in 1999. The ESU consists of three extant populations in one MPG. These populations spawn and rear in the mainstem Columbia River and its tributaries between Rock Island Dam and Chief Joseph Dam (a barrier to upstream migration).

The most recent 10-year average return of natural-origin Upper Columbia River spring Chinook salmon was 1,873 adults at Rock Island Dam (2004–13). The most recent four-year average return was 2,896 adults (Figure 7). An analysis of adult returns from 1990-2013 indicates that there was no statistically significant ESU-level trend in abundance during this period. Neither the Early Warning Indicator nor the Significant Decline trigger for this ESU were tripped in 2013.

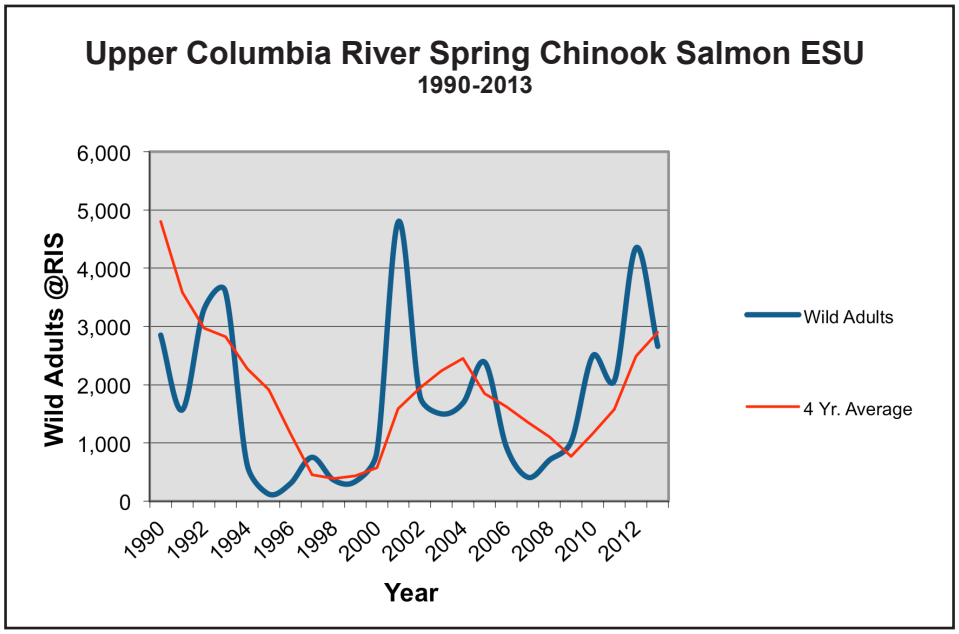


Figure 7. Returns of naturally produced adult Upper Columbia River spring Chinook salmon at Rock Island Dam, 1990–13. An analysis of adult returns from 1990 to 2013 indicates that there was no statistically significant ESU-level trend in abundance during this period.

Upper Columbia River Steelhead

The Upper Columbia River steelhead DPS was listed as endangered in 1997 but was recently relisted as threatened. The DPS consists of four populations in one MPG. These populations spawn and rear in the rivers and tributaries draining

the eastern slope of the Cascade Mountains upstream of Rock Island Dam.

The most recent 10-year average return of natural-origin Upper Columbia River steelhead was 3,849 adults (2004-2013). The most recent four-year average return was 4,378 adults (Figure 8). An analysis of adult returns from 1990-2013 indicates that the DPS-level trend in abundance was positive during this period. Neither the early warning indicator nor the significant decline trigger for this DPS were tripped in 2013.

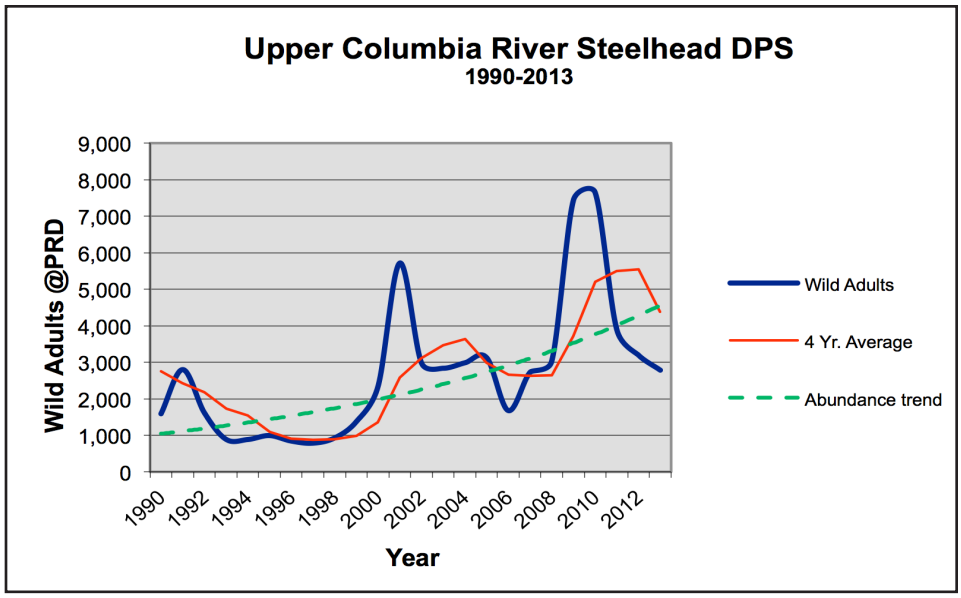


Figure 8. Returns of naturally produced adult Upper Columbia River steelhead at Rock Island Dam, 1990–2013. The ESU-level trend in abundance was positive during this period.

Middle Columbia River Steelhead

The middle Columbia River steelhead DPS was listed as threatened in 1999. The DPS comprises 17 individual populations in four Major Population Groups (MPGs). These populations spawn in Oregon and Washington drainages upstream of the Hood River and Wind River systems, up to and including the Yakima River Basin. Almost all populations within this DPS are summer-run steelhead; the exceptions are the winter-run populations returning to the Klickitat Creek and Fifteen Mile Creek watersheds.

Due to the difficulty in obtaining estimates of DPS-level abundance for middle Columbia River steelhead, the BiOp relies on abundance estimates based on dam counts for the Yakima River MPG of this DPS. Based on preliminary estimates, the most recent 10-year average return from this MPG was 3,975 natural-origin adults (2004–13). The most recent four-year average return was 5,392 natural-origin adults (Figure 9). The abundance trend for this MPG between 1990 and 2010 was positive. Neither the early warning indicator nor the significant decline trigger for this MPG were tripped in 2013.

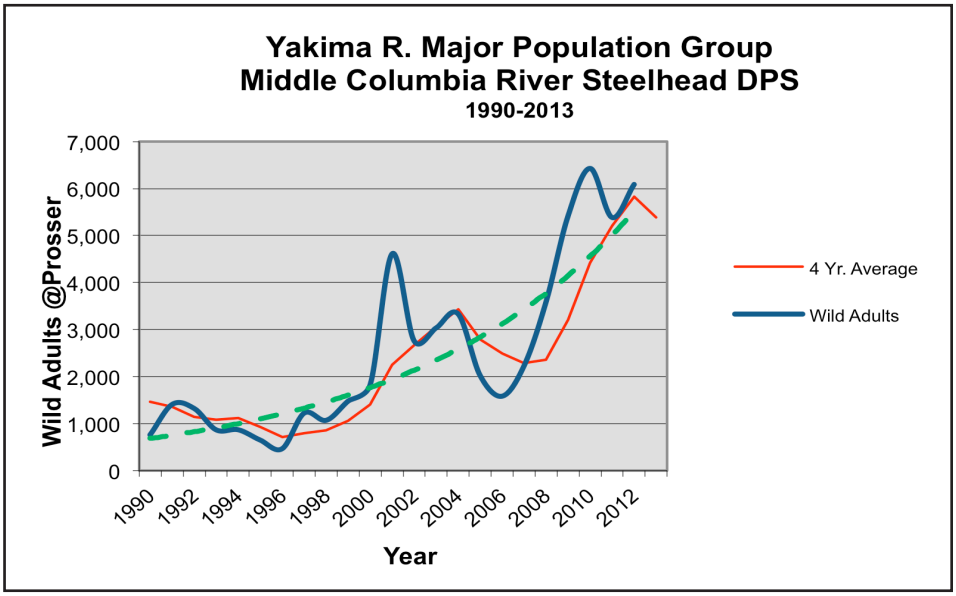


Figure 9. Returns of naturally produced adult Middle Columbia River steelhead (Yakima River MPG) at Prosser Dam, 1990–2013. The ESU-level trend in abundance was positive during this period.

Lower Columbia and Willamette River ESUs/DPSs

A total of six ESUs in the Willamette and lower Columbia rivers are currently listed under the ESA. The two listed species in the Willamette River are also covered by a separate biological opinion for the Willamette Project. Quantitative status information is lacking for many of the populations in these species. For those populations for which data are available, the information indicates that abundance, while well below historic levels, is stable or increasing.[4] These species are

4. Information taken from 2010 Pacific Coast Salmon Recovery Funds report to Congress. http://www.nwr.noaa.gov/salmon-recovery-planning/pcsrf/pcsrf-documents.cfm.

currently threatened by a broad array of habitat and other environmental factors. Because they, for the most part, do not migrate through the Federal Columbia and lower Snake River dams, the proposed operation of the Columbia/Snake projects of the FCRPS has a limited impact on these populations, with the exception of certain populations located in the Columbia River gorge. However, the Action Agencies' estuary habitat program provides survival benefits for all populations in these ESUs and DPSs, including those that spawn below Bonneville Dam.

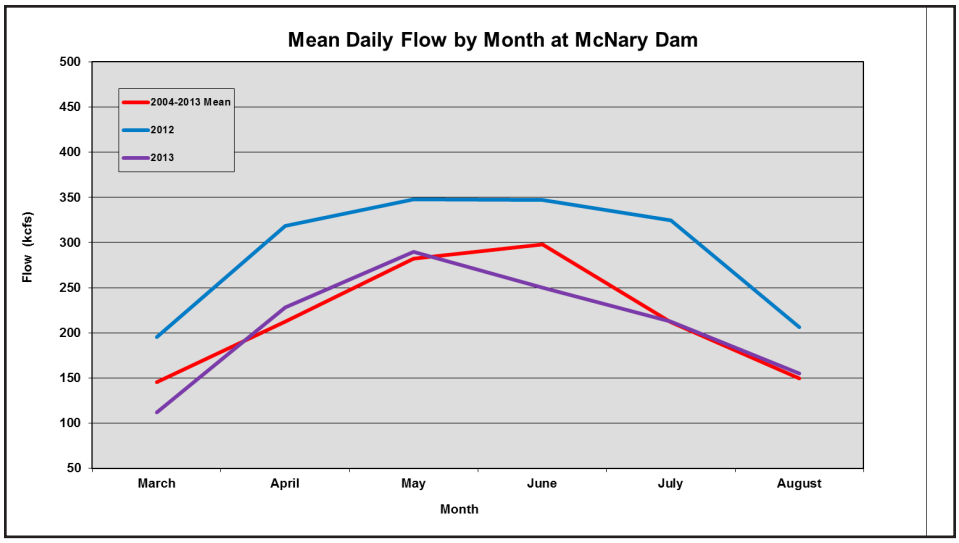


Figure 10. Mean daily flow shown by month at McNary Dam, 2012 through 2013, with average values for the 2004–13 period.

Environmental Conditions

Water Year and Streamflow Summary

In 2013, the Columbia River had a near average water year, with the January through September volume, as measured at The Dalles Dam, at 97 percent of average (Figure 10). For the early part of the water year, October – December, precipitation was above average for most of the Columbia Basin, except the extreme southern portions and snowpack accumulation was near normal at the end of December, 2012. January and February 2013 were quite dry, with almost the entire basin receiving well below average precipitation during this time period. March weather brought the storm track over the northern portion of the Columbia Basin and the month's precipitation ended above average in Canada and portions of Montana while the southern part of the basin remained dry. At the beginning of May the snow distribution and precipitation was clearly demarcated, above average to the north and below average to the south. The Dalles water supply forecast (WSF) for April – August was about 94 percent of average and the Snake River at Lower Granite Dam had a WSF (April – July) of only 73 percent. The first half of May was mostly dry and overall much warmer than average, resulting in a relatively early freshet with regulated flow peaking on the Snake and the Columbia about mid-May. The second half of the month and June was cooler and wetter than average over the northern portion of the Basin, with the Snake River basin remaining dry. Flow on the mainstem Columbia River for the second half of July and August followed recent historical averages as can be seen in Figure 10.

Ocean and Climate Conditions

Recent conditions confirm that Columbia River Basin salmon and steelhead abundance is strongly correlated with periods of relatively warm or cold off-coast ocean conditions. In general, warmer conditions are less favorable for salmon and colder conditions are more favorable. Pronounced warm and cold cycles have occurred over most of the past century, lasting approximately 20 to 30 years each (Figure 11). This climate pattern is known as the Pacific Decadal Oscillation (PDO).

A cool PDO regime in place from about 1947 to 1976 was characterized by abundant salmon returns to the Columbia River Basin. The PDO shifted to a warm phase in about 1977, which coincided with a significant decline in Columbia River Basin salmon runs. Although it is not clear yet whether another longer-term shift has taken place or what effects might be associated with climate change, ocean conditions have been variable since about 1999, though recent years have been favorable for salmon. For more information, see the Pacific Northwest Climate Impacts Group website at *http://www.jisao.washington.edu/pdo/*.

NOAA Fisheries' Northwest Fisheries Science Center (NWFSC) administers the Ocean Ecosystem Indicators Project to track specific climatic and biological indicators believed to influence the growth and survival of juvenile salmon once they reach the ocean. The NWFSC forecasts the returns of coho and Chinook salmon

based on a survey of a range of ecosystem indicators.

In 2013, ocean conditions were mixed. Biological indicators were very favorable for salmon. However, physical indicators were less so, see Figure 12. However, the NWFSC assigns greater weight to the biological indicators and therefore predicts good returns of coho salmon in 2014 and Chinook salmon in 2015.

Climate Change

The Action Agencies support implementation of a substantial program of habitat protection and restoration actions, such as creation of riparian buffers, managing water withdrawals to increase tributary flows, and restoring and connecting wetlands and floodplains to store water, that can serve as beneficial ways to limit effects of increasing temperatures in the face of climate change. The Action Agencies also support the Climate Change River Management Joint Operating Committee's climate research modeling and forecasting. In addition The Action Agencies collaborate with other climate research efforts in the region, such as the Northwest Climate Science Center, which is setup to incorporate research findings into adaptive management.

The BiOp calls for the Action Agencies' annual progress reports to include NOAA Fisheries' review of recent scientific literature on the potential long-term effects that climate change may have on Columbia River Basin salmon and steelhead. These reviews are provided by researchers at the Northwest Fisheries Science Center (NWFSC) and can be found at *http://www.nwfsc.noaa.gov/trt/lcm/freshwater_habitat.cfm. The 2014*

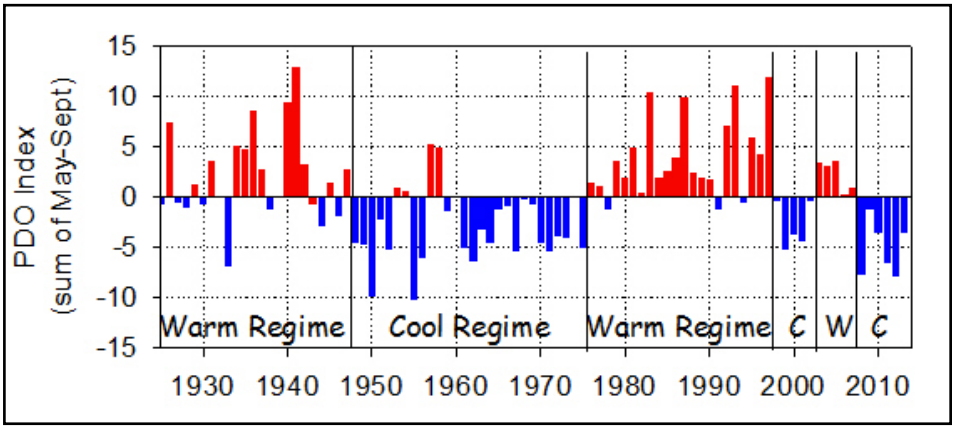


Figure 11. Time series of shifts in sign of the Pacific Decadal Oscillation, 1925 to 2013. Values are averaged over the months of May through September. Red bars indicate positive (warm) years; blue bars negative (cool) years. Note that 2008 was the most negative since 1956. From NOAA Fisheries website: http://www.nwfsc.noaa.gov/research/divisions/fed/oeip/ca-pdo.cfm.

	Juvenile Migration Year				Adult Return Outlook	
	2010	2011	2012	2013	coho 2014	Chinook 2014
Large– scale ocean and atmospheric indicators						
PDO (May - Sept)	🟨	🟩	🟩	🟨	🟡	🟢
ONI (Jan - Jun)	🟥	🟩	🟩	🟨	🟡	🟢
Local and regional physical indicators						
Sea surface temperature anomalies	🟨	🟨	🟨	🟥	🔴	🟡
Coastal upwelling	🟥	🟥	🟥	🟨	🟡	🔴
Deep water temperature and salinity	🟥	🟨	🟨	🟥	🔴	🟡
Local biological indicators						
Copepod biodiversity	🟥	🟩	🟩	🟩	🟢	🟢
Northern copepod anomalies	🟨	🟩	🟩	🟩	🟢	🟢
Biological spring transition	🟥	🟩	🟨	🟨	🟡	🟡
Winter Ichthyoplankton	🟩	🟨	🟨	🟩	🟢	🟡
Spring Chinook– June	🟨	🟥	🟩	🟩	--	🟢

Key
- 🟩 good conditions for salmon
- 🟨 intermediate conditions for salmon
- 🟥 poor conditions for salmon
- 🟢 good returns expected
- -- no data
- 🔴 poor returns expected

Figure 12. Ocean ecosystem indicators of the Northern California Current. Colored squares indicate positive (green), neutral (yellow), or negative (red) conditions for salmon entering the ocean each year. In the two columns to the far right, colored dots indicate the forecast of adult returns based on ocean conditions in 2013. From http://www.nwfsc.noaa.gov/research/divisions/fed/oeip/g-forecast.cfm, see this site for more information on terminology.

report is also available in Section 2, Appendix A (Crozier et al. 2014).

Generally, the 2013 literature review is consistent with past reviews in its forecasts for the impacts of climate change. It is also worth noting that the Action Agencies' mitigation measures, particularly in regards to hydro and habitat, are consistent with the recommendations of the Independent Scientific Advisory Board (ISAB) and continue to be appropriate responses to climate change.

Implementation Overview

The Action Agencies have established RPA action implementation strategies and actions using the "All-H" approach—hydropower, habitat, hatchery, and harvest, plus predator management—to benefit salmon and steelhead in the Columbia River Basin. 2013 work performed is summarized below. Detailed descriptions can be found in Section 2, the RPA action implementation portion of this 2013 annual progress report.

Hydropower Actions

Actions to improve survival of fish through the hydro system are an essential part of BiOp commitments. Over the past decade, juvenile fish survival past the dams has improved substantially through dam modifications and improved operations designed to achieve hydro performance standards. Hydro performance standards in the BiOp call for juvenile dam survival of 96 percent for spring migrating fish and 93 percent for summer migrating fish. Under the hydropower strategy, the Action Agencies implemented juvenile and adult dam passage modification, operational improvements for spill and transport of juvenile fish, water management operations, and operational and maintenance activities aimed at improving juvenile passage survival and adult returns. These improvements in turn increase overall system survival and in-river survival. Results in 2013 continue to show the success of the significant hydrosystem changes for improving fish survival.

Water Management and Flow Operations

In 2013, FCRPS storage reservoirs were actively managed to enhance flows and water quality to improve conditions for salmon and steelhead. The dams in the FCRPS were authorized by Congress for multiple purposes. The Action Agencies developed an annual Water Management Plan (WMP) to balance multiple priorities including providing salmon flows, cooling water temperatures, protecting listed and unlisted resident fish, managing flood risks, and serving other authorized purposes consistent with RPA Action 4 specifications. The 2013 WMP can be found at http://www.nwd-wc.usace.army.mil/tmt/documents/wmp. The WMP was developed and implemented in coordination with regional sovereigns. Adjustments were made in-season to respond to changing environmental conditions with the help of the interagency Technical Management Team (TMT), a coordination group consisting of regional sovereign biologists and hydrologists.

Managing water in the Columbia River system for its many purposes is particularly challenging given the relatively small portion of the annual runoff volume that can actually be stored in reservoirs. Available storage—water that actually can be managed—is limited relative to total annual runoff in the Columbia River Basin. This means that storage projects do not have the capacity to store water in one year to use in a subsequent dry water year.

Providing flows for fish is an important component of water management in the Columbia River Basin. Today, operators manage the storage reservoirs very differently than they did a few decades ago. In 2013, both the storage projects (Libby, Hungry Horse, Albeni Falls, Grand Coulee, and Dworshak dams) and the run-of-river Columbia River and Snake River projects (Bonneville, The Dalles, John Day, McNary, Chief Joseph, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams) were operated consistent with the WMP, in part, to aid juvenile fish passage. Winter drafts were limited so that there was a high probability that the storage reservoirs could be as full as possible (considering flood control requirements) by April 10. This allowed for higher flows during the spring juvenile migration when storage reservoirs were refilling. The storage projects also have summer refill and draft targets to provide flows for fish during the summer.

Columbia River flows are primarily driven by snowmelt with over 60 percent of the annual runoff occurring between April and June. Natural flows drop significantly by late July and into August. To enhance fish flows, BPA and the Corps negotiated an agreement with Canada that allowed storage of an additional 1 million acre-feet (MAF) of water accounted for in Columbia River Treaty space in Canadian storage projects. This water was stored during the winter months and released in the spring and summer to support flow augmentation in the United States. To help augment flows for fish, about 5 MAF of stored water was added to Columbia Basin flows – about one-sixth of approximately 32 MAF of storage available in U.S. and Canadian storage reservoirs. Because much of the available storage is in Treaty projects in Canada, use of this storage is governed by the Columbia River Treaty.

BC Hydro has additional water storage space that is not governed by the Columbia River Treaty. In 2012, BPA entered into a new long-term Columbia River non-Treaty storage agreement (NTSA) with BC Hydro which allows for coordinated use of non-Treaty storage in Canada to shape flows within the year for fisheries benefits and provides up to an additional 0.5 MAF of water to benefit fish in dry water years.

In 2013, Reclamation provided 427,000 acre-feet (AF) of flow augmentation water from the upper Snake River above Brownlee Reservoir. The NOAA Fisheries 2008 Upper Snake River Irrigation Projects biological opinion calls for up to 487,000 AF, recognizing that the full amount will not be available under all w ater conditions. Water supply conditions in 2013 were well below average across the Snake River Basin above Brownlee Reservoir (Reclamation 2013).

Water Quality

In January 2009 the Corps, in a collaborative effort with regional sovereign partners, finalized a detailed multi-year Water Quality Plan for the Columbia River Basin. Structural and operational measures identified in the plan were implemented based on effectiveness and available funding. In 2013, the Action Agencies continued to implement those measures based on effectiveness and available funding.

Fish passage spill operations may result in the generation of total dissolved gas (TDG) supersaturation in the Columbia and lower Snake rivers at levels above 110 percent, the current State and Federal water quality standard. The States of Washington and Oregon provide limited exceptions to the standard for juvenile fish passage spill. In 2013, the Corps provided fish passage spill consistent with the BiOp and the August 2011 Opinion and Order from the U. S. District Court for the District of Oregon and monitored TDG levels in the river. Spill patterns and spill rates were adjusted to manage TDG consistent with the applicable water quality standard to the extent practicable.

Spill also occurs when high flows exceed the turbine capacity at any dam or when hydroelectric generation is reduced to keep the electricity supply from exceeding demand. High flows combined with low electricity demand, such as at night, can sometimes lead to spill that exceeds the applicable TDG limits. In 2013, BPA continued to implement its Oversupply Management Protocol, replacing other generation with Federal hydro generation when necessary to reduce uncontrolled spill and manage TDG levels to the extent practicable while balancing energy supply and demand.

In February 2013, the Corps also finalized the "Location and Use of Adult Salmon Thermal Refugia in the Lower Columbia and Lower Snake Rivers" report (ACOE 2013), which provided a comparison of existing tributary and lower Columbia and lower Snake River temperature data, a summary of Snake and Clearwater River confluence study/modeling operations and Dworshak project releases and a compilation of University of Idaho studies of temperature regimes during upstream migration and the use of thermal refugia by adult salmon and steelhead in the Columbia River Basin.

To help manage water temperatures in the lower Snake River in the summer, cold water is released from Dworshak Dam on the North Fork Clearwater River from early July through mid-September. In 2013, water temperature at the tailwater temperature gauge for Lower Granite Dam exceeded 68 degrees Fahrenheit for 133 hourly readings on 9 days in late August and mid-September. Due to the very warm conditions in the summer of 2013, all Dworshak temperature management water was exhausted by September 20. The maximum hourly temperature was 69.04 degrees F on September 20. For a more thorough discussion of how the system was operated in 2013, see the 2013 Dissolved Gas and Water Temperature Report at: http://www.nwd-wc.usace.army.mil/tmt/wqnew/tdg_and_temp/2013/.

Improvements for Fish at the Dams

Most salmon and steelhead in the Columbia River Basin encounter one or more hydropower dams as they migrate to and from the ocean. The BiOp's hydropower strategy

addresses both juvenile and adult migration through the system as described below.

Adult Passage Improvements

In 2013, the Corps continued to improve adult passage at several dams. The Corps prepared a design report for the east ladder auxiliary water supply improvements at The Dalles Dam. The Corps began a two-year study of the north ladder at The Dalles Dam to assess whether construction of the spillwall has resulted in migration delays for adults attempting to use that ladder. At John Day Dam, modifications to the lower section of the north ladder and its entrance and auxiliary water supply were completed in 2013 prior to the migration season.

At Little Goose Dam on the Snake River, it appears that installation and operation of a spillway weir which aids downstream passage of juveniles can, under some conditions, hinder the upstream passage of adults. Beginning in 2011 a new spill pattern was implemented to reduce adult passage delay. The Corps continued to use that spill pattern in 2013, and began a two-year study to assess the effectiveness of that spill pattern adjustment.

At Lower Granite Dam in late July, 2013, warm river surface temperatures in the forebay made the temperature difference between adult ladder exit and entrance large enough that adult passage was delayed, especially for Snake River sockeye. In coordination with regional parties, the Corps modified powerhouse and spill operations and installed emergency auxiliary water supply pumps to pump cooler sub-surface water from the forebay into the ladder. The Corps is currently designing modifications to the auxiliary ladder pump intakes and discharge routing for possible construction in 2015. The actions taken are discussed in more detail in Section 2 of this report under RPA Action 9.

Juvenile Passage Improvements

Juvenile fish pass dams by many routes: through turbines, through juvenile bypass systems, through spillways, or by collection and transport in barges or trucks downstream. Operations and structural improvements have been tailored to the specifics of each dam to both reduce the overall proportion of juvenile fish that pass through turbines and improve overall dam survival. Juvenile bypass systems, spill, and other surface passage routes are used to divert a large majority of migrating fish away from the turbines. Depending on location, time of year, and species, about 76 to 99 percent of the juvenile fish use these non-turbine routes. In addition to implementing alternatives that minimize the amount of fish passing through turbines the Action Agencies have installed improvements to juvenile bypass systems and spillways that reduced fish passage delay, improved safe conveyance of fish, minimized juvenile fish exposure to predation, and therefore increased juvenile fish survival through those non-turbine routes.

Under the BiOp, hydro performance standards are established based on dam passage survival through all passage routes, with a benchmark of 96 percent average dam passage survival for migrating spring fish and 93 percent for migrating summer fish. Juvenile passage improvements such as spillway weirs and spill walls have been completed at all eight federal dams in order to provide more effective spill to achieve the hydro performance standards.

In 2013, field investigations and design of fish survival improvements to Bonneville's Powerhouse II juvenile bypass system continued. The Corps continued to work with the region to identify and test changes to address the unanticipated increased levels of injury associated with the improvements made to Bonneville's Powerhouse II juvenile bypass system. Increased levels of injury occur particularly when the turbines are operated at the upper end of the ±1 percent peak efficiency range. To address this, Powerhouse II turbine units were operated in 2013 at the lower end of the ±1 percent peak efficiency range. This operation reduced flow into the gatewells and reduced the injury to fish passing into the juvenile bypass system.

In 2013, the Corps continued to work with the region to identify improvements to the juvenile bypass system at Lower Granite Dam, which are needed to improve juvenile survival. The design of modifications to the juvenile bypass system included changes to orifices, dewatering, the primary bypass, and a new outfall.

Adult Fish Survival

Adult fish survival in the Columbia and Snake Rivers is influenced by the operation and configuration of fish ladders at the FCRPS dams, as well as sea lion predation, levels of straying, and harvest-related mortality. Annual survival rates of listed adult salmon and steelhead through defined hydrosystem reaches are estimated based on detections of fish tagged with passive integrated transponder (PIT) tags at Bonneville, McNary, and Lower Granite Dams, with adjustments for harvest and straying.

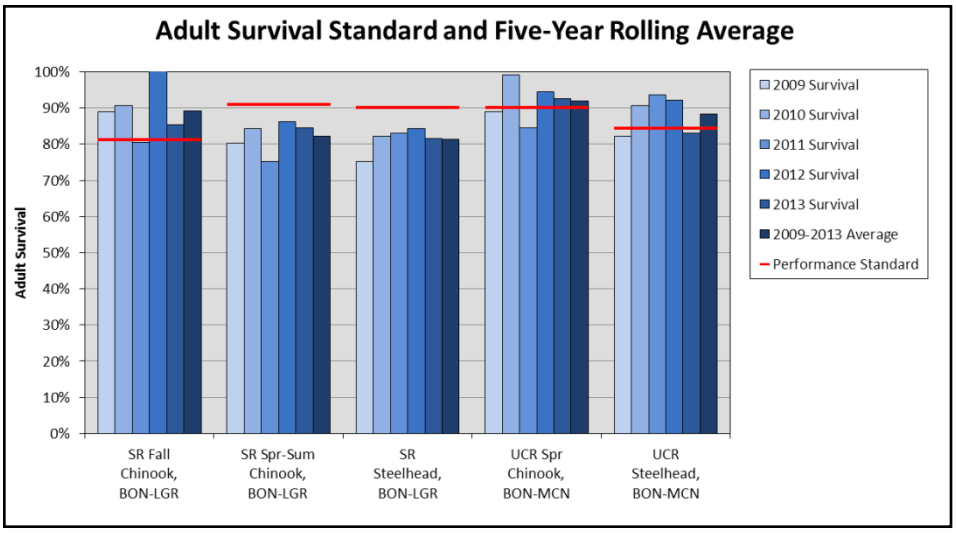


Figure 13. 2008 FCRPS BiOp adult survival standard and five-year rolling average survival of adults that migrated in-river as juveniles, based on PIT tag conversion rates of Snake River (SR) and Upper Columbia River (UCR) ESUs. (BON = Bonneville, MCN = McNary, LGR = Lower Granite). Data from NOAA Fisheries.

Survival through the hydrosystem for adult fish is evaluated for five stocks using a 5-year rolling average of annual survival estimates. Snake River stocks are used as surrogates for Snake River sockeye and mid-Columbia steelhead.

For 2013, the 5-year rolling averages (2009-13) and 2013 results for Snake River fall Chinook, Upper Columbia River spring Chinook and Upper Columbia steelhead surpassed the BiOp performance standard. However, the 5-year rolling averages and 2013 results for the Snake River spring/summer Chinook salmon ESU and the Snake River steelhead DPS were below adult performance standards (Figure 13), which is a change from recent experience.

The adult fish performance standards are survival estimates of PIT tagged adult fish migrating between Bonneville and McNary dams (Upper and Mid-Columbia ESUs) and Bonneville and Lower Granite dams (Snake River ESUs). The method to calculate these survival estimates attempts to isolate the effects of dam passage from other mortality sources by adjusting Bonneville to McNary or Lower Granite survival rates with estimates of harvest and straying. Nevertheless, the adult performance estimates are influenced by effects of dam passage as well as unreported harvest and inaccurate stray rate estimates that cannot be determined through detection of PIT tagged fish at dams. Also, high flows and high spill levels at dams can affect the estimates because they are known to increase fallback and delay of adults. Increased fallback and delay can result in increased losses due to sea lion predation below Bonneville Dam. These potential factors are being assessed through BiOp Research, Monitoring & Evaluation (RME) actions and are described under Hydro RME. In 2013, the Corps initiated a two-year adult passage study and added PIT tag detection capabilities to adult passage facilities at The Dalles, Lower Monumental, and Little Goose dams to better understand and quantify higher than expected losses within lower Columbia River reaches. In addition, the parties in United States v. Oregon are also researching the higher than expected losses. As part of this research, the United States v. Oregon technical advisory committee, as well as the NOAA Fisheries' Science Center, are reviewing PIT tag data to evaluate potential causes.

Juvenile Dam Passage Survival

Passage improvements to achieve dam passage survival performance standards, identified in coordination with the region, have largely been completed at seven of eight Snake and lower Columbia river dams. Performance standard testing continued in 2013, based on a methodology included in the BiOp and refined in collaboration with NOAA Fisheries and other regional interests (2012 FCRPS Performance Standard Paper). For a given dam to achieve the juvenile dam passage survival performance standards, two years of testing must occur with survival either meeting or exceeding the performance standard each year.

In 2013, the second full year of performance standard testing was conducted at Little Goose and Lower Monumental dams for summer migrants. The 2013 estimates of subyearling Chinook dam passage survival at both Little Goose and Lower Monumental dams were 90.76 and 92.97 percent, respectively (Table 2). This lower survival at Little Goose was unexpected because the 2012 estimates significantly exceeded the performance standard (Table 2). The Corps, in coordination with NOAA Fisheries and the other Action Agencies in 2014 are reviewing the 2012/2013 testing results to assess the cause of this difference, and determine the next steps to satisfy the juvenile dam passage survival performance standards for summer migrants at Little Goose Dam.

Fish Transportation and Barging

Juvenile fish transportation is an ongoing program that collects fish

Table 2. Juvenile dam passage survival estimates with standard errors, passage times, and spill passage efficiency for subyearling Chinook salmon derived from performance standard tests at Little Goose Dam and Lower Monumental Dam in 2012 and 2013. Spill Passage Efficiency is the percent of all downstream migrating juvenile salmon and steelhead that pass a dam through the spillway and other surface passage routes. (Skalski et al. 2013a, Skalski et al. 2013b, Skalski et al. 2014).

Species	Dam Passage Survival (SE) (percent)	Median Forebay Passage Time (hours)	Spill Passage Efficiency (SE)
Lower Monumental (2012) – 17 thousand cubic feet per second (kcfs) Spill			
Subyearling Chinook	97.89 (0.79)	2.60	83.56 (0.48)
Lower Monumental (2013) – 17 kcfs Spill (June 6-July 8)			
Subyearling Chinook	92.97 (1.05)	2.99	89.10 (0.43)
Little Goose Dam (2012) – 30 Percent Spill			
Subyearling Chinook	95.08 (0.97)	2.80	72.49 (0.86)
Little Goose Dam (2013)- 30 Percent Spill (June 4-July 6)			
Subyearling Chinook	90.76 (1.39)	3.66	76.83 (0.83)

from juvenile bypass facilities at Lower Granite, Little Goose, and Lower Monumental dams and transports them by either barge or truck to release sites below Bonneville Dam.

The 2010 FCRPS BiOp recommended that fish transport operations be adaptively managed on an annual basis. The timing and conditions for fish transportation are based on annual research comparing adult returns to Lower Granite Dam of transported fish versus fish that migrated in-river. In general, Chinook return at higher rates when migrating in-river in early April, but return at higher rates when transported beginning in late April or early May. Also, steelhead generally exhibit higher survival when transported during the spring migration.

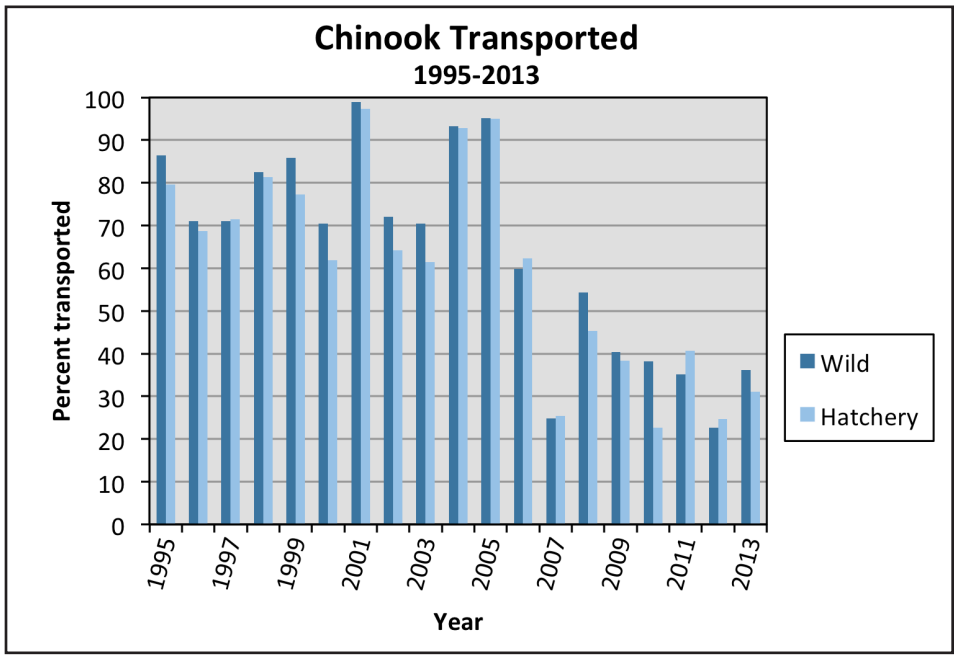
In 2013, after coordination with the Technical Management Team, collection for transport began on April 27 at Lower Granite Dam, May 3 at Little Goose Dam, and May 7 at Lower Monumental Dam. Until these dates, juveniles collected at Snake River dams were bypassed back to the river. Juvenile fish were not transported from McNary Dam in 2013. For comparison, in 2012 collection for transport began on May 2 at Lower Granite Dam, on May 4 at Little Goose Dam, on May 6 at Lower Monumental Dam, and on July 21 at McNary Dam.

Estimated percentages of non-tagged spring/summer Chinook salmon juveniles that were transported during the entire 2013 season were 36.1 percent for wild fish and 31.0 percent for hatchery fish. For non-tagged steelhead, estimated percentages transported were 40.0 percent for wild fish and 35.0 percent for hatchery juveniles (Figures 14 and 15). Of the fish transported, 99.0 percent were barged, and the balance transported by truck.

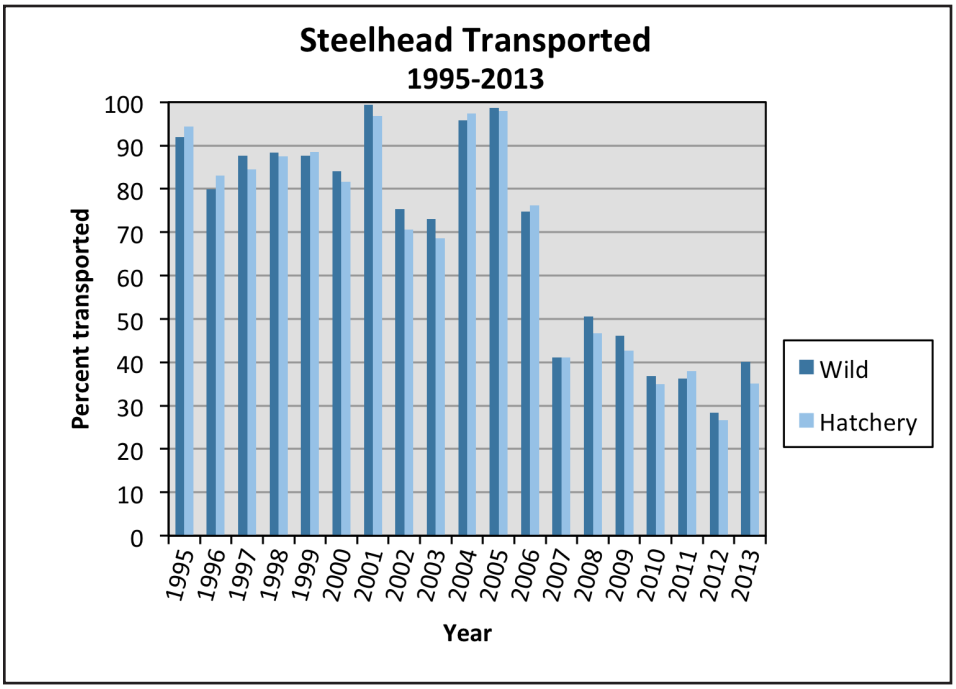
These percentages are substantially lower than those for years prior to 2007. However, for yearling Chinook salmon and steelhead the estimated percentages are slightly higher than the record low estimated percentages for 2012. The increase appears to be due to a combination of earlier transport start dates and a later arrival of juveniles at transporting projects in 2013 (Faulkner et al. 2013).

Juvenile System and In-river Survival

Hatchery and wild juvenile salmon and steelhead that migrate to the ocean through the Snake and Columbia rivers can either be left "in-river" to migrate past the dams or be transported by barge or truck to below Bonneville Dam. Empirical evidence is used to track the percent of fish that return as adults among those transported and those left in-river to migrate, and generally fish are transported during time periods that yield higher adult returns than



Figures 14 and 15 (next page). Estimated percent of yearling Chinook salmon and steelhead, respectively, transported to below Bonneville Dam, by year (1995-2013) (data from Faulkner et al. 2013).



in-river migration. In 2013, generally less than 40 percent of the Snake River steelhead and Chinook were estimated to be transported.

Ninety-eight percent of the transported juveniles are assumed to have survived to the point of release below Bonneville Dam. For juvenile fish, total system survival is a combination of transportation and in-river survival. Total system survival from Lower Granite Dam to the Bonneville tailrace (survival of in-river and transported groups combined) was about 71 percent for wild Chinook, 74 percent for combined wild and hatchery Chinook, 64 percent for wild steelhead, and 69 percent for combined wild and hatchery steelhead. Because juvenile Upper Columbia Chinook and steelhead are left to migrate in-river, in-river survival rates are equivalent to total system survival rates for those species.

In-river survival of migrating fish has improved significantly over time as a result of operation and passage improvements at the FCRPS dams. Figure 14 shows the trend of these improvements, including 2013 survival. To put these results in perspective, while study methods have changed, estimated juvenile survival in recent years with improved fish passage through eight dams is now roughly comparable to what it was in the 1960s when fish passed fewer dams.

In 2013, in-river survival was lower than that in 2012, which may reflective of lower river flows in 2013 compared to those in 2012 (see Figure 16). However, even with an average water year, 2013 in-river survivals were still considerably above the survival for most years prior to implementation of the BiOp.

Travel time through the hydropower system during 2013 was shorter than the long-term average for most of the migration season (Figures 17 and 18). The difference between the long-term average and 2013 travel time was greater for steelhead than for yearling Chinook. This may indicate that juvenile steelhead, being more surface oriented, are receiving a greater benefit from surface passage structures than are yearling juvenile Chinook. In general, travel times seem to be improved through the reduced delay seen from spillway weirs and other surface passage routes.

The BiOp included a metric to estimate in-river survival performance for Snake River and Upper Columbia River Chinook

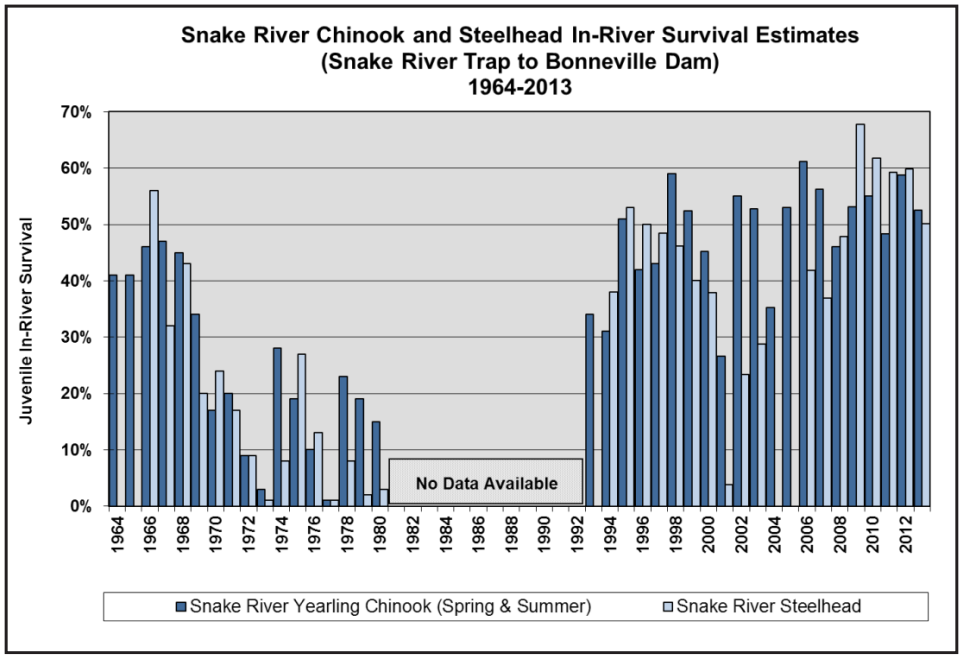
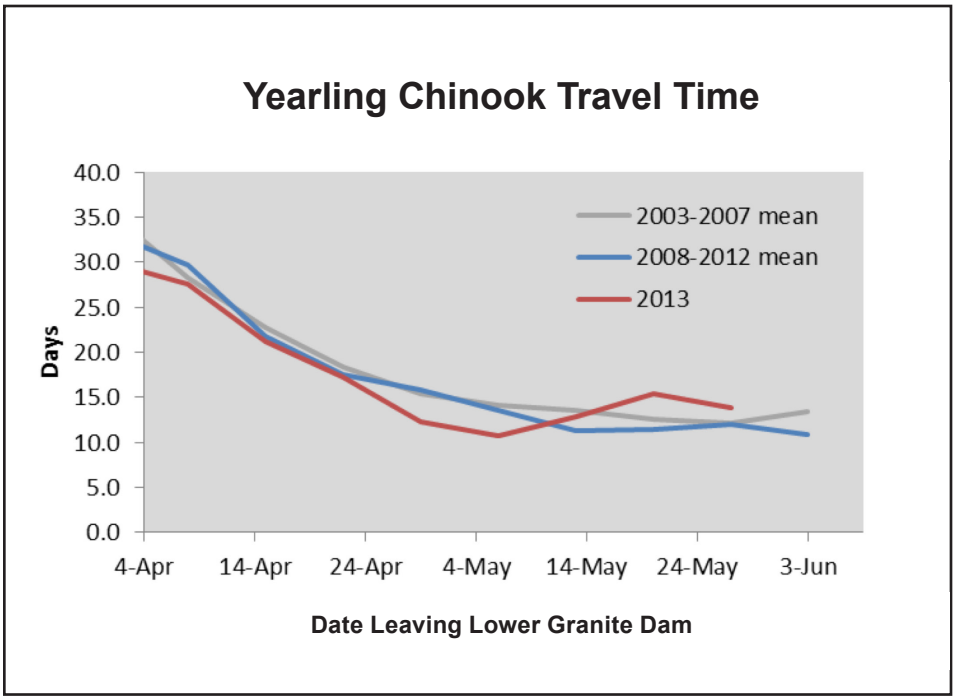
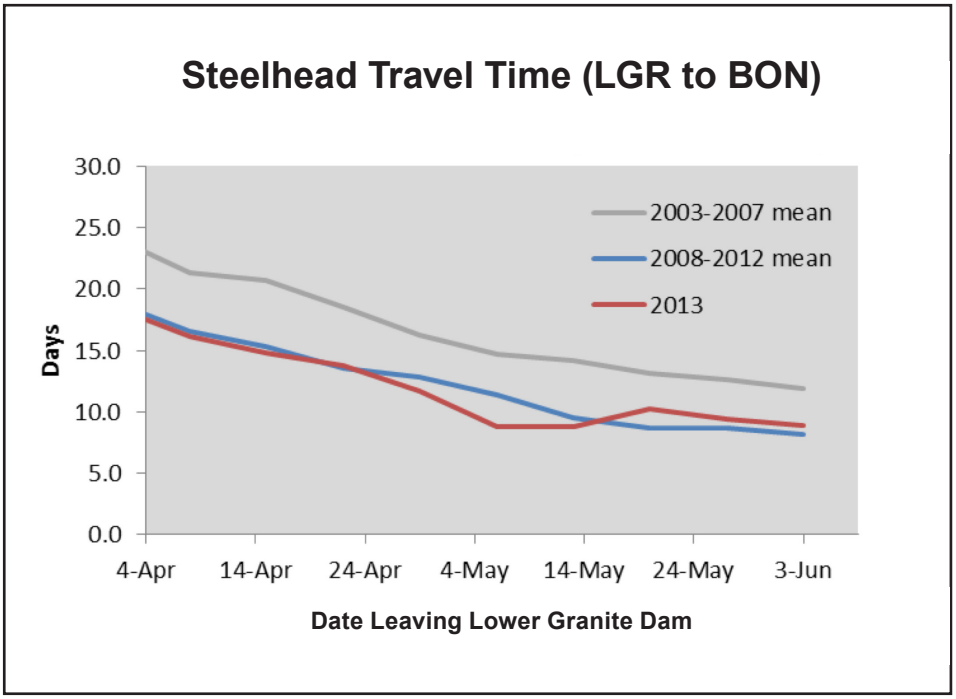


Figure 16. In-river Survival Estimates (Hatchery and Wild Combined) for Snake River Chinook and Steelhead. Steelhead estimates for 2004 and 2005 are unavailable due to lower PIT tag detection efficiency at Bonneville Dam. Survival estimates are not available for 1981 through 1992.





Figures 17 and 18. Median travel time from Lower Granite Dam to Bonneville Dam for weekly release groups of Snake River yearling Chinook salmon (Figure 15) and steelhead (Figure 16), 2006-2013. (Faulkner et al., 2013)

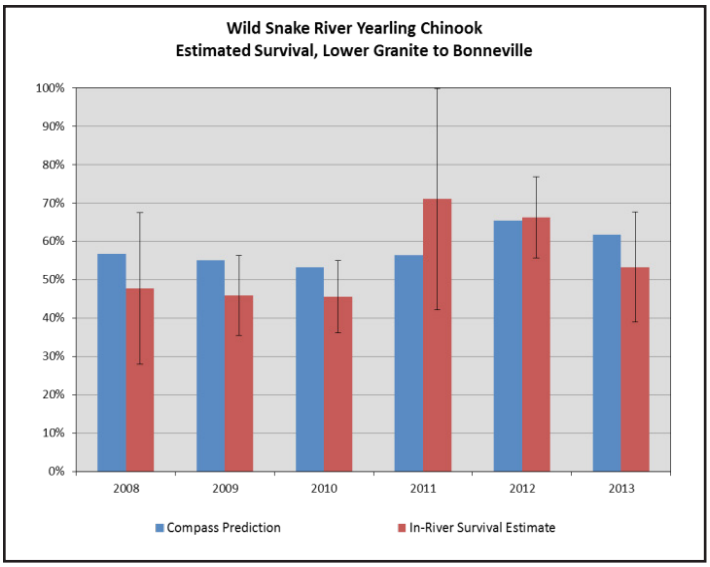
and steelhead. The Action Agencies empirically estimated in-river survival for 2013 (Lower Granite to Bonneville and McNary to Bonneville) and compared that with the survival estimates derived from Comprehensive Fish Passage (COMPASS) modeling. For this comparison, the COMPASS Model was run with survival estimates for the actions implemented at the start of the 2013 migration season using 2013 river conditions, fish migration patterns, and dam and transport operations. Figures 19-22 (next page) show the results of these comparisons. Results indicate that the benefits from the hydro operation, passage improvements, and predation deterrent actions implemented to date are generally accruing as expected in the BiOp analysis.

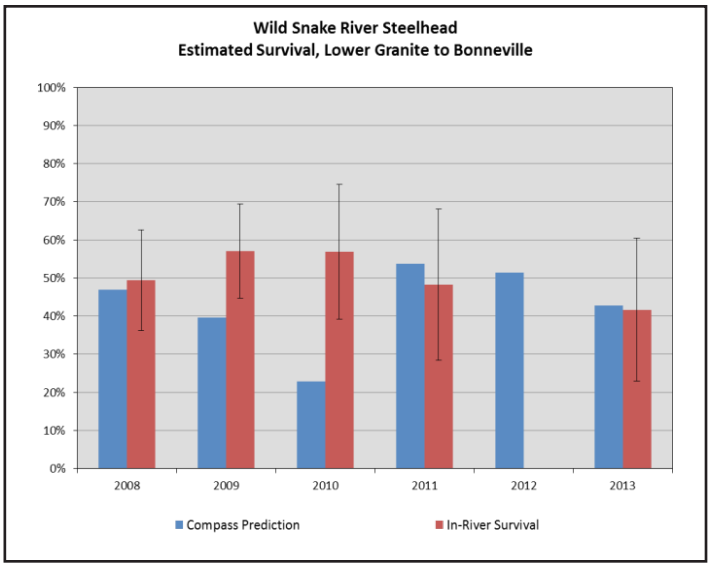
In 2013, PIT tag in-river juvenile survival estimates for wild Snake River yearling Chinook and steelhead were lower than the mean COMPASS estimates, although the differences were not statistically significant. The PIT tag estimates for Upper Columbia River yearling Chinook and steelhead were higher than the COMPASS estimates, and the differences were statistically significant. As in previous years, from these results it appears that benefits from system improvements are in line with, and in some cases exceeding, expectations from the COMPASS Model.

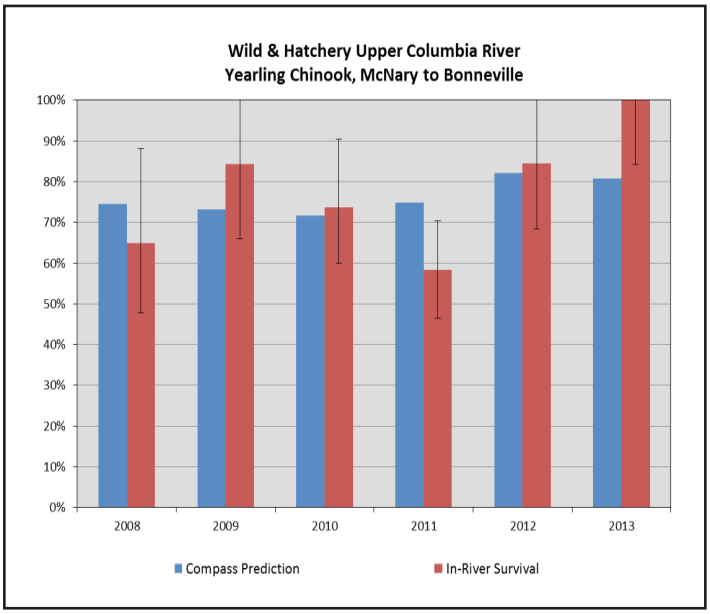
Kelt Management

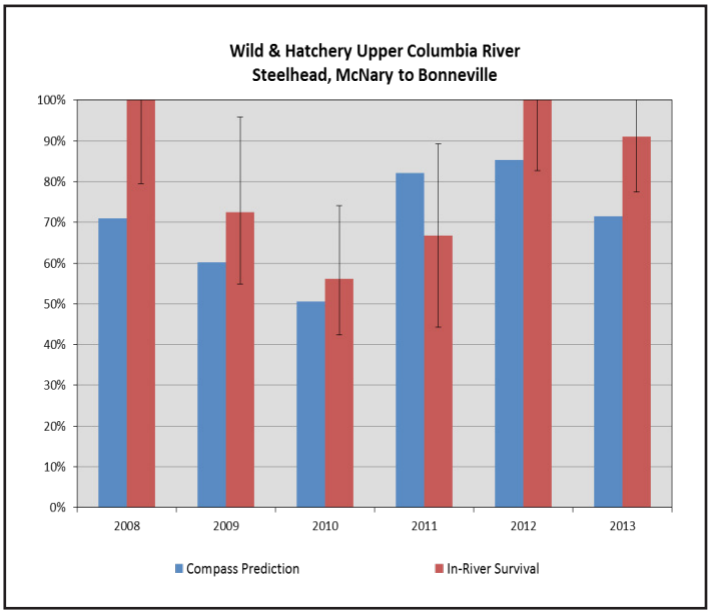
Kelts are steelhead that survive to spawn again in subsequent years. The goal of kelt management actions is to improve survival and productivity of listed steelhead by facilitating kelt survival through transport, in-river migration improvements, and reconditioning. Kelt reconditioning is the process of collecting steelhead during their seaward migration, containing them in a hatchery setting, and rehabilitating the fish through special diets and treatment of pathogens. Fish are then released back into the collection stream(s) to spawn again.

In order to implement the kelt objectives in the BiOp, BPA and the Corps completed the 2013 Kelt Management Plan (KMP) annual supplement (BPA and Corps 2014). The 2013 version of the KMP built upon the framework of previous plans, but also identified future direction through the remainder of the BiOp. The report can be found at *http://www.salmonrecovery.gov/Hatchery/KeltReconditioning.aspx*.









Figures 19, 20, 21, and 22. 2008-2013 COMPASS Model Predictions and PIT Tag Estimated In-river Survival for Juvenile Snake River (SR) Wild Spring/Summer Chinook and Steelhead and for Upper Columbia River (UCR) Wild/Hatchery Spring Chinook and Steelhead. Error whiskers indicate 95 percent confidence intervals. PIT estimate not available for wild Snake River steelhead for 2012. (BON = Bonneville, MCN = McNary, LGR = Lower Granite)

In 2013, reconditioning of Snake River B-run kelts at Dworshak National Fish Hatchery has moved from experimental to full scale implementation. The 2013 release from the reconditioning program, which included fish collected both at Lower Granite Dam and at the Fish Creek weir, represents the highest contribution of the reconditioning program to date towards meeting the 2018 BiOp target. Opportunities to collect good condition fish continue to be identified.

Several research studies were also carried out focusing on kelt in-river out-migration survival. The Corps completed the second year of its in-river dam route and river reach survival study, using acoustic tags, at three of the lower Snake dams. Survival results suggest that surface passage improvements made at the dams to benefit juveniles also have a benefit for outmigrating kelts. Kelts most frequently passed through spillway routes (spillway weirs or traditional spill). The Corps also conducted a direct survival test of hatchery origin steelhead passing through spillway weirs and turbine routes at McNary Dam and commissioned an analysis of PIT data to assess trends in kelt repeat spawning rates of winter and summer steelhead from subpopulations throughout the Columbia Basin.

Due to low collection numbers, no transportation of kelts occurred in 2013. The Action Agencies and relevant coordinating entities will reconsider the transport strategy when the number of collected kelts exceeds the capacity of reconditioning programs.

Habitat Protection and Improvement Actions

Productive habitat in the Columbia River estuary and tributaries is critical to the life cycle of salmon and steelhead. Each year, the Action Agencies spend tens of millions of dollars under the BiOp and the Columbia Basin Fish Accords to improve the quantity and quality of salmon habitat in the estuary and tributaries. This program, one of the largest and most complex of its kind in the nation, is designed to provide "off-site mitigation" for impacts of the hydropower system.

Tributary Habitat

The hundreds of tributary habitat improvement actions implemented or in various stages of development in 2013 represent a mature habitat program and steady progress toward achieving the 2018 targets for habitat improvement. An increasing list of habitat improvement actions includes flow acquisition, increased stream cover and complexity, installation of fish screens, and improved access to stream habitat. Actions have increased in size and complexity. Improved planning and assessment has resulted in strategic prioritization based on ecological concerns, habitat conditions and the needs of fish. In all cases, the Action Agencies consult local technical teams on design details of habitat improvement actions. The expected benefits to habitat from these actions are estimated through an expert panel process convened by the Action Agencies using the Habitat Workgroup Methodology developed through the sovereign collaboration that resulted in the 2008 BiOp (http://www.usbr.gov/pn/fcrps/habitat/panels/index.html).

Research and monitoring is increasingly appearing to support the fundamental premise of the tributary habitat program (BPA 2014). Likewise, research and monitoring is increasingly illustrating how in some watersheds density dependence is limiting fish numbers and survival because the quality and availability of existing habitat is insufficient to support large numbers of fish (Walters et al. 2013). These findings underscore the importance of continued tributary habitat improvement actions to rebuild listed species.

Summary of Tributary Habitat Accomplishments

Significant accomplishments for 2013 are presented and summarized below, illustrating Action Agency progress toward meeting the 2018 BiOp targets. Flow protection, barrier removal, and habitat enhancement are just some of the tributary habitat improvements that deliver benefits to listed salmon and steelhead. Metrics by population are included in Sections 2 and 3. Below are some examples of improvements to habitat function and the cumulative habitat metrics that have been delivered over time follow.

Protecting and Improving Instream Flow

The Action Agencies support water transactions through dedicated water transactions programs that have resulted in flow augmentation to streams historically impacted by withdrawals. In 2013, four water transactions were implemented on Catherine Creek that put 2 cubic feet per second of flow back instream. These transactions augmented flows in a reach above Davis Dam that is typically dry in late summer benefitting a priority population of Snake River spring/summer Chinook. Likewise, in Pole Creek in the upper Salmon River, flow acquisition increased flows restoring access

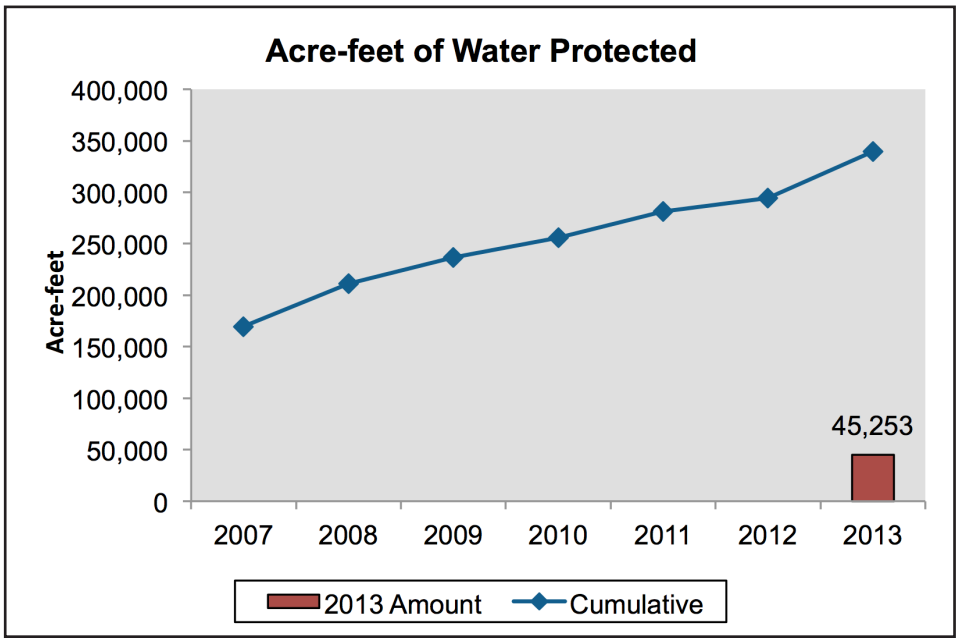


Figure 23. Water secured and protected, in acre-feet of instream flow, 2007-2013. Cumulative acre-feet/year can include annually renewed water leases.

for juvenile Chinook that use Pole Creek for rearing during the summer irrigation season.

Improving Habitat Complexity

Instream habitat actions that improve complexity have benefitted a wide range of salmon and steelhead populations with specific focus on those priority populations identified in the BiOp. Treatments directly addressing limiting factors include levee removal, floodplain and riparian enhancement, and placement of log structures which facilitate creation of complex habitat. Each of these treatment types has shown a positive fish response that has been captured by post-implementation action effectiveness monitoring (Martens and Connolly 2014). In 2013, an action in Catherine Creek placed large wood structures at one site to encourage "scour" that would create deep pools at another site (see Figure 25). Likewise in the Methow River a similar action improved side-channel and floodplain habitat by removing a levee and installing numerous log structures that were designed to increase floodplain inundation and pool habitat (see Figure 26). Because an understanding of stream channel morphology and hydrology is critical to realizing the benefits of these types of actions, the Action Agencies have enlisted staff with specialized skills in hydrogeology and engineering to support these efforts.

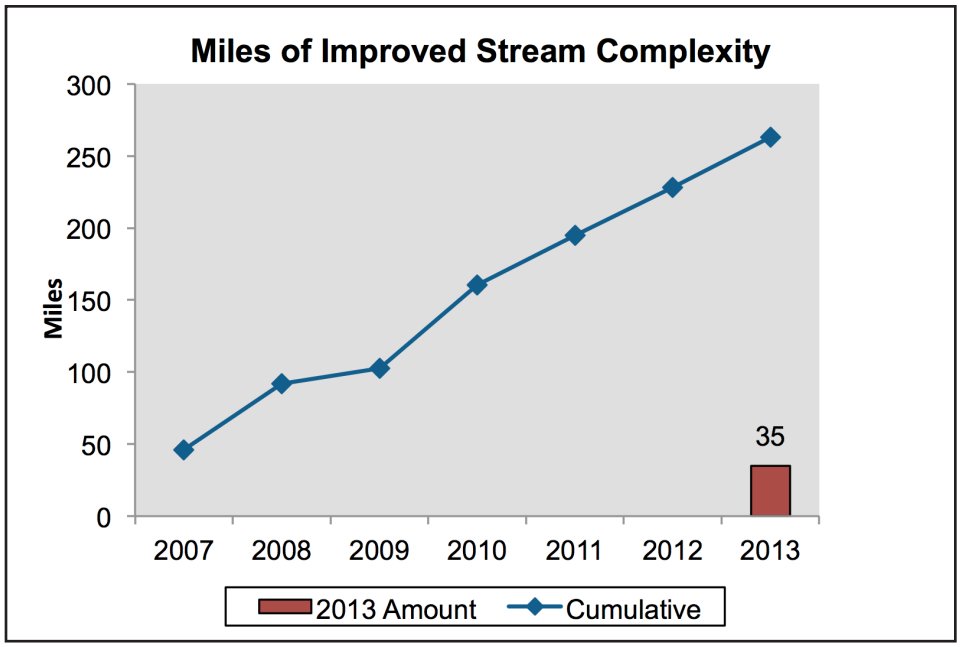


Figure 24. Miles of improved stream complexity, 2007–13.

Improving and Protecting Riparian Areas to Improve Water Quality

Unlike flow restoration or barrier removal actions that deliver immediate benefits to fish, improvements from riparian revegetation generally accrue over time (Roni et al. 2013). As the features of habitat mature and improve so

Figure 25. Catherine Creek, CC-44 Phase 1 Habitat Enhancement Project.

Figure 26. Methow River Habitat Improvement Project M2 Reach.

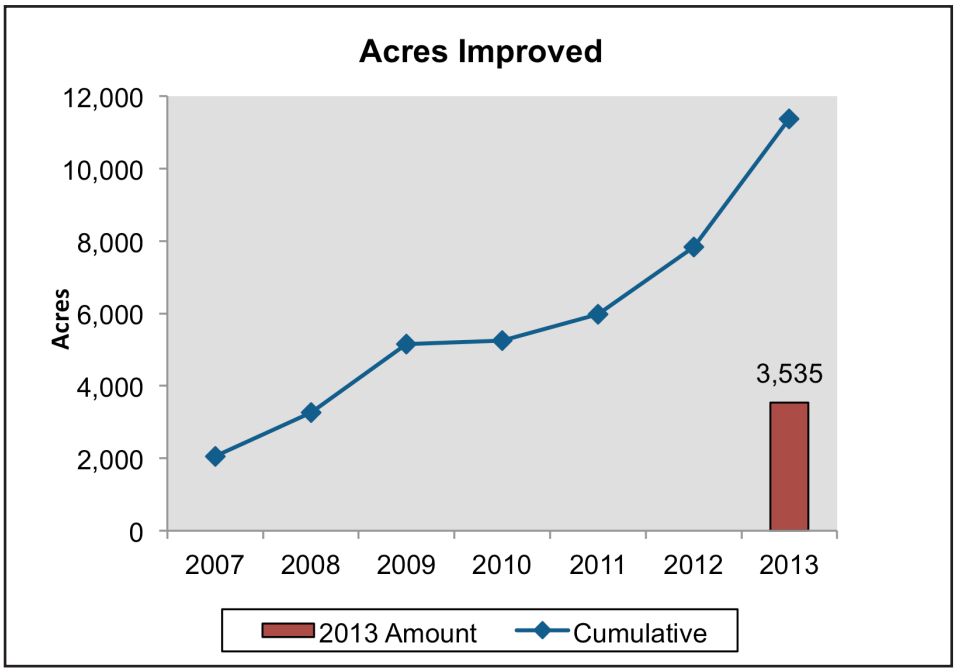


Figure 27. Acres of riparian habitat improved, 2007–13.

will conditions for fish. In addition to improving physical habitat, these actions also improve water quality and enhance forage resources for fish. Riparian fencing is a treatment type that facilitates passive rehabilitation allowing plants to recover in areas that have been impacted by grazing or agricultural production. Figure 28 illustrates a riparian project on the Methow River that was implemented in 2013. Figure 29 below shows the results of a riparian fencing project in the John Day Basin that was implemented a number of years ago. Although the timeframe for accruing benefits varies, both riparian revegetation and fencing projects will deliver significant improvements for fish. Recent studies regarding these and other actions have shown cumulative short term survival improvements (BPA 2014).

Reducing Fish Entrainment at Irrigation Diversions

The Action Agencies continue to support the improvement and replacement of screens to prevent fish from being drawn into irrigation diversions. In 2013, the Action Agencies funded programs in Oregon and Idaho that fabricate screens. The screen shop crews are involved in the installation and replacement of updated screens and in coordinating what is necessary for maintenance with private landowners. The working relationships that are established through these efforts are reflective of long term stakeholder engagement. The photographs below (Figures 31 and 32) illustrate a project constructed in 2013 in the John Day Basin to bring a screen up to current NOAA Fisheries criteria for improved fish survival.

Figure 28. Methow River Riparian Improvement Project.

Figure 29. Oregon Fencing Project in the John Day Basin.

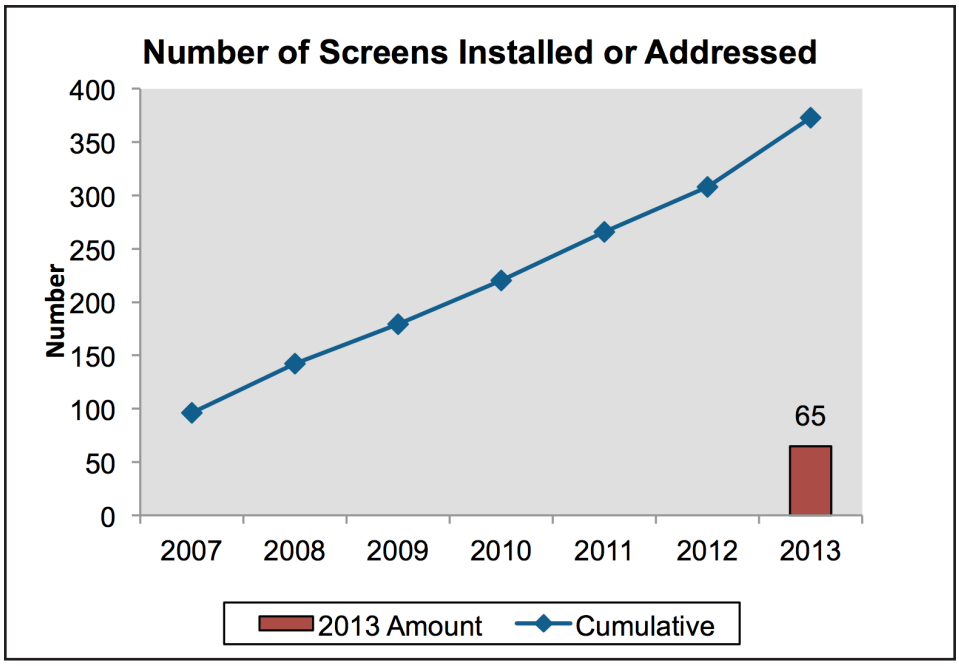


Figure 30. Number of fish screens installed or improved, 2007–13.

Figures 31 and 32. Pre- and post-construction condition Site 164 (Oregon Department of Fish & Wildlife) in the John Day Basin.

Improving Access to Spawning and Rearing Habitat

The Action Agencies continue to work with partners to replace culverts and irrigation diversions that block or impede fish passage (Figure 33 next page). Culvert replacement and barrier removal have some of the most immediate benefits to fish because they quickly reopen habitat (Figure 34). In 2013, two culvert barriers that were replaced with full-spanning bridges allowed immediate access of upper Lemhi River fish to previously inaccessible habitat in Hawley Creek (J. DiLuccia, Pers. comm.).

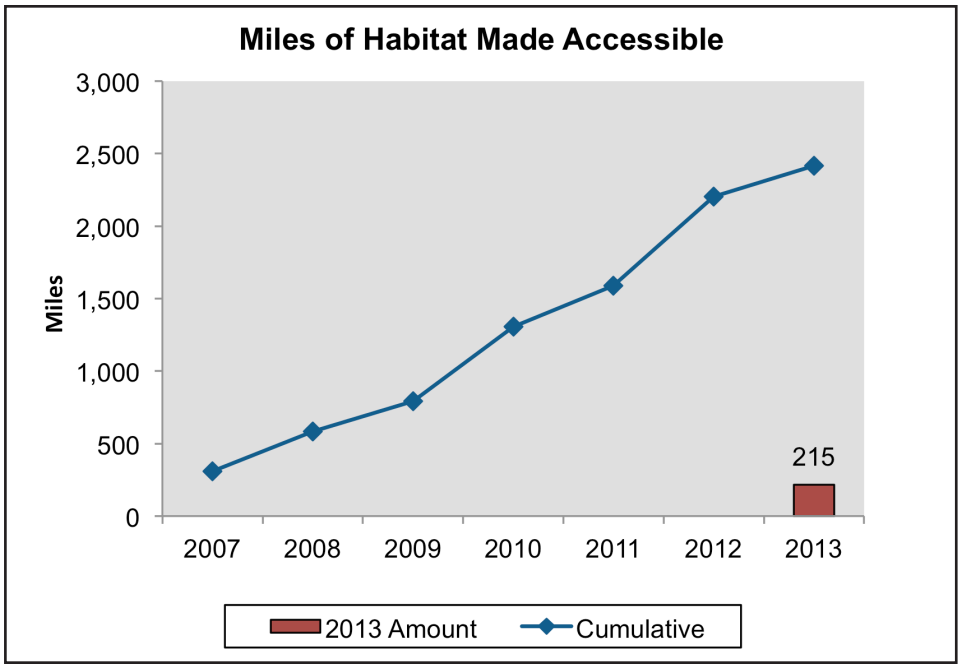


Figure 33. Miles of Habitat Made Accessible, 2007–13.

Figures 34 and 35. Hawley Creek before and after culvert-to-bridge replacement project.

Tributary Habitat Improvement Metrics by Species

Actions that improve stream conditions for the freshwater life-stages of salmon and steelhead are categorized and tracked through metrics. These metrics are summarized for 2013 in Table 3 by ESU/DPS, displayed in the metrics charts in Figures 23, 24, 27, 30 and 33. More details for the various watershed scale populations can be found in Section 3.

Estuary Habitat Actions

Implementation of the habitat program in the lower Columbia River and estuary has steadily improved over the course of the BiOp period. Progress was relatively slow and steady up to 2012 as expanded infrastructure for implementation was developed. Habitat improvement efforts made significant progress in 2013, taking advantage of a strong pipeline of restoration projects planned and developed by the Action Agencies and their partners in recent years. Overall accomplishments for the year in terms of salmon benefit units (SBUs), the currency for measuring and tracking the benefits of estuary habitat improvements for fish, nearly matched the total accomplishments for all previous years under the BiOp combined. The progress reflects the steady acceleration of habitat improvements in the estuary and demonstrates the Action Agencies' commitment to reach their 2018 BiOp targets.

The estuary's diverse habitats provide food and refuge for rearing and migrating juvenile salmon as they make their critical transition from fresh water to productive marine feeding grounds, where they grow at higher rates than are obtainable in freshwater systems. Recent research has increasingly demonstrated the importance of estuary habitat rich in food resources in giving juvenile salmon and steelhead an opportunity to feed and gain strength before entering the ocean (Diefenderfer et al. 2011, Diefenderfer et al. 2012). The Action Agencies' projects in the estuary are focused on restoring this critical estuarine habitat for the benefit of listed juvenile salmon and steelhead.

The success of 2013 was the result of several factors, including research

Table 3. 2013 Tributary Habitat Improvement Metrics.

2013 Tributary Habitat Improvement Metrics	Snake River Spring/ Summer Chinook	Snake River Steelhead	Upper Columbia River Spring Chinook	Upper Columbia River Spring Steelhead	Mid-Columbia River Steelhead
Acre-feet/year of water protected	6,148	6,148	11,212	20,984	18,121
Acres protected	155	186	45	52	3,230
Acres treated	1,094	1630	11	195	1710
Miles of enhanced or newly accessible habitat	109	109	5	5	101
Miles of improved stream complexity	8	18	3	4	13
Miles protected	15	16	2	2	188
Screens installed or addressed	6	6	2	22	37

and monitoring results that have been applied to helped shape projects in ways that maximize the benefits for fish. For instance, research has indicated that the full reconnection of tidal wetlands and floodplains to tidal influence is more beneficial to fish than the installation of tidegates. The Expert Regional Technical Group, independent scientific experts who assess the benefits of prospective projects, emphasized the same findings in making recommendations to the Action Agencies. The Action Agencies have therefore focused resources on projects that provide such reconnections. The Action Agencies have also sought out larger and more complex habitat improvement projects close to the mainstem, which also have been shown to provide additional benefits for fish.

Improved Capacity of Estuary Partners

In addition, partner organizations that develop and propose habitat actions in the estuary have also expanded their capacity to develop more complex projects. They have built improved relationships within estuary communities and with landowners and used advice from the Expert Regional Technical Group and their growing experience to develop an extensive pipeline of future projects. The result is that prospective projects are more focused on the science of habitat improvements expected to deliver the most benefits for interior Columbia Basin salmonids. In that way, 2013 was a year of validating and following through on the strategies outlined in the Columbia Estuary Ecosystem Restoration Program documents (CEERP 2013a, CEERP 2013b). Given the accelerating progress and improved project planning and development, the Action Agencies are on track to complete estuary habitat improvement projects in 2014 that should exceed the pace accomplished in 2013.

Research has shown that virtually as soon as wetland and floodplain habitat is reopened to tidal influences, juvenile salmon and steelhead begin using it almost immediately – often before the rejuvenated habitat matures (Roegner et al. 2010, Johnson et al. 2012). This highlights the value of restored estuary habitat, which benefits all populations of Columbia Basin salmon and steelhead migrating toward the ocean. Fish that do not actually use the habitat benefit from insects and other food resources produced in the wetland environments and flushed into the river's mainstem, where they are available to passing fish. Research continues to advance the state of the science in terms of estuary restoration, investigating issues such as the optimal channel density in restored areas, the role of large wood in tidal systems and the ecological impacts of invasive reed canary grass.

Two examples of the most significant habitat improvements in the estuary in 2013 follow.

Sandy River Dam Removal

One of the most complex and significant estuary habitat projects of 2013 entailed the Corps' removal of a 1930s era diversion dam that had blocked the main channel of the Sandy River near its confluence with the Little Sandy River. The dam removal reconnected approximately 190 acres of the river's historical channel with the lower river and estuary. Such complex river channels and deltas provide important refuge and feeding areas for juvenile salmon and steelhead. The project restored flows to the river's east channel, restarting normal physical and biological processes that historically shaped such habitat for the benefit of local and interior Columbia Basin stocks. Crews replanted disturbed riparian areas and treated invasive plants along the river bank.

Figures 36 and 37. Sandy River Dam during removal and after.

Sauvie Island-Ruby Lake Restoration

The Columbia River Estuary Study Taskforce, a partner organization in the estuary, began the first phase of a three-phase project to restore fish habitat and natural hydrology in the North Unit of the Sauvie Island Wildlife Area, northwest of Portland. The first phase involved removing a water control structure in Ruby Slough, reopening seasonal wetlands in Ruby Lake to the Columbia River and its tidal influence. Also, crews

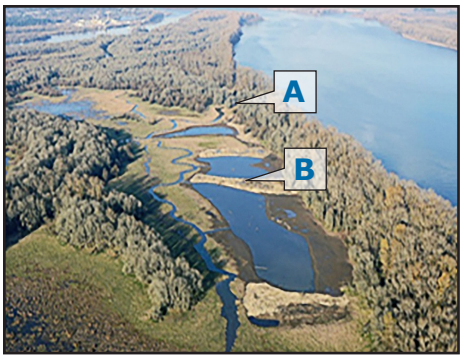


Figure 38. Aerial view of Sauvie Island. Area A illustrates increased access through structure removal. Area B illustrates increased capacity and quality of the habitat by lowering the marsh plain, controlling Reed Canarygrass, and adding plantings.

Table 4. Summary of Estuary Habitat Restoration Metrics, 2013. "CRE" refers to an action type described in NOAA Fisheries' "Columbia River estuary ESA recovery plan module for salmon and steelhead" (NOAA Fisheries 2011).

Action	Acres
Protect riparian areas (CRE 1.3)	0.69
Restore off-channel habitat (CRE 9.4)	61.88
Restore full hydrology/access (CRE 10.1)	436.00
Improve hydrology/access (CRE 10.2)	70.10
Improve access (CRE 10.3)	104.60
Reduce invasive plants (CRE 15.3)	195.20
Use dredged materials beneficially (CRE 6.3)	0.00
Land Acquisition (CRE 9.3)	598.40
Total	**1466.87**

excavated marsh plain surfaces to lower elevations so water could reach more of the wetlands to promote growth of native plant species. Removal of the control structure reopened more than 123 acres of historical habitat to juvenile salmon and steelhead and improving connectivity of the estuary food web so food resources can be naturally exported from the wetlands to benefit fish migrating past.

2013 Implementation

In 2013, Estuary habitat restoration ramped up, nearly doubling the number of SBUs produced over the ten-year term of the BiOp in a single year. Specifically, the Action Agencies completed on-the-ground habitat actions for eight projects in the estuary and continued planning and development of additional projects for future implementation (See Section 3, Attachment 4 for status of projects). These projects yielded 3.89 Ocean SBUs and 1.35 Stream SBUs by restoring a total of 1,467 acres throughout the Columbia River estuary. In addition to restoration actions, protecting land (CRE 9.3) supports habitat both by enabling future active restoration and by allowing landscape processes to passively restore the site.

As shown in Table 4, the nearly 1500 acres protected and restored in 2013 brings the BiOp period cumulative total to over 5000 acres. Projects with full hydrologic reconnection (CRE 10.1) made up the largest proportion of the actively restored acres. The Action Agency restoration strategy has intentionally prioritized full hydraulic reconnection given the high biological benefits associated with these types of projects. The other types of restoration described in Table 4 continue to be a useful when developing a comprehensive suite of actions at a site and when full reconnection is not possible for social or technical reasons.

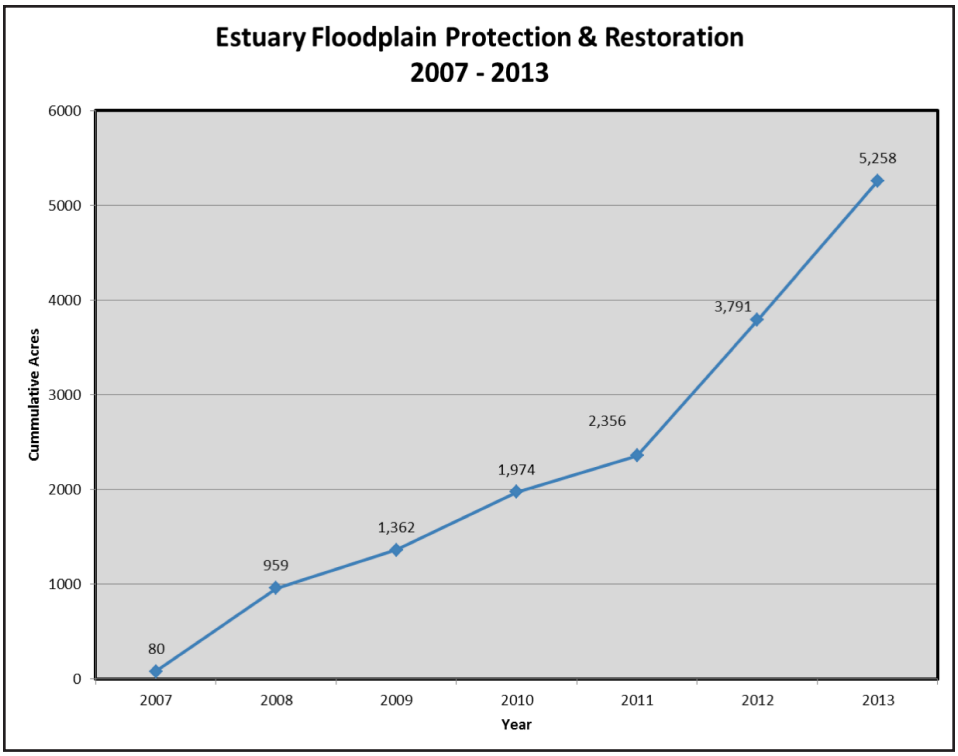
Hatchery Actions

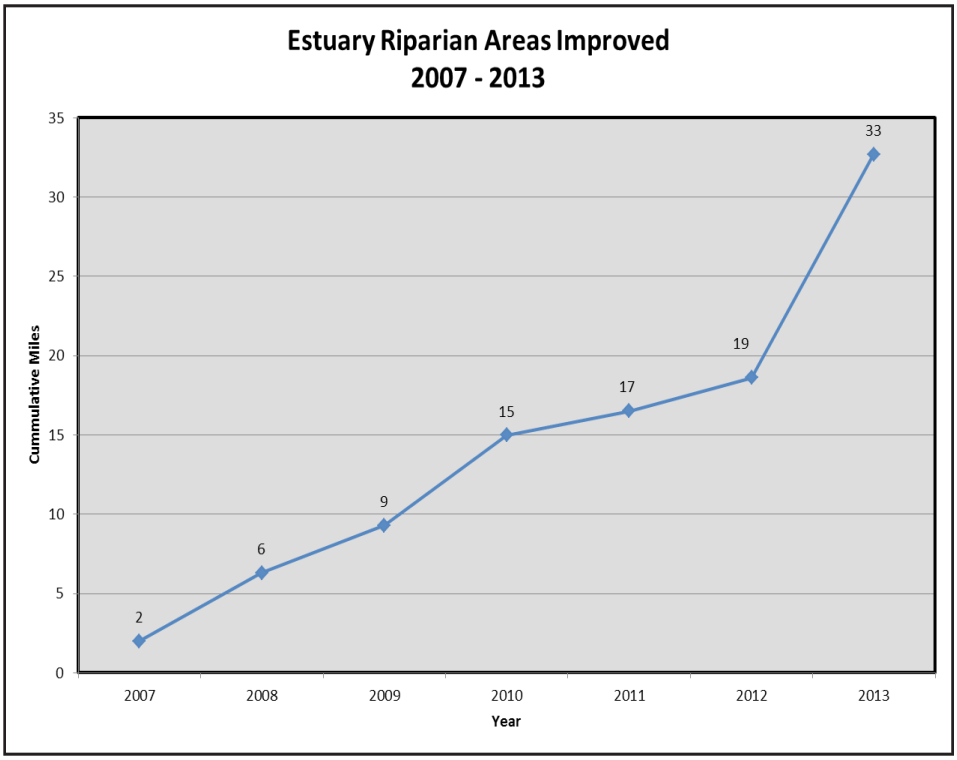
The Action Agencies continued to fund an extensive existing hatchery program as off-site mitigation for the Federal dams, including conservation hatcheries for ESA-listed fish. In order to ensure that these programs do not impede recovery of ESA-listed salmon and steelhead, the Action Agencies worked with hatchery operators to prepare updated hatchery and genetic management plans (HGMPs) (Figure 41, page 26). The HGMPs identify operations to meet production requirements and to reduce or eliminate detrimental genetic and ecological effects on listed species. The Action Agencies' strategy is to ensure that FCRPS mitigation hatchery programs are aiding conservation and not impeding recovery of salmon ESUs or steelhead DPSs.

By the close of 2013, the Action Agencies had reviewed draft HGMPs for all of the 44 Action Agency-funded hatchery programs and provided comments to hatchery operators. By the end of 2013, a total of 28 HGMPs had been determined by NOAA Fisheries to be sufficient for formal ESA consultation and 9 site specific biological opinions had been completed.

Conservation and Safety Net Programs

The Action Agencies continued to fund hatchery conservation programs for salmon and steelhead to preserve and rebuild genetic resources and assist in promoting recovery of listed ESUs and DPSs. During 2013, BPA continued to fund projects reconditioning upper and mid-Columbia River and steelhead kelts. Progress in 2013 for reconditioning includes:





Figures 39 and 40. Cumulative summary of Estuary Acres of Floodplain Improved; and 2013 and Cumulative summary of Estuary Acres of Riparian Areas Improved, 2013, respectively.

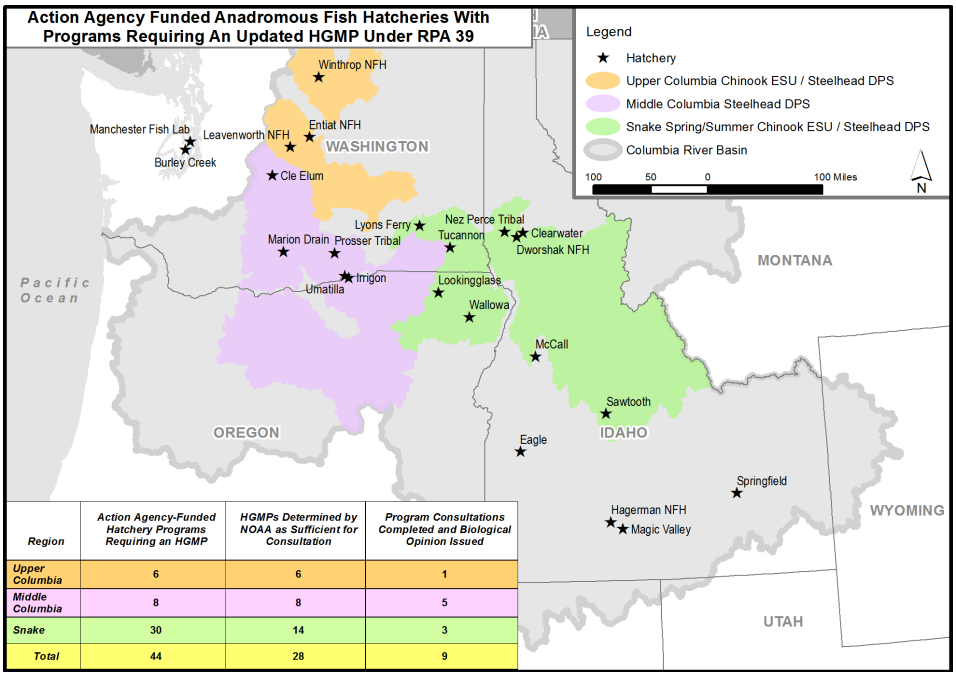
- Expanded collection opportunities to known B-Run steelhead tributaries (e.g. Fish Creek); and
- Continued reconditioning research including assessments of fish culture techniques such as diet composition, monitoring of ocean return rates of kelts released from different reconditioning programs, experimental treatments, and stock origins, and estimation of reproductive success rates including long-term reconditioned kelts which did not undergo a repeat ocean migration.

BPA also continued to fund and support supplementation programs using local origin broodstock such as Snake River and upper and mid-Columbia River and steelhead as well as Snake River Spring/Summer Chinook Salmon. In addition, construction of the Chief Joseph Hatchery was completed in 2013. The hatchery is anticipated to serve as the production facility for ESA-listed Upper Columbia River spring Chinook for reintroduction in the Okanogan Basin.

As part of their review of the John Day Mitigation Program in 2013, the Corps continued an engineering study. The final report, due in 2014, will recommend specific improvements to the current mitigation production program.

For Upper Columbia steelhead in the Methow River, Reclamation funded a scope of work to increase efforts at Winthrop National Fish Hatchery to continue the transition to local broodstock for the steelhead program, and to manage returning adult steelhead. Sufficient local broodstock were collected to produce 81,000 juveniles. In 2013, the hatchery operator began removing hatchery-produced adult steelhead from the spawning grounds consistent with the program's HGMP.

The Action Agencies also continued to fund safety-net programs to reduce the extinction risk of at-risk populations of ESA-listed Snake River sockeye salmon and Snake River spring/summer Chinook. One of those programs, the Snake River Sockeye Salmon Captive Broodstock Program, preserves this critically



Region	Action Agency-Funded Hatchery Programs Requiring an HGMP	HGMPs Determined by NOAA as Sufficient for Consultation	Program Consultations Completed and Biological Opinion Issued
Upper Columbia	6	6	1
Middle Columbia	8	8	5
Snake	30	14	3
Total	44	28	9

Figure 41. Action Agency-funded anadromous fish hatcheries with hatchery programs requiring an updated HGMP and ESA consultation under BiOp RPA Action 39.

imperiled species. The captive broodstock hatchery program has produced hundreds of thousands of progeny from the remnants of the wild stock. This hatchery program, which is carefully managed to preserve genetic diversity, annually produces fry and juveniles that are released in natural habitat to migrate downstream and return from the ocean as adults. The program also produces mature adults for release into Redfish Lake to spawn naturally. Since 1999, 4,824 adults from the program have returned to Idaho's Redfish Lake or to the Sawtooth Hatchery weir on the upper Salmon River (Figure 42). In 2013, 270 adults returned to these two locations. The Action Agencies, along with NOAA Fisheries, are continuing to work with the region to further research and evaluate factors contributing to the source of disparity between returns to Lower Granite and returns to Redfish Lake/Sawtooth Hatchery weir.

The BiOp calls for the Action Agencies to expand the Snake River sockeye program to produce between 500,000 and 1 million juveniles annually. For several years, BPA worked with the State of Idaho and the Idaho Department of Fish and Game to acquire a hatchery site with adequate water quantity and quality to achieve the expanded production level. In 2013, construction of the Springfield Hatchery facility in southeastern Idaho was completed and the expanded production in this facility is expected to achieve this BiOp RPA action.

Harvest

Harvest impacts on ESA-listed fish species in the Columbia River Basin are managed primarily through states, tribes, and federal agencies other than the Action Agencies, and are addressed in separate biological opinions. The Action Agencies have supported the identification and implementation of approaches or conservation measures to reduce the effects of harvest on ESA-listed species and/or increase the precision of enumeration of impacts. In 2013, the Action Agencies continued funding the implementation and evaluation of live-capture fishing gear that can be used to selectively harvest marked hatchery fish while allowing ESA-listed natural-origin fish to escape unharmed. Terminal area

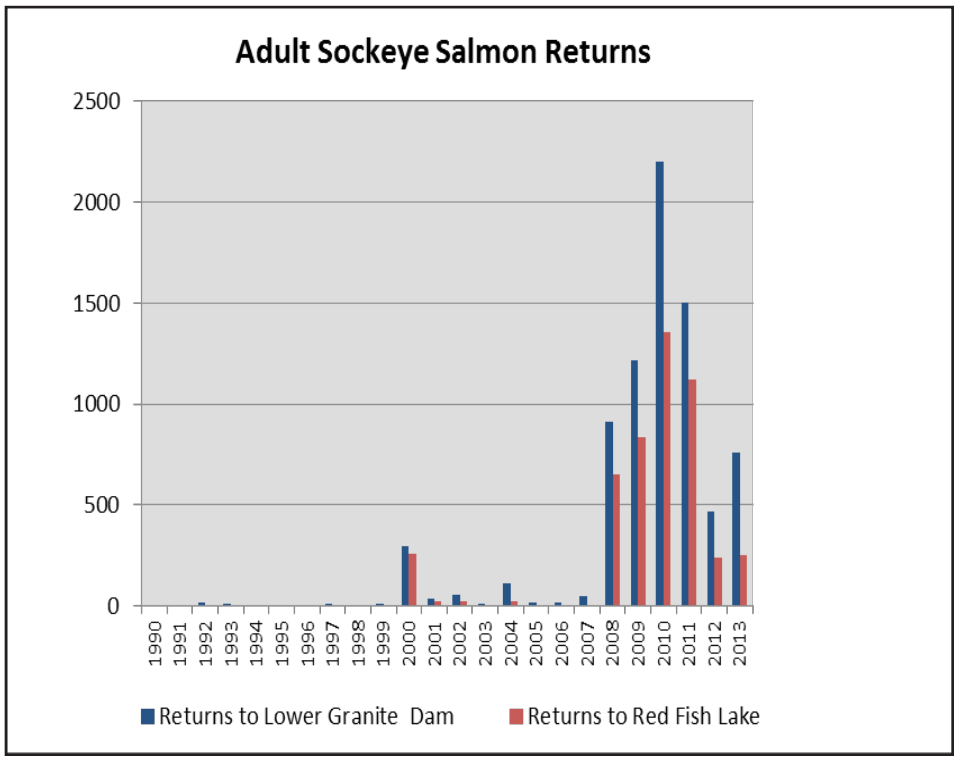


Figure 42. Adult sockeye salmon returns to Lower Granite and to Redfish Lake/Sawtooth Hatchery weir on the upper Salmon River, Idaho, 1991–2013.

fishing was also supported through BPA funded Select Area Fisheries Enhancement Program. In addition, the Action Agencies continued to fund research into harvest managers' sampling regime and estimation model to assess whether improved methodologies could provide more precise estimates, especially with the use of PIT technology.

Predator Management

Four main predator species are a major cause of mortality of ESA-listed fish in the Columbia River system. Populations of Caspian terns and double-crested cormorants, which eat large numbers of migrating juvenile fish, have increased over the last two decades in the Columbia River Estuary. These two species are also present in the mid-Columbia region, but at lower numbers. Reducing avian predation of juvenile salmon and steelhead would result in increased adult returns. Both Caspian terns and double-crested cormorants are protected under the Migratory Bird Treaty Act of 1918; which requires additional processes to reduce the impacts of these birds on the ESA-listed salmon and steelhead.

Among fish, northern pikeminnow are consumers of juvenile salmon and steelhead. Predation by introduced fish species such as smallmouth bass and walleye is also a concern. California and Steller sea lions are known to consume substantial numbers of adult spring Chinook salmon and winter steelhead below Bonneville Dam, and injure many fish that pass upstream. Under the BiOp, however, the Action Agencies efforts to manage predation by sea lions are limited to non-lethal deterrent actions at Bonneville Dam, while NOAA Fisheries and others take the lead on lethal removal options and permits.

Federal and state agencies, and other entities, are cooperating in efforts to manage and reduce predation on listed species of salmon and steelhead. Programs to redistribute Caspian terns currently nesting in the estuary, deter and block sea lions from Bonneville Dam fish ladders, and reduce the northern pikeminnow population through a sport-reward program have been successful in decreasing the loss of adult and juvenile salmon to predation. In 2013, the Action Agencies continued these efforts to control specific predators and improve survival of juvenile fish.

Avian Predation

Caspian Terns in the Estuary

Under the BiOp, the Action Agencies have created Caspian tern nesting habitat outside of the Columbia Basin to allow reduction of nesting habitat on East Sand Island in the estuary. In 2013, a total of 7.8 acres was available to terns nesting in southern Oregon and northern California. These sites are listed in Table 5 below. Of these, all, except for Orems Unit provided functional nesting habitat in 2013. Due to the number of alternative nest sites made available in interior Oregon and northern California, the area made available for tern nesting at East Sand Island was limited to 1.58 acres, as in 2012. This acreage is about 32 percent of the colony area that was available in 2001-2007.

The Caspian tern colony on East Sand Island in the Columbia River estuary consisted of about 7,400 breeding pairs in 2013. This is an increase from the estimate of 6,400 pairs in 2012, and the first increase since the initiation of habitat reduction on East Sand Island in 2008 when the colony numbered about 10,000 breeding pairs (Figure 43). Average nesting density in 2013 was 1.17 nests/m^2, an increase from 1.06 nests/m^2 in 2012, and is the highest tern nesting density so far observed in the Columbia River estuary.

The average proportion of juvenile salmon and steelhead in the diet of Caspian terns during the 2013 nesting season was 32 percent, similar to 2009-2012. The estimated total smolt consumption by Caspian terns nesting at East Sand Island in 2013 was 4.6 million (95 percent c.i. = 3.9 - 5.3 million), similar to 2012 and 2011

Table 5. Status of Caspian Tern Nesting Islands for the 2013 Breeding Season. Productivity measured as offspring per nest.

Location	Acres Available in 2013	Completion Date	Social Attraction	Watered
Fern Ridge Reservoir (OR)	1.0	Feb 08	Yes	Yes
Crump Lake (OR)	1.0	Mar 08	No	Yes
East Link Unit, Summer Lake Wildlife Area (OR)	0.5	Dec 08	Yes	Yes
Dutchy Lake, Summer Lake Wildlife Area (OR)*	0.0	Feb 09	NA	NA
Sump 1B, Tule Lake NWR (CA)	2.0	Aug 09	Yes	Yes
Gold Dike Unit, Summer Lake Wildlife Area (OR)	0.5	Sep 09	No	Yes
Orems Unit, Lower Klamath NWR (CA)	1.0	Sep 09	Yes	No
Sheepy Lake, Lower Klamath NWR, (CA)	0.8	Feb 10	Yes	Yes
Malheur Lake, NWR (OR)	1.0	Feb 12	Yes	Yes

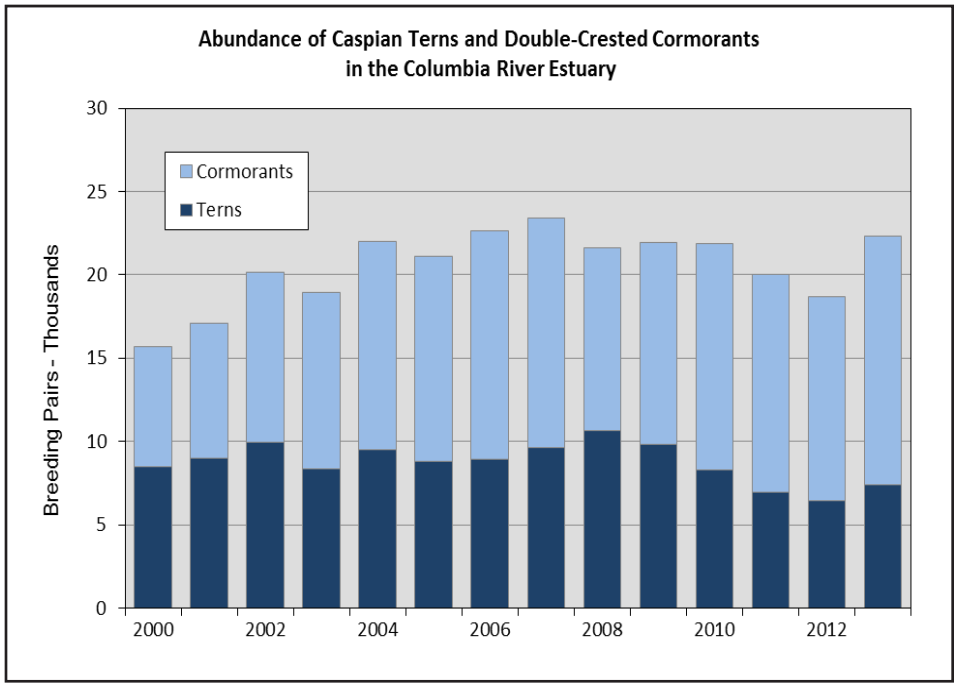
*Island removed in 2012. No management of monitoring in 2013.

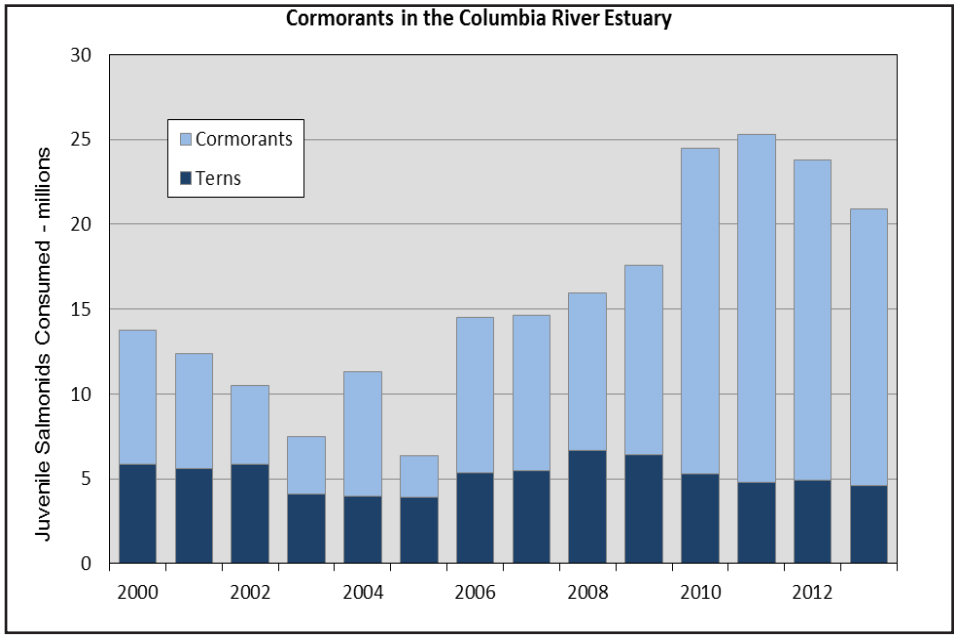
(Figure 44). Tern predation rates were significantly higher on steelhead populations (8.6 – 12.5 percent, depending on the population) compared with other juvenile salmonid populations (0.6 – 1.4 percent, depending on the population).

Cormorants in the Estuary

In 2013, the Action Agencies continued to evaluate potential management techniques to reduce losses of juvenile salmon and steelhead due to double-crested cormorant predation in the Columbia River estuary. Available nesting habitat was reduced to 4.5 acres using privacy fencing to isolate the nesting colony area. Human hazing was used to evaluate the efficacy of diverting the double-crested cormorants into the nesting colony. Both methods were successful at crowding double-crested cormorants into one contiguous colony area.

In 2013, the colony consisted of about 14,916 breeding pairs, the largest double-crested cormorant colony recorded on East Sand Island, and about 15 percent larger than was recorded in 2011-2012 (Figure 43). Double-crested cormorants nesting at this colony consumed approximately 16.3 million juvenile salmon and steelhead (95 percent c.i. = 11.4 – 21.1 million), not significantly different from the number of juveniles consumed by cormorants in 2012 (Figure 44). The majority of their diet was comprised of sub-yearling Chinook salmon (about 11.4 million or 70 percent). Spring migrants (coho, yearling Chinook, sockeye salmon and steelhead) comprised about 4.8 million juveniles (95 percent c.i. = 3.8 – 5.8 million). For the past five years at East Sand Island, smolt consumption by double-crested cormorants has been significantly greater than that by Caspian terns.





Figures 43 and 44. Abundance of colonial birds in the Columbia River Estuary and Consumption of juvenile salmon in the Columbia River Estuary, respectively. (Tern data and 2003-2013 cormorant data from Roby et al. 2014. Cormorant data 2000-2002 from K. Collis, pers. comm.)

Adult and juvenile double-crested cormorants were banded with a field readable leg-band, and eighty-three adults were tagged with a satellite transmitter for the purpose of evaluating dispersal patterns and potentially identifying alternative, preferred nest sites. Of those that dispersed, most remained in the Columbia River estuary, returning to East Sand Island; some were re-sighted or detected in the Salish Sea/ Puget Sound region, western British Columbia; outer Washington coast; interior Washington, Oregon coast; Willamette Valley; California coast; and interior California. Although there were no banded cormorants re-sighted in the Columbia Plateau region during 2013, one cormorant

banded at the East Sand Island colony was re-sighted near Richland, Washington during the post-breeding season 2012.

In 2012, the Corps initiated development of a Draft Environmental Impact Statement (DEIS) for Double-Crested Cormorant Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary. Development of that DEIS continued through 2013 with the consideration of a range of alternative management actions.

Inland Avian Predation

In 2013, the Action Agencies continued development of the Inland Avian Predation Management Plan (IAPMP) for Corps owned and managed lands and associated shallow water habitat upriver of Bonneville Dam as part of RPA Action 47. A draft IAPMP was released for public comment on October 31, 2013 with subsequent completion and Phase 1 implementation in January 2014 (USACE 2014b). Based on results of RME conducted as part of RPA Action 68, the Corps and Reclamation agreed to expand the scope of the plan to include Reclamation-owned lands at Goose Island in Potholes Reservoir (near Othello, Washington), where the Caspian tern colony appears to be preying heavily on Upper Columbia River steelhead.

Northern Pikeminnow

Large northern pikeminnow are predators of juvenile salmon. Since 1990, BPA has funded the Northern Pikeminnow Management Program (NPMP) to reduce the numbers of larger pikeminnow and improve survival of juvenile salmon. The NPMP relies on private-sector fishing efforts to provide the majority of the catch of northern pikeminnow. In 2013, the BPA monetary reward for the catch of this predator was sustained at a higher level than first initiated in 2005. This reward structure helps sustain the higher catches. In addition, program managers continued the dam-angling program component initiated in 2009. This program provided two fishing crews that focused on the forebay and tailrace sections of The Dalles and John Day dams—areas not accessible to the general fishing public. A total of 4,039 northern pikeminnow were caught at those locations in 2013.

In 2013, the exploitation rate on northern pikeminnow was 10.8 percent. This rate was based on a numerical catch of 166,023 from the sport reward and dam angling fisheries.

The NPMP has removed close to 4 million pikeminnow from the Columbia River since 1990. Evaluation indicates that, as a result, pikeminnow predation on juvenile salmon has declined 38 percent in that time, saving 4 to 6 million juvenile salmon annually that otherwise would have been eaten by this predator.

Sea Lions at Bonneville Dam

In recent years, sea lions, which are protected under the Marine Mammal Protection Act, have been observed swimming more than 140 miles up the Columbia River to Bonneville Dam to prey in increasing numbers on adult spring Chinook salmon, winter steelhead, and white sturgeon. Generally arriving from middle to late February and leaving by the first week in June, the male sea lions are gaining weight in preparation for the summer mating season.

Corps biologists began gathering data on sea lion presence and predation at the dam in 2001. By 2003 the number counted had grown to more than 100. Not all sea lions counted were at the dam at the same time; usually about 20 were present on any one day. From 2002 through 2007, most of the pinnipeds present were California sea lions. Beginning in 2008, Steller sea lions, which are listed as threatened under the ESA, began arriving in larger numbers. By 2011, the total number of Steller sea lions seen at the Bonneville Dam tailrace was greater than the number of California sea lions seen (Figure 45).

The number of fish eaten by sea lions reached a peak in 2010, but has decreased substantially since then (Table 6). In 2010, the expanded consumption estimate was 6,081 adult salmon and steelhead that would otherwise have passed Bonneville Dam from January 1 through May 31 ("expanded" estimates correct for the fact that observers are not present at all hours of daylight and most weekends for all locations). By 2012 the expanded estimated had dropped to 2,107, or about 1.2 percent of the January 1 – May 31 run. 2013 consumption was somewhat higher, at 2,714 (2.2 percent of the run). Salmon and steelhead consumption by Steller sea lions has increased greatly in the last several years, with them now responsible for approximately half of the total consumption.

Program goals for the pinniped program are 1) annual installation of devices to keep sea lions out of fish ladder entrances; 2) providing hazing efforts; 3) monitoring the number of sea lions present and their consumption of salmon and steelhead and other fish; and 4) evaluating the effectiveness of hazing and other deterrent measures.

In 2013, the Corps again contracted with Department of Agriculture (USDA) Wildlife Services to harass

sea lions away from fishways and other dam structures, as they have each year since 2006. Dam-based harassment by USDA agents began each year in March and was conducted daily through the end of May. Harassment involved a combination of acoustic, visual, and tactile non-lethal deterrents, including above-water pyrotechnics (cracker shells, screamer shells, or rockets), rubber bullets, rubber buckshot, and beanbags. Also since 2006, sea lion exclusion devices (SLEDs) have been installed annually at Bonneville Dam's 12 primary fishway entrances to prevent sea lions from entering the fishways. The SLEDs feature 15.38-inch (39.05-centimeter) gaps that are designed to allow fish passage. Floating orifice gates are also equipped with similar barriers.

In 2013, the Action Agencies again supported boat-based harassment conducted by the Columbia River Inter-tribal Fish Commission (CRITFC). The Corps granted access to the Bonneville Dam boat restricted zone but, given concerns about human and fish safety, harassment was not allowed within 30 meters of dam structures or within 50 meters of fishway entrances. The use of "seal bomb" deterrents was prohibited within 100 meters of fishways, collection channels, or fish outfalls for the Powerhouse 2 corner collector and smolt monitoring facility. Boat crews ceased use of seal bombs inside the boat restricted zone after adult salmon and steelhead passage exceeded 1,000 fish per day. Corps biologists coordinated with USDA agents and boat-based crews from Oregon Department of Fish and Wildlife (ODFW), Washington Department of Fish and Wildlife (WDFW), and CRITFC on all sea lion harassment activities at Bonneville Dam to ensure safety and increase the effectiveness of harassment efforts.

Table 6. Consumption of Salmon and Steelhead by California Sea Lions, Steller Sea Lions, and Harbor Seals at Bonneville Dam, from Surface Observations Conducted Between 2002 and 2013. Total salmon and steelhead passage counts include all adult salmon and steelhead that passed Bonneville Dam from January 1 through May 31. "Expanded" estimates correct for the fact that observers are not present at all times. "Adjusted" estimates further correct to account for catch events where the prey species could not be identified. Stansell et al. 2013.

Year	Bonneville Dam salmon and steelhead passage (Jan. 1-May 31)	Expanded salmon and steelhead consumption estimate		Adjusted salmon and steelhead consumption estimate	
		Estimated consumption	Percent of run (Jan. 1 to May 31)	Estimated consumption	Percent of run (Jan. 1 to May 31)
2002	284,732	1,010	0.4	1,010	0.4
2003	217,934	2,329	1.1	2,329	1.1
2004	186,771	3,533	1.9	3,533	1.9
2005	81,252	2,920	3.4	2,920	3.4
2006	105,063	3,023	2.8	3,401	3.1
2007	88,474	3,859	4.2	4,355	4.7
2008	147,558	4,466	2.9	4,927	3.2
2009	186,056	4,489	2.4	4,960	2.7
2010	267,127	6,081	2.2	6,321	2.4
2011	223,380	3,557	1.6	3.970	1.8
2012	171,665	2,107	1.2	2,360	1.4
2013	120,619	2,714	2,2	2,928	2.4

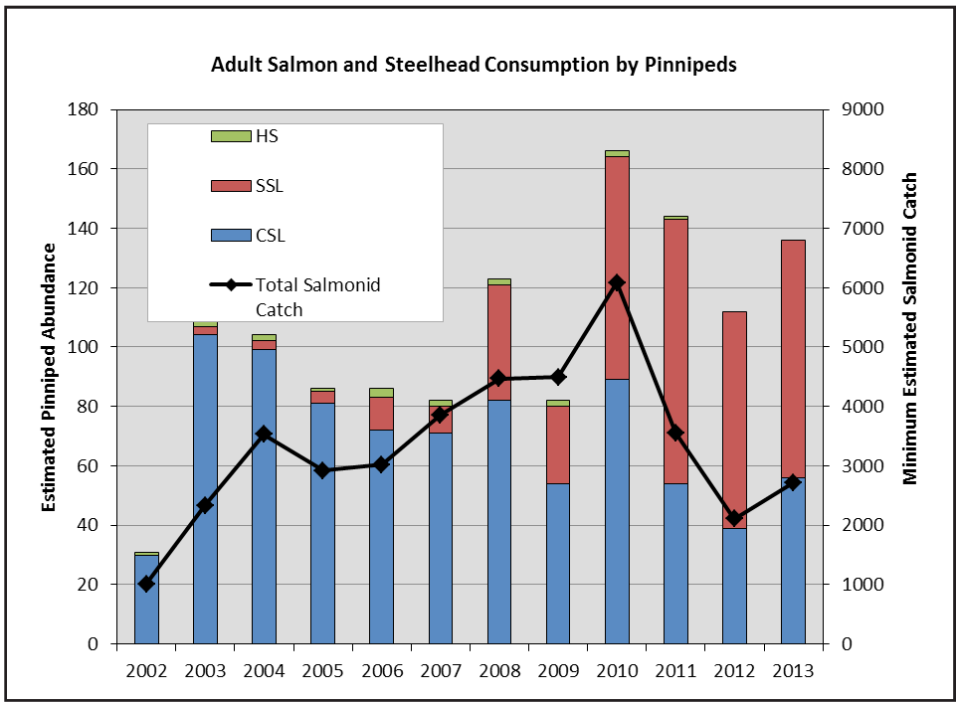


Figure 45. Estimated minimum number of adult salmon and steelheads consumed by pinnipeds and estimated total number of pinnipeds seen at Bonneville Dam January 1–May 31, from 2002 to 2013. In 2005, regular observations did not start until March 18. Pinnipeds observed included California sea lions, Steller sea lions, and harbor seals. Stansell et al. 2013.

In 2013, personnel from ODFW and WDFW operated four floating sea lion traps at Bonneville Dam at various locations across the season, trapping a total of 15 different California sea lions. Trapped animals were branded and/or tagged (acoustic and/or GPS). Four of the 15 sea lions met the criteria for removal from the population; two of those were relocated to a zoo and the other two were euthanized.

Research, Monitoring, Evaluation, and Adaptive Management

The Action Agencies provide tens of millions of dollars each year for an extensive Research, Monitoring, and Evaluation (RME) Program. This program supports accountability for implementation of BiOp actions and addresses critical uncertainties through adaptive management. The Action Agencies use the best available scientific information from this program to help ensure that actions meet the BiOp goals and performance standards.

RME is implemented through various programs: BPA's Fish and Wildlife Program, the Corps' Anadromous Fish Evaluation Program, and Reclamation's technical assistance activities. The programs are coordinated with RME activities of other regional agencies. The Action Agencies work closely with state, federal, and tribal aquatic habitat and ESA-listed salmon and steelhead monitoring program, and state and tribal constituents through a forum called the Pacific Northwest Aquatic Monitoring Partnership.

The Action Agencies have implemented several RME strategies and associated actions with regard to fish population status, hydro, tributary habitat, estuary/ocean, harvest, hatchery, predation, and regional coordination and data management. Work implemented and key lessons learned relative to all-H implementation is summarized below.

Refer to Section 2 of this APR for a summary of Action Agency funded RME projects that are presented in the following RME sections. BPA project reports can also be accessed at (*http://qa.cbfish.org/BiologicalOpinionAction.mvc/Index/2013/BiOpRpaStatus*) using the project number provided.

Fish Population Status Monitoring

The fish population status and trend monitoring program supports monitoring of population and ESU/DPS indicators of wild and hatchery adult and juvenile abundance, distribution, productivity, survival, and genetic diversity. This information provides important indicators of the condition of fish populations and species relative to performance targets and BiOp contingency triggers. These indicators support assessments of the priority and benefits of tributary and estuary restoration actions, hatchery management actions, predation management, and hydropower actions. The fish population status and trends monitoring includes natural origin spawner abundance in spawning streams and tributaries ("fish-in"), juvenile fish abundance in spawning and rearing areas at various life stages ("fish-out"), and adult and juvenile salmon passage and survival through the hydro system passage/survival.

Significant Results

- Since 2001, natural origin adult spawner abundance has increased for many populations (see Figures 3-9).
- A recently developed, extensive PIT tag Tributary Detection System (PTDS) has allowed for increased monitoring of ESA-listed adults in the basin at a level not previously possible, especially the Snake River steelhead DPS. This monitoring allows for effective assessments and reporting on three viable salmonid population (VSP) criteria – abundance, productivity, and diversity – for the Snake River Chinook salmon ESU and steelhead DPS. NOAA Fisheries and the Action Agencies use this information to assess the status and trend of ESA-listed stocks and to assess FCRPS mitigation progress and planning. A similar system has been developed for the Upper Columbia (see RPA Action 50 in Section 2 for a comprehensive list of PIT Tag funded projects).
- In the Upper Columbia, steelhead redd surveys were shown to be downward biased with highly variable results, while the newly developed PTDS with a properly implemented PIT tagging program is expected to produce unbiased and precise estimates of adult spawners (BPA Project 2001-003-00). This is a significant improvement in assessing population status and providing needed information for action effectiveness assessments. This may also eliminate the need for redd surveys or weirs in some populations and provide net cost savings.
- A hatchery monitoring program in the Hood River Subbasin confirmed that PIT tags are a very useful tool for estimating real-time adult spawner abundance, as well as for documenting and monitoring life history and migration traits. Having information from PIT tags along with the portfolio of other monitoring activities gave Hood River biologists the tools to identify life stage timing and survival rates, and accurately inform fisheries managers of over harvest impacts. The result of this monitoring program shows that PIT tags can provide useful information for managing harvest in real time (BPA Projects 1988-

053-03 and 1988-053-04).

- Straying of hatchery and out-of-basin fish still appears to be a problem for some populations (e.g. Asotin, Tucannon and Klickitat) (multiple projects, see RPA Actions 51, 52, 54, 62, and 63 in Section 2 for comprehensive project list).

- Genetic Stock Identification (GSI), via parental based tagging, has been shown to be a reliable tool to estimate escapement. GSI can definitively identify unmarked hatchery origin adults and provide independent estimates of escapement. Multiple agencies are now using GSI to further advance RME. See also RPA Sub-action 62.5 in Section 2 for comprehensive list of GSI funded projects.

- Recent analysis suggests that the Snake River fall Chinook hatchery project has accelerated the growth of the natural-origin population in combination with improved survival in other factors, such as hydro, harvest, and habitat (e.g. BPA Project 2012-013-00, see also RPA Actions 64 and 65).

- Recent findings by the Confederated Tribes of the Umatilla Indian Reservation from adult and juvenile data showed that many sections of the Umatilla River are at carrying capacity and are impacted by density dependence (BPA Project 1990-005-01). Planned monitoring and restoration efforts at Meacham Creek drainage is an example of how the Action Agencies' Action Effectiveness Monitoring (AEM) program intends to monitor changes in carrying capacity over time in order to better address density dependence issues and improve overall abundance, growth and survival of salmonids.

- Significant differences in age at return between hatchery- and natural-origin fall Chinook salmon were observed, indicating a decrease in ocean residency for hatchery-origin fish. Stray rates from non-local hatchery-origin fish into the Snake River were low (BPA Project 1983-350-03).

Hydro RME

RME actions are conducted in the FCRPS to evaluate compliance with survival and performance standards prescribed in the BiOp as well as to provide a record of status and trends for population level indices including, juvenile dam survival, smolt survival in-river and adult passage survival. RME also assess the effectiveness of management actions, such as transportation, surface passage operation and spill levels, as well as addressing critical uncertainties such as evolving life history strategies for fall Chinook, and issues related to latent mortality.

Significant Results

- In 2013, for Snake River yearling Chinook salmon (hatchery and wild combined), estimated survival through the entire hydropower system (from the head of Lower Granite Pool to Bonneville tailrace) was 52.5 percent. For juvenile steelhead (hatchery and wild combined) estimated survival was 50.1 percent. Both values were higher than the 15-year average. NOAA Fisheries estimated the median travel time of spring-migrating juveniles to be shorter than the long-term average (Faulkner et al. 2013). This likely reflects the effects of surface passage systems and the current tailored spill regime.

- NOAA Fisheries used PIT tagged juveniles from the Upper Columbia Basin to estimate juvenile survival for those ESUs as they migrated through the Lower Columbia River. Survival probability and standard errors from McNary Dam to the tailrace of Bonneville Dam were estimated as: 0.910 (0.075) for steelhead, and 0.776 (0.106) for sockeye (Faulkner et al. 2013).

- Transportation studies are addressing several lines of inquiry. NOAA Fisheries continues to refine the seasonal operations for initiating transport by updating, synthesizing, and analyzing the most recent adult return information for PIT tagged fish. For spring-migrating Chinook and steelhead the preferred trigger dates for initiating transport differ somewhat by species. For summer-migrating Chinook, initial results suggest that prior to mid-June in-river migration yields higher returns, whereas after the date, transported fish yield higher returns. A physiological study suggests that current barging operations may affect imprinting by steelhead juveniles, and may explain increased stray rates observed for some populations (Dittman et al. 2013).

- The survival probability of adult Snake River sockeye salmon through the FCRPS to tributaries was estimated in 2013 and expands the historical data (2008-2012) set for this rebounding ESU (Crozier et al. 2014). Survival estimates in 2013 from Bonneville Dam to Lower Granite Dam were lower than previous estimates for the period from 2008-2012 (44 percent in 2013 versus 53 percent to 78 percent from 2008 to 2012). Survival estimates in 2013 from Lower Granite Dam

to Sawtooth Hatchery were also one of the lowest estimates for the period of 2008-2013 (30 percent in 2013 versus 30 to 77 percent from 2008-2012). Based on magnitude of effect, the most important predictors of survival across reaches and years for adult Snake River sockeye were thermal exposure and fish travel time (Crozier et al. 2014). The early onset of warm temperatures in 2013 likely exacerbated cumulative thermal stress resulting in lower survival observed in 2013.

- A suite of adult passage investigations are providing insight regarding the effects of recent changes to the hydrosystem on upstream salmon migration and survival. At the system level, multi-agency investigations are using PIT and radio tag information to assess FCRPS passage success and identify areas and mechanisms responsible for inter-dam losses. Site-specific studies provided more detail about the effect of dam operations and facilities on adult passage. At Bonneville Dam a radio tag investigation provided detailed information regarding adult use of the various fishways, some of which have been modified in recent years. Compared to 2009 and 2010, entrance efficiency was somewhat low for spring Chinook in 2013, but higher for other species and stocks. At The Dalles Dam, high spill reduced adult approach to the north ladder entrance. Even so fish were observed shifting toward the alternative ladder on the OR side of the river. At the newly renovated John Day Dam North Fishway, entrance efficiency has improved over previous years and appears acceptable (Burke et al. 2013).

- Preliminary findings from turbine survival analysis indicate that survival of juvenile yearling and Subyearling Chinook and steelhead passing through Bonneville Powerhouse 1 turbines is high (≥95 percent) at operating ranges from the low end of 1 percent efficiency to the generator limit, which is above the 1 percent efficiency range. In addition, preliminary findings suggest that there was not a difference in survival for salmonids passing within the 1 percent of peak operating efficiency and salmonids passing at operations above the upper 1 percent operating efficiency (Weiland et al. 2013).

- Model-based studies at the University of Washington continue to explore factors affecting salmon survival during marine residence. Recent analyses indicate that smolt size at the time of ocean entry, marine predatory fish abundance and size, and PDO are important explanatory variables (BPA Project 1989-107-00).

- Research and monitoring on kelts and adult steelhead has indicated that adults are effectively finding and using spillway weirs and other surface passage routes which have been installed in the eight FCRPS dams between Lower Granite and Bonneville dams. Future downstream passage studies will provide further insight regarding opportunities to increase downstream survival through the FCRPS (2013 Kelt Management Plan).

Tributary Habitat RME

The Tributary Habitat Research Monitoring and Evaluation program is identifying factors that limit fish survival (limiting factors) and the effect that habitat actions have on fish survival and productivity. This information is used to identify and prioritize habitat improvement projects and substantiate progress toward targeted benefits for specific fish populations. The Integrated Status and Effectiveness Monitoring Program (ISEMP) and Columbia Habitat Monitoring Program (CHaMP) efforts, in addition to other IMWs and fish population monitoring, have moved from testing and confirmation of the best approaches to habitat and fish monitoring to more advanced stages of evaluation and modeling needed to provide further quantitative support for habitat planning and assessment needs. In addition, a project level habitat effectiveness program (AEM) was started in 2013 to further support local, project specific, implementation planning.

The status and trend monitoring from these multiple projects identifies and tracks habitat and fish conditions. Action effectiveness research assesses the effects of habitat actions on habitat and fish condition. Both status and action effectiveness monitoring and research are used to develop and support fish habitat relationships.

Significant Results

- Throughout the Columbia River Basin, monitoring of habitat actions and fish habitat relationships (like the Lemhi Production Model) indicate that projects are improving tributary spawning and rearing habitat and improving growth and survival for numerous populations of salmon and steelhead (BPA Project 2013-017-00).

- Studies in the Methow River watershed found that side channels were productive habitat for salmon and steelhead (Martens and Connolly 2014).

- Survival of young-of-year salmon and steelhead was higher in pools 100 centimeters or deeper. Juvenile Chinook salmon densities were higher in side-channels than in tributary and mainstem lateral margins. The results indicate that improving pool habitat within seasonally disconnected side channels can improve survival for juvenile salmon and steelhead and is an important restoration strategy, especially when full connectivity is not practical. The findings are informing plans for future habitat improvements.

- The treatment of a Middle Methow River side channel near Whitefish Island created a mostly permanent side-channel with extensive wood placements resulting in more pool and riffle habitat. The average depth of the pools substantially increased. Martens and Connolly (2014) report a significant increase in age-0 and age-1 steelhead and age-0 Chinook in the treated side channel.

- The ISEMP Watershed Production Model (BPA Project 2013-017-00) is proving to be a useful tool for evaluating the potential outcome of completed habitat restoration actions and identifying suites of restoration actions that could achieve targeted increases in salmon and steelhead productivity. Currently, the watershed model is being used in the Lemhi, Secesh, John Day, and Entiat sub-basins to test its exportability to other regions.

- ISEMP analyses (BPA Project 2013-017-00) indicated that the four most important metrics in predicting juvenile Chinook density were percent pools, spawner density, year effect, and the amount of wood in the stream. For juvenile steelhead, the top four metrics were spawner density, flow, amount of gravel, and stream width. These fish/habitat relationships will be used in life-cycle models and can help with identifying projects that will improve juvenile fish density.

- In the Okanogan River Basin, ecosystem diagnostic and treatment (EDT) model is identifying potential limiting factors and expected fish responses, and expert panels are using the EDT results to help guide and estimate the effects of habitat restoration actions. Model results indicate that restoration of stream flows within Salmon Creek and improved access in Antoine Creek can significantly improve steelhead production in the basin. EDT modelers are effectively using network maps of fish use and habitat impairments monitoring results from the Okanogan Basin Monitoring and Evaluation Program (OBMEP) (BPA Project 2003-022-00).

- In John Day subbasin's Bridge Creek, habitat improvement actions have led to increased density, production, and survival of juvenile steelhead, compared to a reference stream. Projects have restored floodplain processes that result in increased base flow, lower summer temperatures, decreased sediment loads, and greater habitat complexity (see Figure 46 below) (BPA Project 2003-017-00).

- The Bridge Creek IMW has demonstrated that using beavers and beaver dam support structures are an effective means to improve salmon and steelhead habitat in degraded streams. The approach is inexpensive, and if beaver populations are allowed to persist, should be self-sustaining. Degraded streams able to support beavers are ubiquitous throughout the range of endangered salmon and steelhead. Findings are preliminary and ongoing research as the restoration treatment reaches maturity will more clearly document the maximum benefit of restoration (Weigel 2013, Weigel et al. 2013a, Weigel et al. 2013b).

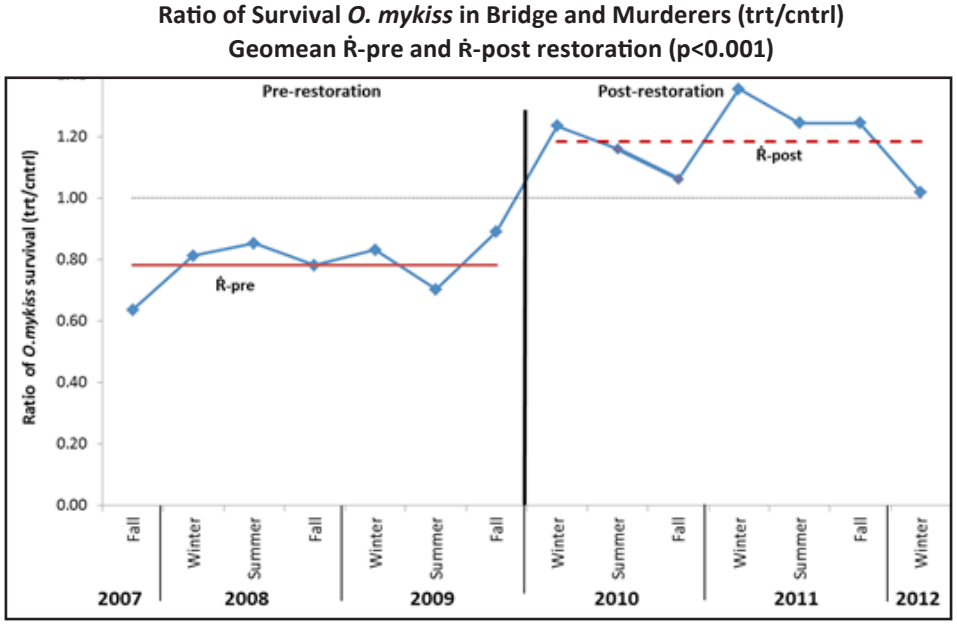


Figure 46. Ratio of survival of steelhead (*O. mykiss*) in Bridge Creek.

- Adult steelhead are spawning and juvenile steelhead and spring/summer Chinook salmon now occupy five tributaries in the Lemhi River Basin after habitat work to reconnect them to the river and provide thermal refugia. Habitat improvements in Little Springs Creek increased juvenile spring/summer Chinook salmon survival from 29 percent prior to restoration to 80 percent immediately following restoration actions (BPA Projects 2003-017-00 and 2011-006-00).

- Results from the Heat Source Model can predict population responses from changes in stream temperature (BPA Project 2009-004-00). The Grande Ronde River Basin partners are using the model to predict future water temperature conditions based on various restoration actions.

- The Grande Ronde Model Watershed is applying a comprehensive project selection tool called the Atlas to inform restoration planning (BPA Project 2007-083-00). The spatial distribution of spawning and fish use by juveniles relative to habitat quality is a key component of this tool. The ODFW's HabRate Model and CHaMP data were used to inform the project and support validation of limiting factor maps to guide development of the "Atlas."

- Reclamation and USGS performed a before-and-after floodplain complexity treatment analysis using a trophic production model that incorporates fish and habitat data in the treated area. The treatment data were collected from the Whitefish Island habitat complexity project in the Methow River. Results indicate a significant increase in local fish productivity capacity due to the restoration (Martens and Connolly 2014, and Bellmore et al. 2014). The model results and field data represent an independent analytic line of evidence that the Whitefish Island tributary habitat complexity project substantially improved salmon and steelhead production capacity and survival during the study periods.

- Research and monitoring in the Middle Fork Salmon River and Okanogan shows that Chinook and steelhead population productivity increases as summer minimum streamflow increases. This supports ongoing mitigation efforts to improve stream flows (BPA Project 1990-055-00).

- In Idaho's Lemhi River, a 15-year effort to install fish screens in irrigation diversions has reduced the stranding of out migrating juveniles from an estimated 71 percent to less than 2 percent, preserving tens of thousands of naturally spawned juvenile salmon (BPA Project 2003-017-00).

Estuary and Ocean RME

Research in the Columbia River estuary, plume and ocean seeks to understand how conditions affect salmon and steelhead survival. Findings help inform management habitat strategies by indicating what actions have the greatest potential to improve juvenile survival and productivity.

Significant Results

- Much of the variability in overall salmon survival from the smolt to adult life stage is primarily the result of ocean conditions. Data indicate that the first months juvenile salmon spend in the ocean is critical to their overall survival and subsequent adult returns for many stocks. In 2013, physical indicators of ocean conditions were neutral; however, biological indicators pointed to good ocean conditions, so overall results lean toward good returns of coho salmon in 2014 and Chinook salmon in 2015 (BPA Project 1998-014-00). Improved understanding of influences on salmon and steelhead survival in the estuary, plume, and ocean continue to improve predictions of adult returns, informing management actions.

- Research indicates that Upper Columbia and Snake River spring Chinook survival is most closely associated with indicators of bottom-up processes such as abundance of zooplankton and fish prey as well as growth and condition of individual fish. Sampling juvenile salmon, food availability and physical conditions in the plume and nearshore ocean indicate that food availability affects juvenile salmon growth and survival. For example, bigger Snake River Chinook salmon juveniles grow faster than smaller juveniles in years of limited food supply, suggesting that large juveniles forage more successfully than smaller juveniles (BPA Project 1998-014-00).

- Model-based studies at the University of Washington continue to explore factors effecting salmon survival during marine residence. Recent analyses indicate that smolt size at the time of ocean entry, marine predatory fish abundance and size, and PDO are important explanatory variables.

- Research indicates that densities and biomass of invertebrates

preyed on by salmon were consistently higher in areas of emergent vegetation compared to open water habitats in the estuary. Estuary habitat actions that restore and improve shallow water habitat and emergent vegetation benefit a variety of salmon stocks at different times of the year by increasing the availability of food and refuge (Diefenderfer et al. 2013).

- Studies indicate that avian predation outside the mouth of the Columbia River (by common murres, sooty shearwaters, and other species) affects early marine survival of juvenile salmon; predation risk is highest in the plume near the river mouth relative to other reaches in the estuary. Predation risk by Caspian terns and double-crested cormorants is influenced by river discharge and the presence of alternative prey such as northern anchovy in the near shore, ocean environment (Harnish et al. 2012).

Harvest RME

In 2013, harvest investigations linked to FCRPS interests included feasibility studies for Zone 6 harvest PIT tag recoveries to help refine upstream adult survival rates. Selective fishing methods and gear were evaluated. Support was continued for coded-wire tagging and recovery operations needed to assess the survival, straying, and harvest rates of specific hatchery fish stocks. Further work was advanced on genetic stock identification techniques.

Significant Results

- The Action Agencies continued to fund the development and implementation of selective fishing gear for harvesting anadromous salmon and steelhead in the Columbia and Okanogan rivers (BPA Project 2008-105-00).
- In 2013, the Colville Confederated Tribe select harvest yielded a total of 8,035 salmon and steelhead (BPA Project 2008-105-00). This study also showed that purse seines are an effective management tool for harvest with very minimal immediate mortality due to handling and release techniques in the upper Columbia and Okanagan rivers and Lake Osoyoos.
- Uncertainty exists regarding whether high observed survival from immediate release techniques for the selective fishery equates to high long-term survival and spawning success resulting from the use of selective fishing techniques (BPA Project 2008-105-00).
- Techniques for the genetic monitoring of stocks have made considerable headway toward identifying markers associated with adaptive traits such as anadromy as well as distinguishing hatchery from wild stock. These improved techniques will allow for more effective monitoring of hatchery and wild fish (multiple BPA Projects, see Section 2 RPA sub action 62.5).
- Harvest managers were able to collect PIT tag data from commercial catch in 2013, thus improving interrogation techniques and better informing harvest managers of stock composition of catch and impacts by gear (BPA Projects 2008-502-00 and 2010-036-00).
- Purse seines are an effective management tool for harvest with very minimal immediate mortality due to handling and release techniques in the upper Columbia and Okanagan rivers and Lake Osoyoos (BPA Project 2008-105-00). The transfer of fishing gear technology may be feasible for other fishing areas within the Columbia River Basin. BPA has identified this potential for transferring gear technology due to requests BPA has received from other tribes to utilize similar techniques.

Hatchery RME

Hatchery RME in 2013 included project implementation monitoring, status and trend monitoring, action effectiveness research, and critical uncertainty research. Project implementation monitoring tracks the performance of hatchery production and progress regarding implementation of best management practices (e.g. fish rearing practices) and hatchery reform efforts. Status and trend monitoring tracks Viable Salmonid Populations (VSP) parameters, such as abundance and productivity, spatial structure, and genetic diversity of hatchery and hatchery influenced natural populations. Action effectiveness research assesses how hatchery reform actions affect the viability parameters of hatchery and natural fish populations. Critical uncertainty research investigates the factors and mechanisms affecting fish viability parameters and Relative Reproductive Success (RRS) studies evaluate the productivity of hatchery fish spawning in the wild relative to the natural fish.

Significant Results

- In general, RRS studies have found that hatchery-origin fish reproduce at a lower rate than naturally produced fish (see Section 2 RPA Action 64). In a couple of projects (e.g., Chinook in Johnson and Catherine creeks)

(BPA Projects 1996-043-00 and 1989-096-00, respectively), hatchery-origin fish reproduced at similar rates when measured at the parr/migrant juvenile life stage, but at lower rates for hatchery fish when measured by returning adult offspring. The causes (mechanisms) for lower relative reproductive success of hatchery-origin fish spawning in the wild are being investigated. One study showed high density rearing in the hatchery environment may contribute to lower RRS in steelhead (Hood River, BPA Project 2003-054-00). Another study in the Wenatchee River showed that differential spawning locations for hatchery versus natural origin fish appears to be another factor (BPA Project 2003-039-00).

- Many studies continue to observe a general reduction in smolts-per-spawner at higher spawner numbers, indicating a density dependent relationship. Information on density dependent effects on juvenile production will assist managers in setting levels of hatchery releases (BPA Projects 1992-026-04 and 1998-007-02).

- One hatchery reform study determined that steelhead juveniles released later (typically in early April) survived downstream to Lower Granite Dam at a significantly higher rate. Further, adult returns were higher for fish released later as juveniles. These results prompted a recommendation to modify the time at release of brood year 2011 supplementation juveniles to a later period (April 1-2). The subsequent survival in 2013 (as assessed by 2,000 PIT tagged fish) was 57 percent, which was the highest survival recorded over the course of the project (BPA Project 2010-050-00).

- Hatchery reform research is investigating whether raising steelhead juveniles for two years instead of the usual one year in the hatchery increases the likelihood that their survival and reproductive success will be similar to that of naturally produced fish. Preliminary results suggest juvenile survival through the hydrosystem varies between years and is positively correlated to size for both groups, but survival and travel time between release and Bonneville Dam is generally faster for fish raised for two years (BPA Project 1993-056-00).

- Hatchery reform research is seeking to better understand how growth and maturation of juvenile hatchery fish affect their subsequent life-history traits. Previous findings show there is a higher rate of early maturation in hatchery fish than in natural origin fish. Results indicate that increased growth rates during certain rearing periods is one contributor of early maturation of primarily male juvenile fish (i.e. jacks and "mini-jacks"). One recent finding indicates there is a difference in "mini-jack" rates between isolated and integrated spring Chinook salmon hatchery programs, with isolated programs having a lower proportion of early maturation. Researchers hypothesize that domestication selection in segregated hatchery programs reduces the likelihood of early male maturation in spring Chinook salmon (BPA Projects 1988-053-03, 2002-031-00).

- Another finding from implementing reform actions involves the use of local broodstock, such as the Tucannon River steelhead supplementation program (BPA project 2010-050-00). The primary purpose of using local broodstock is to improve return rates to natal tributaries and reduce the genetic influence of out-of-basin stocks and genetic introgression that could reduce the viability of naturally produced populations.

- Preliminary results for reconditioning kelts suggest that in summer steelhead, fecundity increased in repeat spawnings. Fertilization rates as well as juvenile growth measures were similar between maiden and repeat spawnings. In addition, preliminary Parental Based Tagging results reveal that reconditioned fish that are released to spawn naturally are contributing to improved adult returns (BPA Project 2007-401-00).

- Many of the hatchery evaluation projects continue to collect the VSP parameters; abundance, productivity, spatial structure and diversity for both natural- and hatchery-origin fish. VSP parameters are indicators of the status of a natural population. VSP information is provided to NOAA Fisheries to assess population viability for obligations under the ESA. In addition, measures of freshwater survival (egg-emigrant) assist other researchers in understand the effects of habitat restoration projects (see Section RPA Actions 63 and 64 for project lists).

- After three generations of study, Yakima Hatchery research results demonstrate that a well-

designed and carefully managed integrated hatchery program using 100 percent natural-origin broodstock can produce fish for harvest and return fish to the natural spawning grounds with minimal negative impacts to the target ecosystem (BPA Project 1995-063-25).

- Results of the Klickitat steelhead monitoring program indicate low levels of genetic introgression between hatchery and wild steelhead along with some differences in spatial and temporal distribution have led managers to adjust artificial production plans (BPA Project 1995-063-35).

- Parental based tagging (genetic tracking) is continuing to show success in determining the proportion of hatchery-origin fish on spawning grounds (BPA Project 2010-031-00).

- All projects continue to collect status and trend monitoring information on life stage survival within the hatchery and other information, such as disease occurrence, tagging rates, and numbers released (see RPA sub-actions 50.6, 63.1 and 64.2). This information helps ensure compliance with hatchery biological opinions and has potential to help improve hatchery best management practices.

Predation and Invasive Species Management RME

Predation RME studies were conducted to evaluate and monitor the northern pikeminnow management results, avian predation rates on juvenile salmon in the lower Columbia River and on the Columbia Plateau, and predation rates of California sea lions on adult salmon below Bonneville Dam. Action Agency management plans to address predation on juvenile salmon and steelhead and predator management projects also continued to include monitoring components to assess action effectiveness.

Significant Results

- Northern pikeminnow RME is conducted to measure interspecific compensation (small mouth bass and walleye responses) and intraspecific compensation (increased growth rate, fecundity, age-class recruitment in the remaining northern pikeminnow population) to see if there are any responses that offset the benefits we see from the Northern Pikeminnow Sport Reward Fishery Program (BPA Project 1990-077-00).

- Predation by northern pikeminnow is being successfully controlled, with significant ongoing salmon survival benefits. 2013 was the last year of studies to examine predation by non-native species, such as shad, walleye, and bass. Management of non-native species predation in waters that fall under the jurisdiction of different states, such as the mainstem Columbia and Snake rivers, may conflict with some state management of exotic warm-water game species (walleye, largemouth and smallmouth bass, northern pike, catfish, etc.) for sport fisheries. The Action Agencies note the recent consideration by the Washington Fish and Wildlife Commission to remove the daily catch limit for channel catfish and the daily catch and size limits for bass and walleye in portions of the Columbia and Snake rivers to reduce impacts on listed salmon and steelhead stocks. The Action Agencies will proceed with sensitivity to other management jurisdictions through well-designed basic research within this topic area (BPA Project 1990-077-00).

- The Corps continued to monitor the effectiveness of predation management efforts on sea lions in the tailrace of Bonneville Dam. SLEDs continue to be effective at keeping sea lions from entering fishways. As in past years, hazing efforts moved some sea lions out of tailrace areas, but the animals typically returned shortly after hazers left the area.

- The multiyear index for estimating system-wide exploitation on northern pikeminnow greater than or equal to 250 mm fork length was calculated as 10.8 percent. The 2013 estimate was near the lower end of the range necessary to achieve project goals (BPA Project 1990-077-00).

- A suite of avian studies continue to document predatory bird abundance, distribution, and movement patterns in the Columbia Basin. Tern populations have been decreasing in size, but nesting success has increased at some locations, whereas at East Sand Island nesting success has decreased over the decade. Cormorant populations have expanded and continue to have a major impact on juvenile salmon. System-wide, gulls have a minor impact on juveniles (see RPA Actions 66, 67 and 68 in Section 2).

- In 2013, the Action Agencies monitored the colony size, reproduction rates, diet composition and predation rates of Caspian tern and double-

crested cormorant colonies on East Sand Island. They also monitored select Caspian tern and gull colonies on the Columbia Plateau. Results are presented under Predator Management, above (see also RPA Actions 66 and 67).

- The Action Agencies continued to fund research and monitoring on shad interactions with non-indigenous predators (small mouth bass and walleye) to understand the effect of those interactions on predator over-wintering survival. The concern is that shad may act as a prey base to sustain juvenile salmon and steelhead predator populations into the fall or buffer juvenile fall Chinook salmon as they are outmigrating (BPA Project 2008-719-00).

Regional Coordination, Data Management and Implementation

Federal, state and tribal partners work together to standardize and integrate their data collection and management efforts. This improves efficiencies and accessibility and exchange of data and allows for synthesis, or "roll up" of data that can identify trends and opportunities at the regional level.

Significant Results

- In 2013, the Pacific Northwest Aquatic Monitoring Program (PNAMP) Integrated Status and Trend Monitoring (ISTM) Habitat Data Sharing (HDS) work was summarized into a report, available on PNAMP's web page at http://www.pnamp.org/document/4266. The report established a crosswalk for operation of data collection methods and metrics for nine states, and Federal and Tribal monitoring programs.

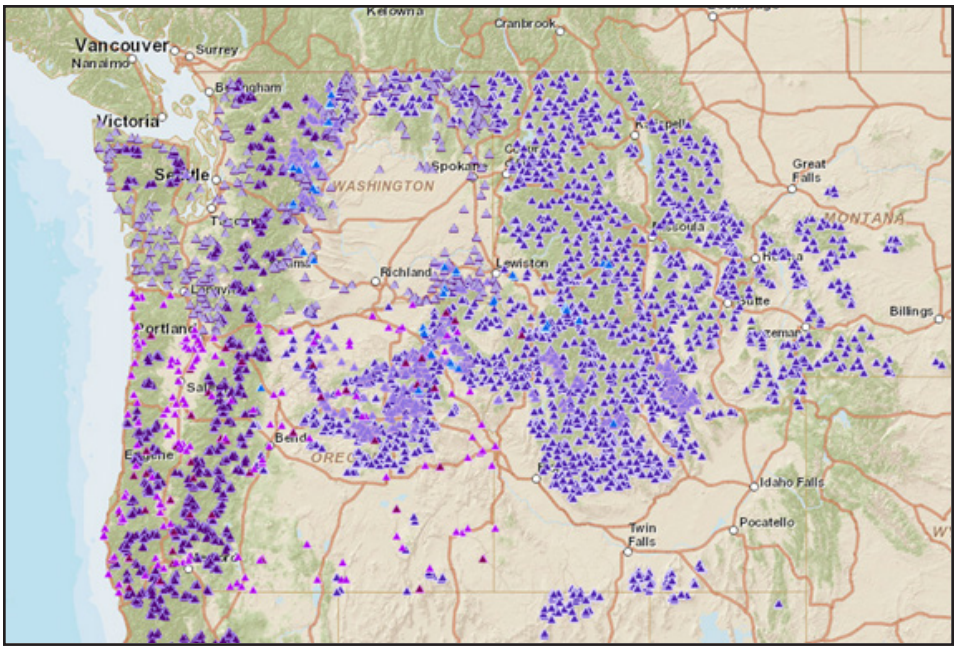


Figure 47. Monitoring Explorer tool: map of monitoring sites and links to data systems.

- The Coordinated Assessments process, facilitated by PNAMP, continued to make progress on standard management and exchange of regional fish data. In addition to ongoing progress on VSP metrics, five important hatchery indicators (juvenile production, adult production, proportion of hatchery-origin spawners, percent of strays by origin, and proportionate natural influence) were added to the regional coordination effort. These standard hatchery performance metrics will support prioritization of study requests and help guide hatchery operations and management (BPA Project 2004-002-00).

- OBMEP continued improving internal data management systems to collect data more efficiently, with fewer opportunities for human error, and improved capacity for sharing data in an automated, web-based format (BPA Project 2003-022-00).

- Major improvements to data access and storage have improved timely assessment of findings and regional cooperation. PNAMP advancement of monitoring access and documentation tools are providing significant, increased support to coordination and data sharing (Figure 47) (BPA Project 2004-002-00).

- Standardization of data collection methods and data entry forms and use of handheld data recording tools have improved the timeliness of data access and sharing of results.

Working with the Region

Regional Forum

The Regional Forum process was developed in 1995 and has been employed since by NOAA Fisheries, the Action Agencies and other Federal agencies, and regional sovereigns to implement ESA provisions for protection of listed salmon species. Members of the Regional Forum include state and tribal sovereigns with management authority over fish and wildlife resources and water quality in the Columbia River Basin and federal agencies with regulatory or implementation authority in the Columbia River, including NOAA Fisheries, USFWS, BPA, Corps, Environmental Protection Agency, and Reclamation. Other agencies and regional interests, such as the Northwest Power and Conservation Council (NPCC), the Idaho Power Company and the mid-Columbia Public Utility Districts, also participate. The Regional Forum consists of the Regional Implementation Oversight Group (RIOG), and several technical workgroups, including the TMT, the System Configuration Team, the Studies Review Work Group, and the Fish Passage Operations and Maintenance Workgroup. As used in this document, "the region" or "regional coordination" generally refers to the Regional Forum technical subgroup appropriate for the issue at hand.

Regional Implementation Oversight Group

The RIOG was established in 2008 to provide sovereign policy review for the Columbia River Basin, bringing together Federal, State, and Tribal agencies with the common aim of salmon protection to discuss and coordinate implementation of the BiOp. The RIOG structure includes technical subgroups (e.g., the TMT) to support regional review. Through this structure, RIOG explores the issues relevant to the effects of the FCRPS on ESA-listed species and ensures that the new and emerging scientific data are identified, reviewed, and available to inform the agency decisions. In 2013, the Action Agencies met with RIOG on five occasions to discuss, review, and coordinate on the Fish Operations Plan, performance standards test results, supplemental documents, the 2013 Comprehensive Evaluation and the 2014-2018 Implementation Plan.

Columbia Basin Fish Accords

Celebrating five years of successful implementation in 2013, the historical Columbia Basin Fish Accords have established long term agreements among the Action Agencies and the Confederated Tribes of the Warm Springs Reservation of Oregon, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes and Bands of the Yakama Nation, the CRITFC, the Confederated Tribes of the Colville Reservation, the Shoshone-Bannock Tribes of Fort Hall, and the States of Idaho, Washington, and Montana. The Fish Accords strengthen the successful planning and implementation of actions under the BiOp, especially tributary and estuary habitat actions. These partnerships help accomplish "on-the-ground" implementation of actions that are beneficial to listed fish.

Northwest Power and Conservation Council Fish and Wildlife Program

Under the Northwest Power Act, the NPCC works to protect and mitigate Columbia River Basin fish and wildlife and their related spawning grounds and habitat that have been affected by hydropower development. The NPCC's Columbia Basin Fish and Wildlife Program guides BPA's funding and must be taken into account by all Federal agencies that manage, operate, or regulate hydropower dams in the basin. The program includes independent science review processes that apply to BPA funded projects. The Act calls for the NPCC to review the Program every five years. In 2013, the NPCC began a regionwide process to review the 2009 Program, which it expects to finalize late in 2014. The 2009 program can be found at: http://www.nwcouncil.org/library/2009/2009-09/Default.asp.

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Abbreviations and Acronyms

AEM	action effectiveness monitoring
BiOp	FCRPS Supplemental Biological Opinions
BPA	Bonneville Power Administration
CHaMP	Columbia Habitat Monitoring Program
c.i.	confidence interval
COMPASS	Comprehensive Fish Passage
Corps	United States Army Corps of Engineers
CRE	Columbia River Estuary. Also refers to numeric designators for different restoration action types as assigned in NOAA Fisheries' Estuary Recovery Module
CRITFC	Columbia River Inter-Tribal Fish Commission
DPS	distinct population segment
DEIS	draft environmental impact statement
EDT	ecosystem diagnosis and treatment
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FCRPS	Federal Columbia River Power System
GSI	genetic stock identification
kcfs	thousand cubic feet per second
HGMP	Hatchery and Genetic Management Plan
IMW	intensively monitored watershed
ISEMP	Integrated Status and Effectiveness Monitoring Program
KMP	Kelt Management Plan
MAF	million acre feet
MPG	major population group
NMFS	National Marine Fisheries Service (also known as NOAA Fisheries)
NPCC	Northwest Power and Conservation Council
NPMP	Northern Pikeminnow Management Program
NTSA	non-Treaty storage agreement
NWFSC	Northwest Fisheries Science Center
OBMEP	Okanogan Basin Monitoring and Evaluation Program
ODFW	Oregon Department of Fish & Wildlife
PDO	Pacific Decadal Oscillation
PIT	passive integrated transponder
PNAMP	Pacific Northwest Aquatic Monitoring Program
PTDS	PIT tag Tributary Detection System
Reclamation	Bureau of Reclamation
RIOG	Regional Implementation Oversight Group
RME	research, monitoring and evaluation
RPA	Reasonable and Prudent Alternative
RRS	relative reproductive success
SBU	salmon benefit unit
SLED	sea lion exclusion devices
TDG	total dissolved gas
TMT	Technical Management Team, a technical subgroup of RIOG
USDA	United States Department of Agriculture
VSP	viable salmonid population
WDFW	Washington Department of Fish & Wildlife
WMP	Water Management Plan
WSF	water supply forecast