Endangered Species Act

Federal Columbia River Power System

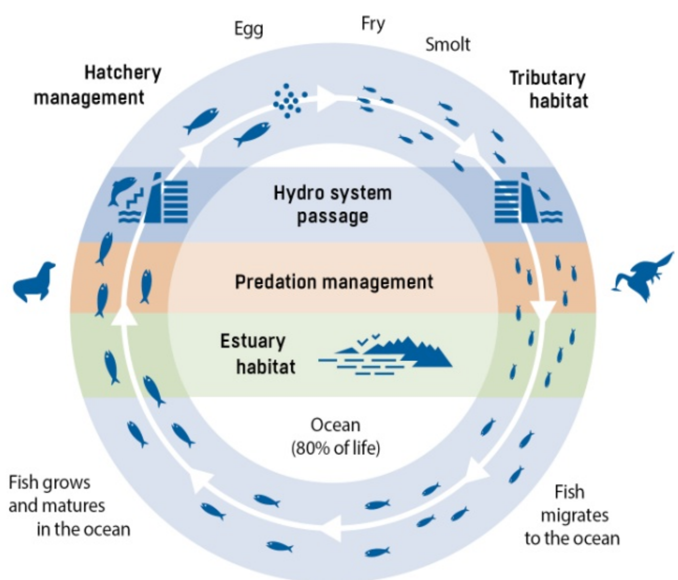
2016 Comprehensive Evaluation – Section 1

JANUARY 2017

Throughout the Columbia River Basin, tribal, state, local, and federal entities are working in partnership to protect and restore stocks of salmon and steelhead. The Columbia River Basin supports 13 Evolutionarily Significant Units (ESUs) or Distinct Population Segments (DPSs) of salmon and steelhead listed under the Endangered Species Act (ESA) as threatened or endangered (Figure 1). These species have been affected over time by harvest, changing environmental conditions, a growing human population with attendant pressures on water resources, and the operation of the Federal Columbia River Power System (FCRPS).

This 2007-2015 Comprehensive Evaluation (CE) provides a cumulative report of progress in carrying out the salmon and steelhead conservation actions included in the National Oceanic and Atmospheric Administration – Fisheries (NOAA Fisheries) 2008 Biological Opinion and 2014 Supplemental Biological Opinion (BiOp) for the operation of the FCRPS. The FCRPS BiOp reflects an extensive effort by the Action Agencies - The Bureau of Reclamation (Reclamation), the U.S. Army Corps of Engineers (Corps), and the Bonneville Power Administration (BPA), in partnership with regional federal agencies, states and tribes - to protect and improve listed species of Columbia and Snake River salmon and steelhead and their designated critical habitat. As a result of the efforts of the Action Agencies and other stakeholders, most populations that suffered severe declines in the past have stabilized and increased.

The Action Agencies are on track to complete the improvements described in the FCRPS BiOp. The core actions include operation and configuration improvements at the 14 federal dams to increase salmon and steelhead survival as they migrate through the system. Testing so far indicates that these improvements are increasing survival as projected. Examples include the addition of surface passage systems which take advantage of juvenile salmon's surface-oriented migration behavior to safely pass fish at dams, and upgraded juvenile bypass systems that improve fish survival. Hundreds of habitat improvements have been completed, and more are underway across the Columbia River Basin tributaries and in the estuary. These actions are guided by the best available science and professional judgment of expert biologists with the most up-to-date knowledge of the limiting factors affecting fish habitat. Habitat actions include reconnecting floodplain habitat and protecting it



All-H Problems – All-H Solutions

Contents – Section 1

with permanent conservation easements, breaching dikes and levees to restore habitat, and other long-term projects that are now showing results. An extensive program of research, monitoring and evaluation allows for adaptive management by assessing the benefits of the FCRPS BiOp actions for listed fish and providing insight into how to make those actions most effective. Syntheses of the findings from the monitoring and evaluation actions support the adaptive management provisions of the FCRPS BiOp calling for the Action Agencies to learn as they go and adjust their actions to address new information.

The Action Agencies have not performed the work described in this report alone. Federal, state, tribal and local partner agencies and organizations have lent their energy and expertise to plan and complete many of the hundreds of BiOp actions outlined in this report. Their involvement makes this a true regional effort. The Columbia Basin Fish Accords demonstrate the regional nature of this effort. These agreements – first signed in 2008 and since expanded – have brought together three federal agencies, six Northwest Indian tribes, the Columbia River Intertribal Fish Commission, and three of the four Northwest states in a sweeping effort to protect and strengthen the basin's threatened and endangered salmon and steelhead populations. The Fish Accords provide dedicated funding

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over ten years to support the Action Agencies and their regional partners in implementing work for fish (and wildlife) and their habitats, and that work will continue to provide measurable benefits for salmon and steelhead in years to come.

The FCRPS BiOp is an important element of a larger regional effort to conserve and restore Columbia River Basin salmon and steelhead and the ecosystems that support them under the Endangered Species Act and the Northwest Power Act. This includes a suite of additional NOAA BiOps addressing the effects of other federal actions on salmon and steelhead in the Basin, including federal land management, in-river harvest, ocean harvest, hatcheries, water quality standards, floodplain management, and toxics. It also includes additional BiOps with the United States Fish and Wildlife Service addressing bull trout and Kootenai River white sturgeon. And it includes broad actions being implemented by federal agencies and non-federal dam owners under the Northwest Power Act, including actions that protect and enhance non-listed salmon and steelhead, resident fish, and wildlife. From an ecosystem perspective, the Action Agencies alone are funding a multitude of actions to benefit both fish and wildlife each year. Funding is provided by the electric ratepayers of the FCRPS, with additional funding provided to meet non-power project purposes, such as flood risk management and navigation, through Congressional appropriations.

In 2016, the United States District Court for the District of Oregon found deficiencies in the current salmon and steelhead BiOp and ordered further consultation on remand to complete a new BiOp by December 31, 2018. The Court acknowledged that the current BiOp provides some protection for listed species, however, and ordered the Action Agencies to continue to fund and implement the 2014 Supplemental BiOp until the new BiOp is prepared and filed. The preparation of this CE is one action in the existing BiOp's Reasonable and Prudent Alternative (RPA) and addresses the Action Agencies' ongoing commitment to implementation of that existing BiOp. It also provides a foundation for the development of future actions for the next ESA consultation.

This report includes a detailed description of implementation progress by the Action Agencies during the period of January 1 through December 31, 2015, with additional information from previous reports to provide some cumulative and contextual information, as well as information from implementation efforts in 2016 available at the time of this report.

Actions described in this report include improvements made at dams to facilitate safe adult and juvenile fish passage, increase fish survival, protect and enhance important habitats, improve hatchery practices, manage and reduce predation, and enhance river conditions for migrating fish. The actions are designed to achieve biological performance standards and programmatic performance targets and address key limiting factors for listed salmon and steelhead.

This report is organized into two sections: Implementation highlights and accomplishments are presented in Section 1; these will inform continued RPA action implementation and provide the foundation for new proposals. Section 2 provides a summary of progress on RPA implementation by action and a comparison to scheduled completion dates, as identified in the RPA or modified in the 2009 or 2013 Implementation Plans.

This FCRPS 2016 Comprehensive Evaluation, as well as the previous Comprehensive Evaluation and Implementation Plans, previous years' annual progress reports, and additional information on other salmon and steelhead protection efforts are available online at:
http://www.salmonrecovery.gov/BiologicalOpinions/FCRPSBiOp/ProgressReports.aspx.

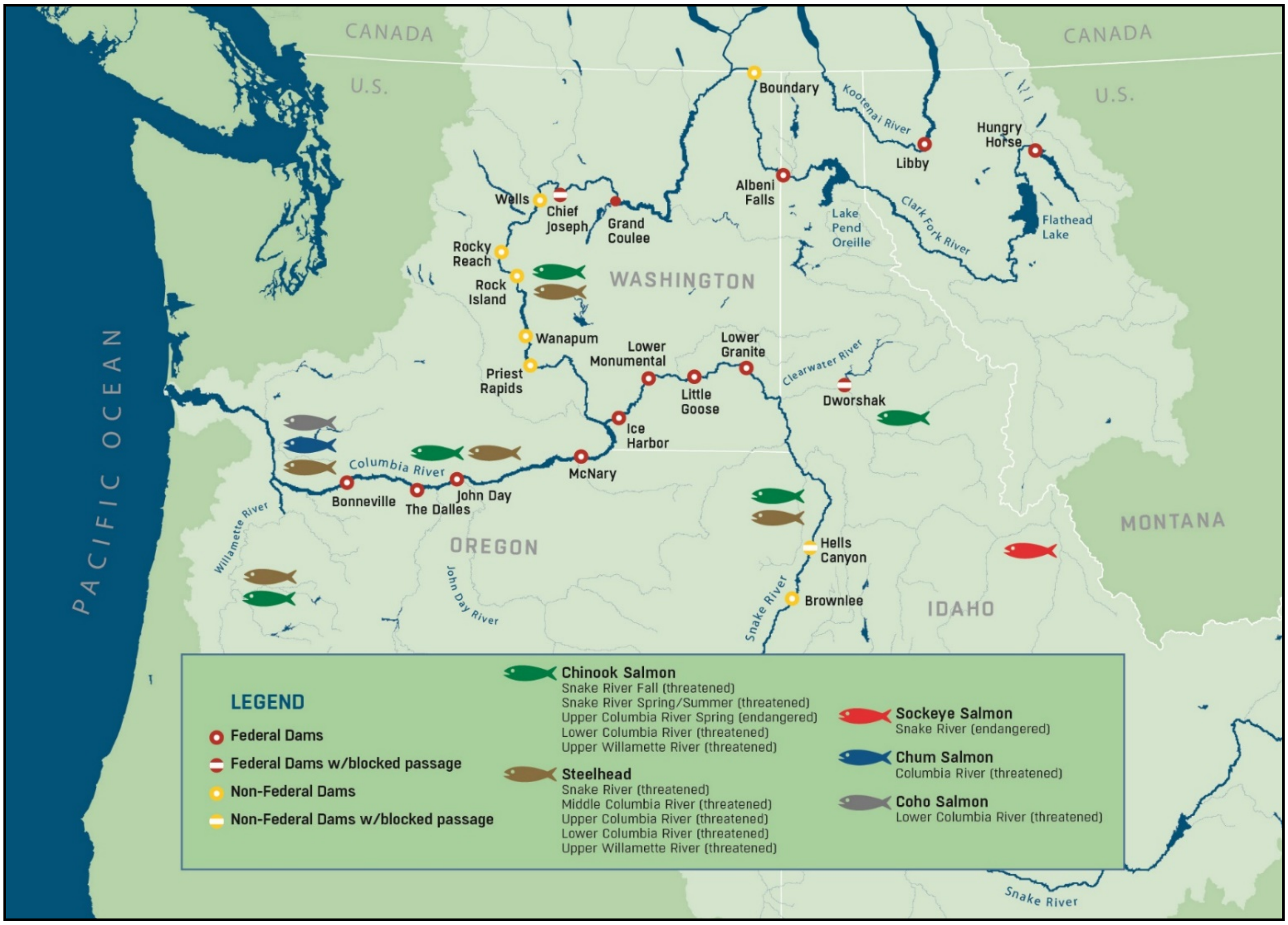


Figure 1. Map of the Columbia River Basin showing action areas, dams, and listed species.

2015 Fish Status and Environmental Conditions

Fish Status

Columbia River Basin salmon and steelhead have been adversely affected by well over a century 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, and 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 adult fish counting stations where annual index tallies are made of the various species as they swim up the fish ladders. In 2015, more than 2.27 million salmon and steelhead were counted as they passed Bonneville Dam, after ocean and lower river harvest. The total count includes both listed and non-listed salmon, both natural-origin and hatchery-origin fish, and both adults and approximately 120,000 jacks, which are young males that mature and return to spawning grounds earlier than others in their age class. The 2.27 million returning fish is the second-highest since counting began in 1938, exceeded only by the count in 2014. 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 hatchery fish are also part of listed ESUs/DPSs. The 2015 total count exceeded the 1938-2000 historical average and the more recent 10-year average (Figure 2).

Counts in 2015 of adult salmon and steelhead passing Bonneville Dam varied by species. The returns of steelhead and of chum and non-native pink salmon were somewhat below 10-year averages (Table 1). Coho were only about one-third of the 10-year

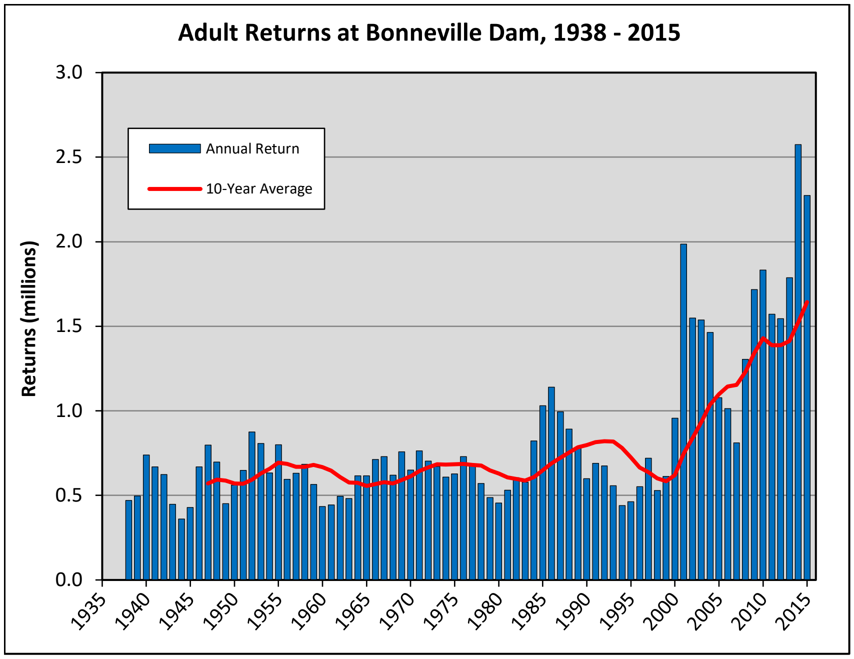


Figure 2. Salmon and steelhead returns at Bonneville Dam, 1938 to 2015. Values shown are for daytime counts, and include both hatchery and natural-origin fish, and both adults and jacks. Harvest levels below Bonneville Dam have varied over time. (Data from ACOE 2016.)

Table 1. Adult salmon and steelhead returns at Bonneville Dam: 2015 returns and 10-year average. These numbers include hatchery and natural-origin fish. Chinook and coho numbers include jacks.

Species	2015 Returns	10-year average
Chinook – Total	1,450,683	876,358
Spring Chinook	233,794	171,288
Summer Chinook	179,465	117,335
Fall Chinook	1,037,424	587,736
Steelhead	268,730	347,762
Sockeye	510,706	285,126
Coho	42,267	133,262
Chum	176	120
Pink	55	459
TOTALS of all species	2,272,617	1,643,084

Period of 10-year average 2006–2015.
Data are for daytime counts – 0400 to 2000 PST.
All data are from ACOE 2016, Table 22b, *except* Chinook data are from Table 23, and 10-year average values have been corrected.
Chinook run dates used here are:
Spring = Jan 1–May 31;
Summer = June 1–July 31;
Fall = Aug 1–Dec 31

average and far below the record run of 2014, reflecting poor ocean conditions for juvenile coho that entered the ocean in 2014 and returned as adults in 2015. In contrast, the total Chinook salmon count at Bonneville was the highest since counting began in 1938, dominated by a fall Chinook salmon run of just over one million fish, while spring and summer run counts were also among the highest recorded. These Chinook salmon numbers reflect the ocean conditions experienced by juveniles entering the ocean in 2012 and 2013, which were considerably better than the conditions in 2014. The sockeye salmon run was the third highest since counting began, behind only 2014 and 2012. However, in 2015 most sockeye failed to reach their spawning grounds due to a period of high ambient air, tributary, and mainstem river temperatures throughout the Columbia Basin that coincided with the peak of the run. For further information on 2015 adult sockeye survival, refer to the Overview by Species status section below.

Overview by Species

The following summaries describe abundance and abundance trends at the species or ESU/DPS level. Species-level status is determined based on a "rolled up" review of population-level status and includes consideration of abundance, as well as the productivity, spatial structure, and diversity attributes of viable salmon and steelhead populations.

Species-level abundance is an important indicator under the ESA and the NOAA Fisheries 2014 FCRPS Supplemental BiOp. The BiOp includes abundance and trend-based indicators intended to signal if significant declines are occurring at the ESU/DPS level. A significant decline is judged to occur when the running four-year average 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. 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)[1]. 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. An estimated 85 percent of the ESU's historical spawning habitat was lost as a result of construction of Swan Falls Dam in 1901 and the Hells Canyon complex in 1958–1967, which blocks all fish passage.

The most recent 10-year average return of natural-origin fish (through 2015) is estimated to be 10,609 adults. The most recent four-year average return is 16,515 adults (Figure 3). An analysis of adult returns from 1990–2015 indicates that the ESU-level trend in

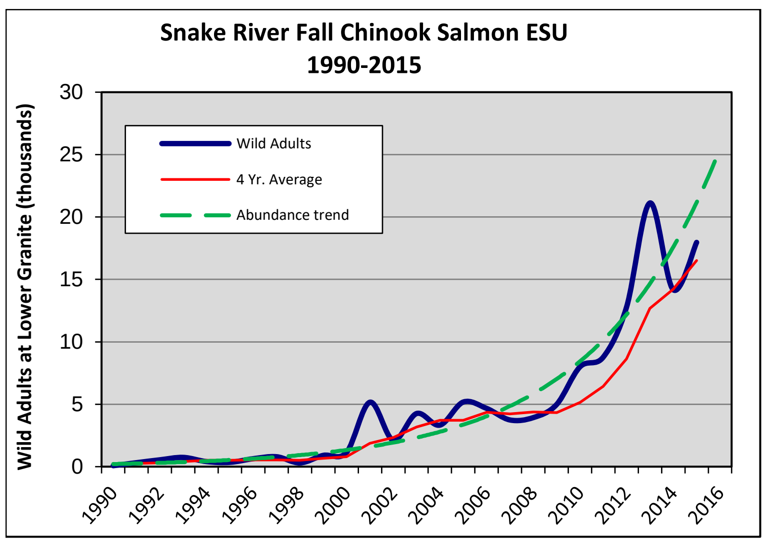


Figure 3. Returns of natural-origin adult Snake River Fall Chinook salmon at Lower Granite Dam, 1990–2015. The ESU-level trend in abundance was positive during this period.

[1] *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 were developed by the Yakama Tribe and reported on Columbia River Data Access in Real Time at* http://www.cbr.washington.edu/dart/*, and Upper Columbia Steelhead numbers, which were developed by the Washington Department of Fish and Wildlife (WDFW) and reported 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).*

abundance was positive during this period. Neither the Early Warning Indicator nor the Significant Decline Trigger for this ESU were tripped in 2015.

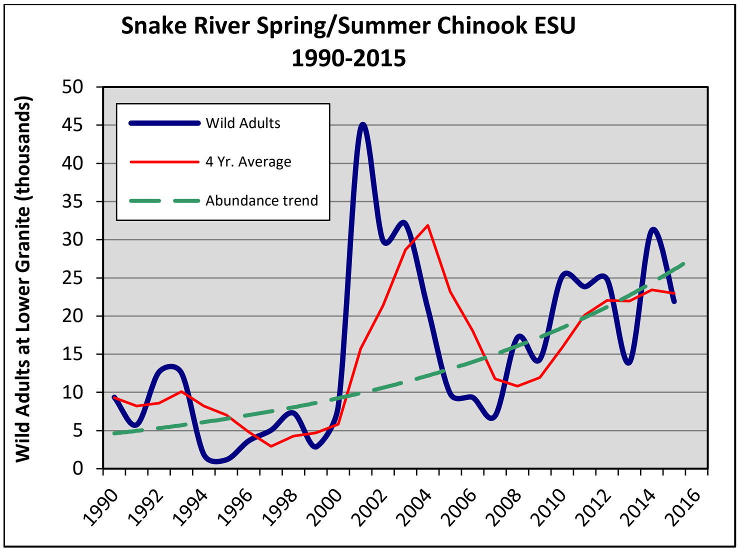


Figure 4. Returns of natural-origin adult Snake River spring/summer Chinook salmon at Lower Granite Dam, 1990–2015. The ESU-level trend in abundance was positive during this period.

Snake River Spring/Summer Chinook Salmon

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 18,864 adults. The most recent four-year average return was 22,966 adults (Figure 4). An analysis of adult returns from 1990–2015 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 2015.

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 further improve ESU numbers.

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 2008–2011 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, increasing again in 2014 and declining in 2015; the most recent 10-year average was 1,072 adult fish and the most recent four year average return was 1,107 fish.

In 2015, an estimated 4,069 Snake River sockeye passed Bonneville Dam. With a low snowpack and record-setting air temperatures in June and July throughout the Columbia River Basin, water temperatures in the lower Columbia and lower Snake rivers were well above the range sockeye normally migrate through. This resulted in high mortality levels; only 1,052 adult

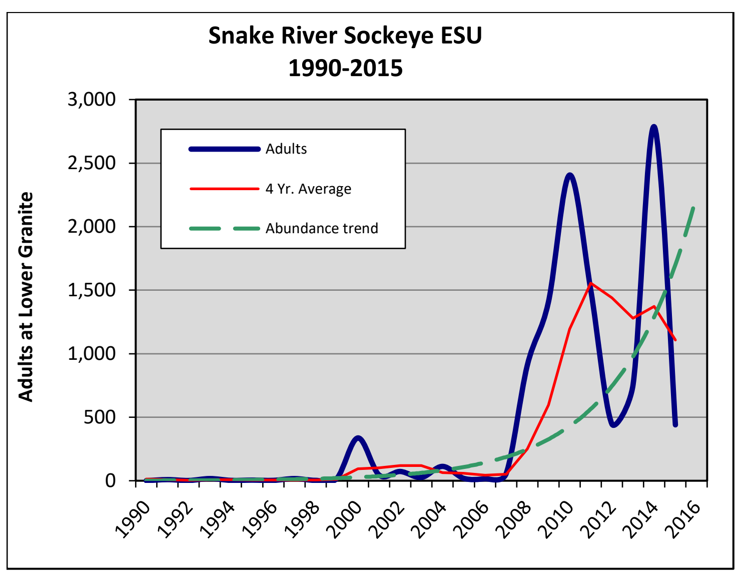


Figure 5. Returns of all Snake River sockeye salmon at Lower Granite Dam, 1990–2015. The ESU-level trend in abundance was positive during this period.

sockeye were counted at Ice Harbor Dam, and 440 were counted at Lower Granite Dam. Of those 440, 51 were collected at the dam and transported to the hatchery at Eagle, Idaho, for use in the captive broodstock program.[2] Of the fish remaining in-river, 56 successfully made the journey to the Sawtooth Valley (NOAA Fisheries 2016). Those in-river fish, along with the captive broodstock, will ensure that the hatchery release target will be met in 2017.

Snake River Steelhead

The Snake River steelhead DPS was listed as threatened in 1997. The DPS is comprised of 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.

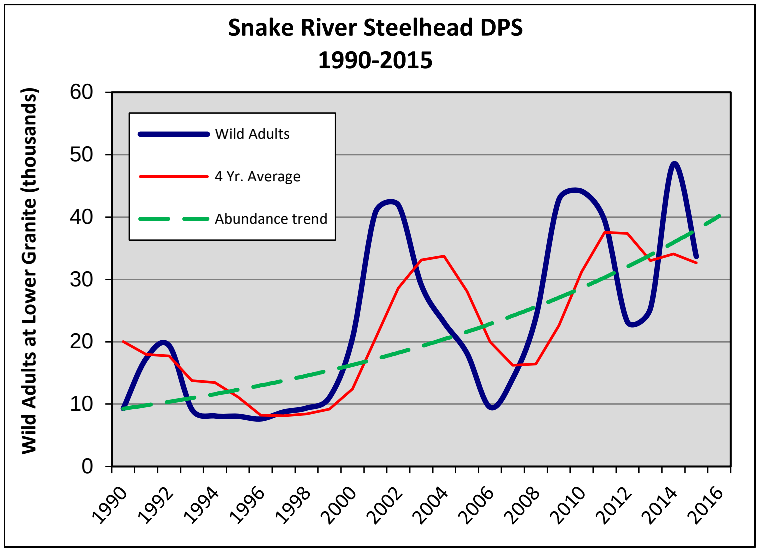


Figure 6. Returns of natural-origin adult Snake River steelhead at Lower Granite Dam, 1990–2015. The DPS-level trend in abundance was positive during this period.

The most recent 10-year average return of natural-origin Snake River steelhead was 30,452 adults (2006-2015). The most recent four-year average return was 32,663 adults (Figure 6). An analysis of adult returns from 1990–2015 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 2015.

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 2,354 adults at Rock Island Dam (2006-2015). The most recent four-year average return was 3,967 adults (Figure 7). An analysis of adult returns from 1990–2015 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 2015.

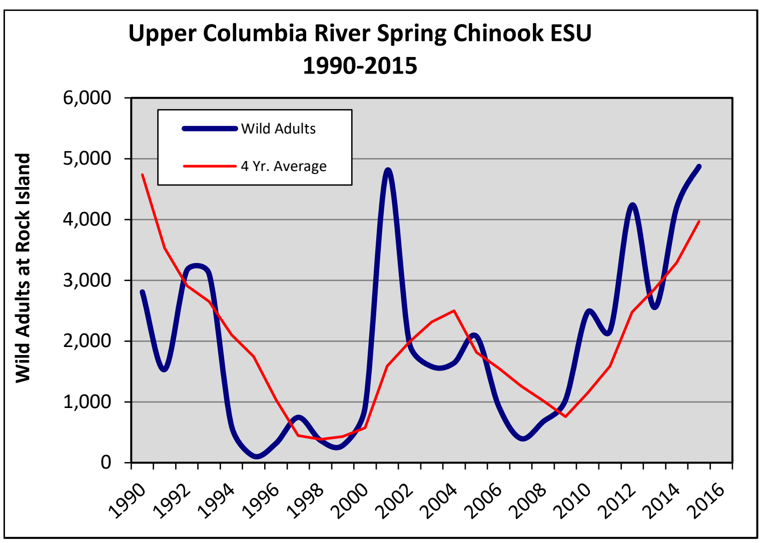


Figure 7. Returns of natural-origin adult Upper Columbia River spring Chinook salmon at Rock Island Dam, 1990–2015. An analysis of adult returns from 1990 to 2015 indicates that there was no statistically significant ESU-level trend in abundance during this period.

[2] *Genetic testing of the adult sockeye collected at Lower Granite Dam revealed that about 30 percent were actually from the upper Columbia River area. If that ratio applies to all the fish counted at Lower Granite, then approximately 310 of the 440 fish counted were actually Snake River sockeye.*

Upper Columbia River Steelhead

The Upper Columbia River steelhead DPS was listed as endangered in 1997 but was reclassified as a threatened species in 2009 consistent with a court ruling. 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 the Yakima River.

The most recent 10-year average return of natural-origin Upper Columbia River steelhead was 4,209 adults (2006–2015). The most recent four-year average return was 4,792 adults (Figure 8). An analysis of adult returns from 1990–2015 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 2015.

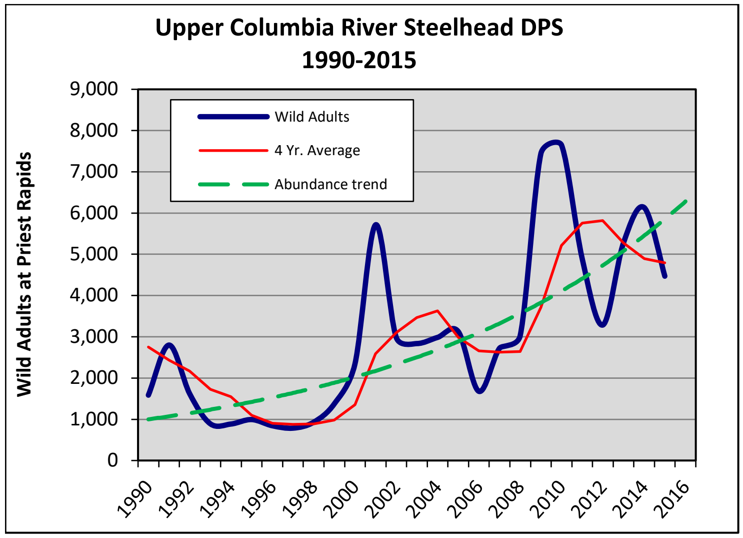


Figure 8. Returns of natural-origin adult upper Columbia River steelhead at Priest Rapids Dam, 1990–2015. The ESU-level trend in abundance was positive during this period.

Middle Columbia River Steelhead

The Middle Columbia River steelhead DPS was listed as threatened in 1999. The DPS comprises 17 individual populations in four 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.[3]

Due to the difficulty in obtaining estimates of DPS-level abundance for middle Columbia River steelhead, the NOAA Fisheries 2014 FCRPS Supplemental BiOp relied 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 4,511 natural-origin adults (2006–2015). The most recent four-year average return was 5,117 natural-origin adults (Figure 9). The abundance trend for this MPG between 1990 and 2015 was positive. Neither the Early Warning Indicator nor the Significant Decline Trigger for this MPG were tripped in 2015.

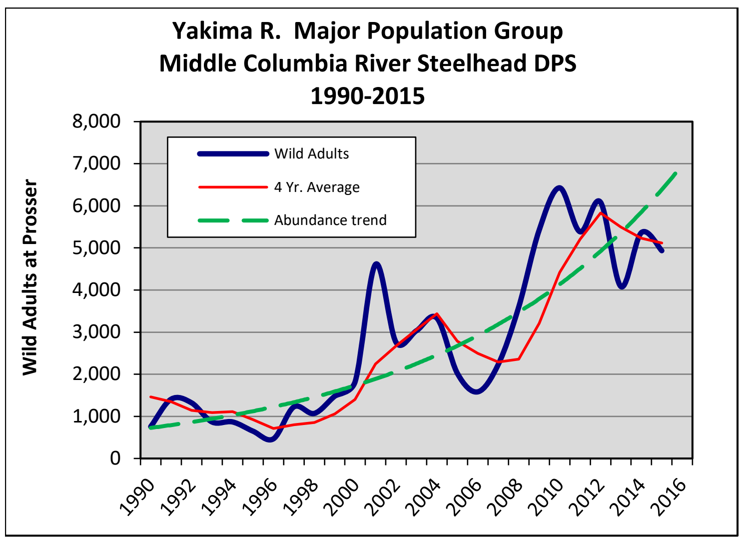


Figure 9. Returns of natural-origin adult Middle Columbia River steelhead (Yakima River MPG) at Prosser Dam, 1990–2015. The ESU-level trend in abundance was positive during this period.

Lower Columbia and Willamette River ESUs/DPSs

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

[3] *The Oregon Department of Fish and Wildlife (ODFW) had classified the Fifteen Mile Creek population as winter run prior to recent PIT tag studies. Returning natural-origin steelhead PIT tagged as juveniles in the mainstem Fifteen Mile Creek watershed exhibit a summer timed return pattern, similar to other populations in the Middle Columbia River DPS (Poxon et al. 2014, cited in NWFSC 2015).*

increasing.[4] These species are currently threatened by a broad array of habitat and other environmental factors. For the most part, these ESUs/DPSs do not migrate through the federal Columbia and lower Snake River dams; therefore the operation of the Columbia/Snake projects of the FCRPS has less impact on these populations, with the exception of certain populations located in the Columbia River Gorge and chum salmon spawning in the tailrace of Bonneville Dam. During chum salmon egg incubation, the Action Agencies control the water surface elevation of the Bonneville tailrace to protect chum redds. In addition, the Action Agencies' estuary habitat and predation management actions provide survival benefits for all populations in these ESUs and DPSs, including those that spawn below Bonneville Dam.

Environmental Conditions

Water Year and Streamflow Summary

The 2015 water year[5] began very warm, due to dominant high pressure ridging and warmer-than-usual ocean temperatures in the eastern Pacific. From October, 2014, through January, 2015, the region experienced long periods of dry and warm conditions which were marked by short lived but intense atmospheric river events, primarily affecting the northern part of the basin. The storm track was northerly, leaving California in an increasing drought and the southern part of the Columbia Basin drier than average. Runoff totals were high during this time, due to warm temperatures with periods of snow melt and rain replacing snow.

Temperatures through March were generally above average across the basin, and peak regulated runoff occurred during the months of February and March in many basins. The warm and dry trend continued until the end of the water year, with an exceptionally hot and dry summer, with temperatures in April and September slightly below normal.

The NOAA Fisheries 2014 FCRPS Supplemental BiOp defines a dry year as a year when the Northwest River Forecast Center May final forecast for April-to-August runoff at The Dalles Dam is below the 20th percentile for the Center's statistical period of record. The statistical period of record is now 1981 to 2010, for which the 20th percentile value is 72.5 million acre-feet (Maf). The 2015 water year was a dry year, with the May forecast coming in at 62.1 Maf or 71 percent of average for the April–August period. The actual runoff volume was 58.4 Maf, or 67 percent of average. Precipitation totals for the Columbia Basin as a whole were below average (84 percent of normal above The Dalles). Flow on the mainstem Columbia River at McNary Dam was well below recent historical averages, as seen in Figure 10.

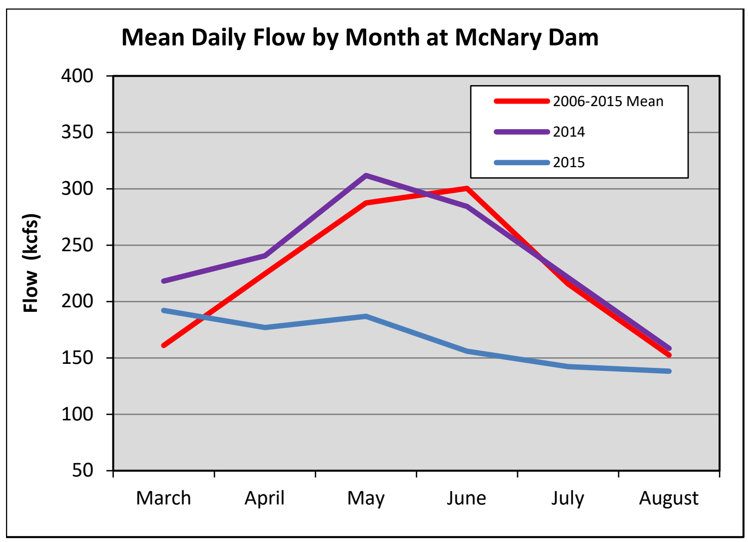


Figure 10. Mean daily flow by month at McNary Dam, 2014 and 2015, with the average values for the 2006–2015 period.

Ocean and Climate Conditions

Columbia River Basin salmon and steelhead abundance is strongly correlated with ocean conditions, where salmon and steelhead spend the majority of their life spans. In general, warmer ocean 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).

[4] *Information taken from 2016 status reviews, which can be found at* http://www.westcoast.fisheries.noaa.gov/publications/status_reviews/salmon_steelhead/2016/2016_lower-columbia.pdf *and at* http://www.westcoast.fisheries.noaa.gov/publications/status_reviews/salmon_steelhead/2016/2016_upper-willamette.pdf

[5] *For hydrosystem (hydro) operations, actions are reported by water year (October through September) and through calendar year 2015 because this is consistent with the actual approach for project operations.*

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. The PDO has been variable since about 1999, with conditions in 2010 through 2013 being favorable for salmon. The PDO index became unfavorable in 2014 and remained so throughout 2015.

NOAA Fisheries' Northwest Fisheries Science Center (NWFSC) administers the Ocean Ecosystem Indicators Project to track specific physical and biological indicators believed to influence the growth and survival of juvenile salmon once they reach the ocean. Each year the NWFSC prepares a report summarizing a range of ocean ecosystem indicators for that year and forecasting the returns of coho and Chinook salmon based on those indicators. The PDO index discussed above is one of the indicators for physical conditions.

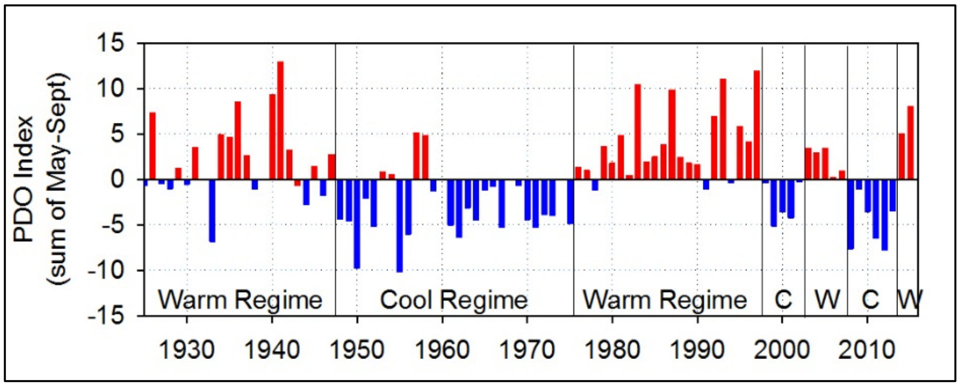


Figure 11. Time series of shifts in sign of the Pacific Decadal Oscillation, 1925 to 2015. Red bars indicate positive (warm) years; blue bars negative (cool) years. Cool PDO conditions are generally favorable for salmon and steelhead. From Peterson et al. 2015, and NOAA Fisheries website: ***https://www.nwfsc.noaa.gov/research/divisions/fe/estuarine/oeip/ca-pdo.cfm*****.**

In the summary report for 2015 (Peterson et al. 2015), many of the ecosystem indicators point toward 2015 being a relatively poor year for juvenile salmon survival (Figure 12). The PDO values were strongly positive (warm) throughout the year, coinciding with a warm "blob" of water centered in the Gulf of Alaska. "The blob" reached Oregon and Washington coastal waters (as well as British Columbia and southeast Alaska) in late 2014 and dominated surface water temperatures there for most of 2015. El Niño conditions also turned positive in April, 2015, and remained so through the rest of the year. While a strong upwelling was observed, only during the strongest upwelling (in June) did surface temperatures dip to normal levels. The biological indicators were also unfavorable. The zooplankton community was dominated by lipid-poor species throughout the year, i.e., there was no transition to lipid-rich species

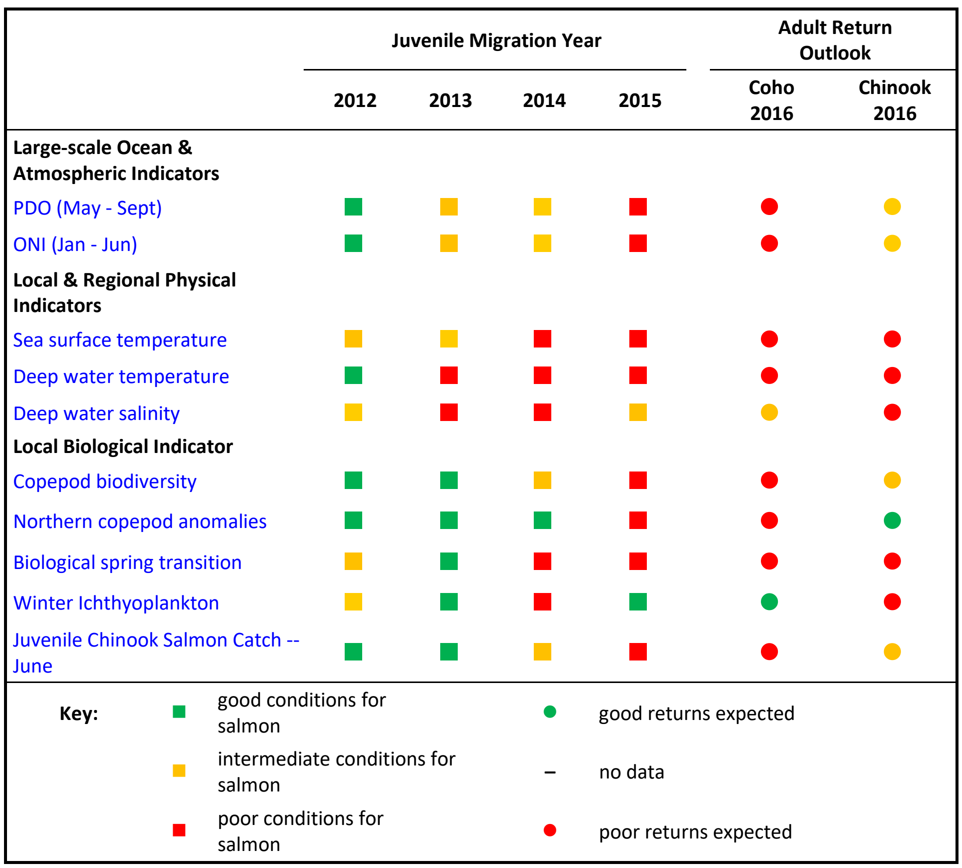


Figure 12. Ocean ecosystem indicators of the Northern California Current. Colored squares indicate positive (green), neutral (yellow), or negative (red) conditions for salmon entering the ocean each year. In the two columns to the far right, colored dots indicate the forecast of adult returns based on ocean conditions in 2015 (coho salmon) and 2014 (Chinook salmon). From Peterson et al. 2015. More information can be found on the NOAA website: ***https://www.nwfsc.noaa.gov/research/divisions/fe/estuarine/oeip/index.cfm.***

as would normally occur with late-spring and summer upwelling. In addition, krill biomass was quite low. While the abundance of winter fish larvae, which develop into salmon prey in the spring, was greater than average, there were high concentrations of larval rockfish and anchovy, which are generally indicators of poor feeding conditions for salmon. Overall, juvenile salmon entering the ocean in 2015 encountered below average ocean conditions off Oregon and Washington. This may result in low returns of adult coho in 2016 and adult Chinook salmon in 2017.

Climate Change

The Action Agencies recognize that as global climate change takes hold in the region, temperatures and streamflow patterns are very likely to also change. Warming temperatures and changing streamflow timing are likely to present challenges to the conservation of species, habitat, and ecosystem functions. Already existing and expanding partnerships between the Action Agencies, the U.S. Fish and Wildlife Service (USFWS), Tribal Nations, and other public, private, and non-governmental stakeholders will help to avoid, minimize, or mitigate the potential effects (direct, indirect, and cumulative) of climate change on species abundance and resilience. The Action Agencies are taking an informed, landscape-scale, and adaptive approach toward addressing potential climate change impacts.

Both existing and ongoing climate change studies indicate that as temperatures warm through mid-century, winter precipitation which historically fell as snow in mountainous areas of the Columbia River Basin, particularly in US basins, will begin to fall as rain. This will result in higher winter flows in lower- and mid-elevation streams, an earlier snow melt peak, and a slight decrease in summer flows (RMJOC Climate Change Study, 2011: available on line at: *http://www.usbr.gov/pn/climate/planning/reports*). However, there are no statistically significant trends toward either a wetter or drier basin as a whole on an annual basis, and the large year-to-year precipitation and runoff variability experienced in the basin is likely to continue. Through ongoing regional climate change studies and work, the Action Agencies will be able to evaluate projected shifts in precipitation and temperature patterns and changes in Columbia Basin streamflow timing and volumes using the latest climate change information. This information can be used to evaluate potential impacts of climate change in the management of the river systems and related effects on resources.

The Action Agencies have incorporated these results into hydrologic, hydraulic and water quality models when analyzing future effects of FCRPS operation on listed species. Furthermore, the Action Agencies have continued to fund studies to improve our understanding of climate change impacts, and to improve hydrologic and water quality models and methodologies. One such study by the University of Washington, Oregon State University, and other research partners, which is co-funded by the Action Agencies, is underway and will be complete in 2017. Other water quality modeling improvements, which take into account the great complexities in the snowmelt-dominated, forested headwater areas of the basin will continue. In addition, Action Agency habitat actions contribute to improvements in conditions in the tributaries that are expected to be impacted by future climate change, and will be discussed in the habitat section below.

Under the NOAA Fisheries 2014 FCRPS Supplemental BiOp, the Action Agencies also receive an annual review of recent scientific literature from NOAA Fisheries' Northwest Fisheries Science Center (NWFSC) relating to potential long-term effects that climate change may have on Columbia River Basin salmon and steelhead. These reviews can be found at: *http://www.nwfsc.noaa.gov/trt/lcm/freshwater_habitat.cfm.* The review of 2015 literature is also available in Section 2, Appendix C.

Generally, the NWFSC 2015 literature review is consistent with past reviews in its forecasts for the impacts of climate change.

Implementation Overview

The Action Agencies have established implementation strategies and actions, using a life-cycle based "All-H" approach, to offset the effects of the hydrosystem with improvements in hydrosystem operations and configuration, as well as implementing habitat actions, hatchery and predator management, and support for harvest management. These actions benefit salmon and steelhead in the Columbia River Basin. Accomplishments and implementation in 2015 are summarized below. Detailed descriptions can be found in Section 2 of this report.

Hydrosystem Actions

Developing and implementing actions to improve the survival of fish as they pass through the hydrosystem is the foundation of the NOAA Fisheries 2014 FCRPS Supplemental BiOp. The survival benefits to fish passing through the hydrosystem that these actions collectively provide are estimated using four different measures of fish survival:

- Juvenile fish dam passage survival performance standards document the survival improvements that specific configuration and operation actions implemented at each dam provide for juvenile fish as they pass individual dams. These performance standards are designed to ensure the implemented actions achieve an average juvenile fish dam passage survival level of 96 percent for spring migrating fish (yearling Chinook and steelhead) and 93 percent for summer migrating fish (subyearling Chinook).
- The juvenile in-river survival performance metric estimates the survival of in-river migrating fish as they pass through the hydrosystem and compares those estimates with Comprehensive Fish Passage (COMPASS) model-generated survival estimates based on the river conditions experienced and the expected benefits of hydro actions that have been completed.
- Juvenile system survival performance targets estimate the expected increase in juvenile fish survival through the hydrosystem that are associated with proposed hydro actions and transport combined.
- Adult performance standards track and confirm that the relatively high observed adult survival is maintained or increased.

Generally, fish survival past the dams has improved substantially over the past decade as a result of dam configuration and operation improvements implemented to date. The following sections describe the progress in implementing those hydro actions identified in the NOAA Fisheries 2014 FCRPS Supplemental BiOp.

Water Management and Flow Operations

In 2015, FCRPS storage reservoirs were managed to enhance flows and water quality to improve conditions for salmon and steelhead. The Action Agencies developed the annual Water Management Plan (WMP) to address multiple purposes including providing flows for salmon, cooling water temperatures, protecting listed and unlisted resident fish, managing flood risks, and serving other authorized purposes consistent with RPA Action 4 specifications (BPA et al. 2014). The WMP was developed and implemented in coordination with federal agencies and regional states and tribes (i.e. 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.

Providing flows for fish is an important component of water management in the Columbia River Basin. In 2015, both the FCRPS 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 risk management requirements) by April 10. 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 through the Columbia River Treaty that allowed use of 1 Maf of water in Columbia River Treaty storage space for release during the spring and summer to support flows for fish downstream in the United States. In addition, BPA and BC Hydro negotiated a Non-Treaty Storage agreement that includes a provision to provide an additional 0.5 Maf of flows during the spring of the driest 20^{th} percentile of years, if not exercised in the previous year. Further, the Treaty itself provides for drafting of reservoirs in drier years (known as proportional draft) that resulted in 5.9 Maf of additional flow from Canadian projects in 2015. Thus releasing water from Canadian projects resulted in a total of 7.4 Maf of additional flow.

In addition Reclamation was able to provide 427 thousand acre-feet (kaf) from the federal storage projects in the Upper Snake River basin above Brownlee reservoir, under the NOAA Fisheries Upper Snake BiOp, to support flows for fish. 2015 was a very dry year for the upper Snake River basin above Brownlee Dam (the April-July runoff was 56 percent of normal). The 427 kaf was made available for flow augmentation by taking extraordinary measures in accordance with the terms of the Nez Perce Water Rights Settlement.

Other US reservoirs also provided flow augmentation, to give a total of 4.1 Maf from U.S. projects and 7.4 Maf from Canadian projects. Thus, roughly one-third of the approximately 32 Maf of storage available in U.S. and Canadian storage reservoirs was used in 2015 to augment Columbia River flows in spring and summer.

Water Quality

In July 2014, the Corps, in a collaborative effort with regional sovereign partners, finalized the Water Quality Plan for the Columbia River Basin in accordance with RPA Action 15. Operational measures identified in the plan were implemented throughout 2015.

Fish passage spill operations often result in the generation of total dissolved gas (TDG) supersaturation in the Columbia and lower Snake River 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 2015, the Corps provided fish passage spill consistent with the NOAA Fisheries 2014 FCRPS Supplemental BiOp and monitored TDG levels in the river throughout the fish passage season. Spill patterns and spill levels were adjusted to manage TDG consistent with the applicable water quality standard to the extent practicable.

Spill at run-of-river projects also occurs when high flows exceed the turbine capacity at any dam or when demand is low for hydroelectric generation. Because these dams aren't designed to store water, high river flow combined with low electricity demand can sometimes lead to spill that exceeds the applicable TDG limits. In most years this will occur during the spring freshet, in late May, June or early July. However, as a result of the low river flows, in 2015 this situation did not occur at any time.

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, generally from early July through mid-September. Due to high river temperatures in 2015, the temperature control operation began on June 17. In 2015, hourly water temperature readings at the tailwater temperature gauge for Lower Granite Dam exceeded 68 degrees Fahrenheit on 8 days in July and 2 days in August. Due to the very warm conditions in the summer of 2015, all Dworshak water available for temperature management was exhausted by September 19, with the reservoir drafted to the BiOp target of 1520 feet. The maximum hourly temperature at the Lower Granite Dam tailwater gauge was 70.5 degrees Fahrenheit on July 10.

For a more thorough discussion of how the system was operated in 2015, see the 2015 Total Dissolved Gas Report (ACOE 2015).

Improvements for Fish at the Dams

Most salmon and steelhead in the Columbia River Basin encounter one or more hydrosystem dams as they migrate to and from the ocean. Previous annual and comprehensive reports have documented the Action Agencies' progress in implementing the hydrosystem configuration actions in NOAA Fisheries 2008 FCRPS BiOp. While work continues on hydrosystem modifications, these actions at the dams and dam operations have improved survival and fish travel times.

As of 2015, most of the RPA actions have been completed as originally envisioned in 2008. In the few cases where an RPA action has been modified or deemed to no longer be applicable those changes have been documented in annual reports and letter exchanges with NOAA Fisheries. Recent actions from 2015 are described below, documenting the BiOp's continuing hydrosystem actions to address both juvenile and adult migration through the system.

Adult Passage Improvements

The Action Agencies recognize the importance of continued improvements in adult passage in the system. Adult passage can be adversely affected (i.e. delay, fallback) by the amount, location, and duration of spill for juvenile passage, requiring a balance at each dam.

In 2015, the Corps completed the analysis of data from a two-year study of the north ladder at The Dalles Dam which assessed whether the spill pattern resulting from construction of the spillwall in 2010 for juvenile fish passage has caused migration delays for adults attempting to use that ladder. The analysis found that as spill increases above 100 thousand cubic feet per second (kcfs), a high proportion of adult salmon use the east ladder. However, it appears that shift does not cause an increase in adult passage time. In 2014 and 2015, the Corps also completed plans and specifications and awarded a contract for improvements to the east ladder auxiliary water supply at The Dalles Dam, which will improve the reliability of that ladder.

At Little Goose Dam, it appears that installation and operation of a spillway weir which aids downstream passage of juveniles can, under certain spill conditions, hinder the upstream passage of adults. Beginning in 2011 a new spill pattern was implemented to reduce adult passage delay, which the Corps continued to use through 2015. The Corps also continued design of a new adjustable spillway weir to allow rapid closure of the weir and provide more flexibility in meeting passage goals for adult and juvenile fish.

At Lower Granite Dam warm river surface temperatures in the forebay during late summer can create a temperature difference between the adult ladder exit and the entrance, causing delays in adult passage. In 2013, 2014, and 2015, the Corps used temporary pumps to add cool water to the fish ladder, which reduced the temperature difference and minimized the delays. In addition, the Corps continued working on the design for permanent modifications to the auxiliary ladder intake pumps and discharge routing. Those improvements were completed during the winter of 2015-2016 and will be evaluated during the 2016 fish passage season.

Juvenile Passage Improvements

Juvenile fish pass dams by many routes: through spillways and surface passage routes, through juvenile bypass systems (JBS), through turbines, or by collection and transport in barges or trucks downstream. Operations and structural improvements have been tailored to the specific conditions and structure of each dam to reduce the proportion of juvenile fish that pass through turbines, reduce forebay delay, and improve overall dam survival. Depending on location, time of year, and species, approximately 76 to 99 percent of the juvenile fish use these non-turbine routes. Major changes to dam configuration, spill, and other actions have been taken since 2008 to achieve hydro performance standards and improve fish survival. In 2015, specific actions included the following.

The Corps continued field investigations and design of fish survival upgrades to Bonneville's Powerhouse II JBS. Previous modifications to that system resulted in improved guidance efficiency but also increased the incidence of injury to juvenile fish, particularly to smaller juveniles when the turbines were operated at the upper end of the ±1 percent peak efficiency range. In 2014, the Corps installed the recommended additional modification, a gatewell flow reduction device, in a single Powerhouse II gatewell. Hydraulic and biological evaluations were carried out in 2015 in a fully modified turbine unit. The results indicate that the objectives have been met, improving hydraulic conditions and juvenile fish survival when operating the turbine unit in the upper 1 percent peak efficiency range. Efforts are underway to fully implement the gatewell modification across all main units at Powerhouse II, after which the effectiveness of the changes will again be evaluated.

Manufacturing continued on an Ice Harbor Dam fixed-blade turbine runner, the revolving component in a turbine. The contractor also began manufacture of the first of two adjustable blade runners. Based on computer and physical models, the new runners are expected to improve survival of turbine-passed fish by reducing the magnitude of pressure change, the probability of blade strike, and turbulence within the turbine passageways.

Also at Ice Harbor, modification of the spillway chute and deflector for the spillway weir bay was completed. Those modifications were evaluated during the juvenile outmigration in the spring of 2015, and show a significantly improved route of passage for the spillway weir bay.

The Corps also began construction of structural improvements to the JBS at Lower Granite Dam. These improvements include replacing 10-inch gatewell orifices with 14-inch orifices, widening the collection channel, daylighting the transport channel, adding new primary dewatering structures, and constructing new primary and emergency bypass outfall structures. The overall JBS upgrade is anticipated to be completed before the juvenile outmigration in 2018. The bypass system upgrades are expected to increase juvenile fish survival by providing more efficient control of flow, improving the removal and passage of debris, increasing attraction flow for juvenile fish, and reducing risk of predation at the outfall release point.

Adult Fish Survival

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. 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 middle Columbia steelhead. In 2015, low snow pack, coupled with extremely high air temperatures throughout the interior Columbia basin resulted in warm water in the major tributaries to the lower Snake and Columbia rivers. Temperatures in the mainstem Columbia River were the highest recorded from roughly mid-June to mid-July. Adult sockeye salmon, which normally migrate during this period, sustained heavy losses in the Columbia River and tributaries. ESA-listed Snake River sockeye salmon were especially affected in the mainstem migration corridor, with losses exceeding 95% between Bonneville and Lower Granite dams.

For 2015, the 5-year rolling averages (2011–2015) and 2015 results for Snake River fall Chinook, Upper Columbia River spring Chinook and Upper Columbia steelhead surpassed the BiOp performance standard. 2015 results for Snake River spring/summer Chinook salmon and Snake River steelhead also met the performance standards, but their 5-year averages were below the standards due to lower survival in earlier years. (Figure 13).

The adult fish performance standards are survival estimates of PIT tagged adult fish migrating between Bonneville and McNary dams (upper and middle Columbia ESUs) and Bonneville and Lower Granite dams (Snake River ESUs). The method used 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 other sources of adult fish mortality such as sea lion predation, high river temperatures, and natural mortality. Also, high river flows, high spill levels, and temperature differentials in ladders at dams can affect the estimates because they are known to increase fallback and delay of adults. Increased fallback and delay at dams can result in increased losses (Keefer et al. 2005). These potential factors are being assessed through BiOp Research, Monitoring & Evaluation (RME) actions.

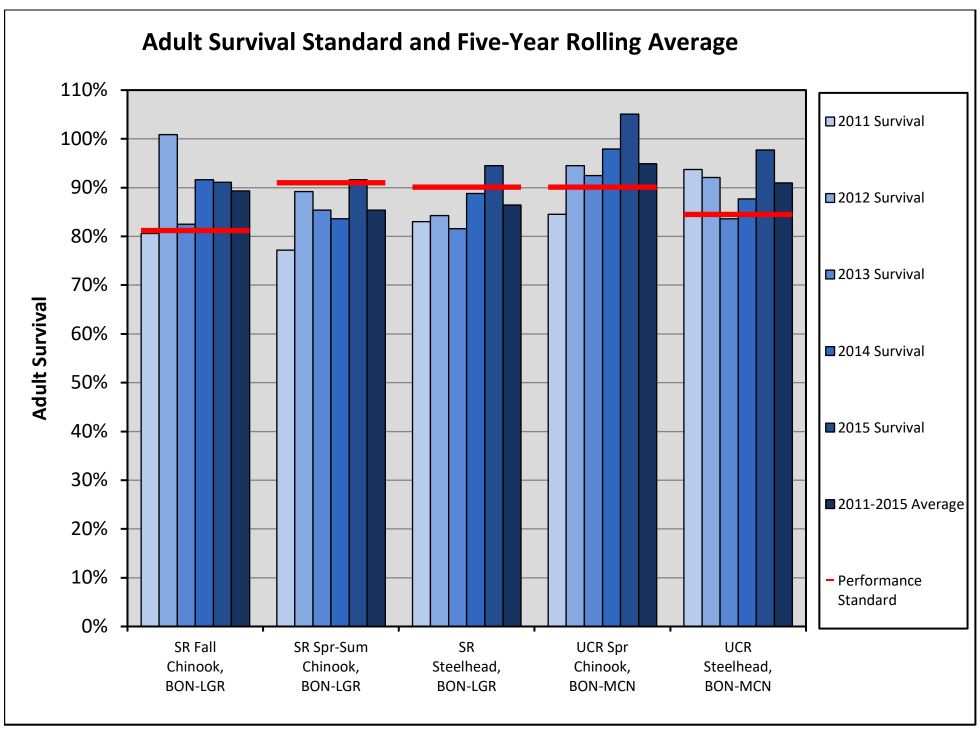


Figure 13. Adult survival standard and five-year rolling average survival of adults that migrated in-river as juveniles, based on PIT tag conversion rates of Snake River (SR) and Upper Columbia River (UCR) ESUs. (BON = Bonneville, MCN = McNary, LGR = Lower Granite). Data from NOAA Fisheries.

Juvenile Dam Passage Survival

The Action Agencies' juvenile dam passage survival performance standards are based on dam passage through all passage routes, with a benchmark of 96 percent average dam passage survival for migrating spring fish (yearling Chinook and steelhead) and 93 percent average dam passage survival for migrating summer fish (subyearling fall Chinook).

- Spill operations are tailored for each dam, based on hydraulic and biological constraints.
- Juvenile passage improvements to provide surface passage routes (e.g. spillway weirs and sluiceways) have been completed at all eight federal dams on the lower Columbia and lower Snake rivers. Not only do they provide more effective passage conditions and survival to achieve the dam passage standards, but in combination with spill provide faster fish travel times through the hydrosystem.
- Other forms of passage improvements (such as spill walls, and improvements to juvenile bypass outfall locations) to achieve dam passage survival performance standards, have been identified and prioritized in coordination with the region, and have largely been completed at seven of eight Snake and lower Columbia River dams.
- Construction of major modifications to the juvenile bypass system at Lower Granite Dam is underway, and expected to be completed in time for the juvenile out-migration in the spring of 2018.

To achieve the juvenile dam passage survival performance standards at any given dam, two years of testing must occur with survival either meeting or exceeding the performance standard each year. A summary of recent performance standard test results is provided in Table 2. Test results to date indicate the estimated survival of yearling Chinook ranged from 95.69% to 98.68%, estimates of steelhead survival ranged from 95.34% to 99.52%, and estimates of subyearling Chinook ranged from 90.76% to 97.89%. This review corroborated NOAA's analysis in the 2014 Biological Opinion that found that, with few exceptions, BiOp measures are performing as expected and are very close to achieving, or are already achieving, the juvenile dam passage survival objectives. No performance testing was scheduled for 2015.

Table 2. Juvenile dam passage survival estimates, passage times, and spill passage efficiency for yearling Chinook, juvenile steelhead, and subyearling Chinook salmon derived from performance standard tests conducted through 2014. There were no tests conducted in 2015. 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. (Sources are provided in Section 2 of this Comprehensive Evaluation, under the RPA Action for the appropriate project.)

Dam	Year	Species	Dam Passage Survival (percent with Standard Error)	Median Forebay Passage Time (hours)	Spill Passage Efficiency (percent)	Spill Operation (Target / Actual)
Bonneville	2011	Yearling Chinook Salmon	95.69 (0.42)	n/a	n/a	100 kcfs / 100 kcfs (30 Apr – 13 May)
Bonneville	2011	Yearling Chinook Salmon	95.97 (1.76)	0.55	59.59	100 kcfs / 181 kcfs (season-wide)
Bonneville	2011	Steelhead	97.55 (1.80)	n/a	n/a	100 kcfs / 100 kcfs (30 Apr – 13 May)
Bonneville	2011	Steelhead	96.47 (2.12)	0.85	64.06	100 kcfs / 181 kcfs (season-wide)
Bonneville	2012	Subyearling Chinook Salmon	97.39 (0.69)	0.48	57.06	85 kcfs day – 121 kcfs night / 149 kcfs 95 kcfs 24 hrs / 149 kcfs
The Dalles	2010	Yearling Chinook Salmon	96.41 (0.96)	1.28	94.66	40% / 39.9%
The Dalles	2010	Steelhead	95.34 (0.97)	1.28	95.36	40% / 39.9%
The Dalles	2010	Subyearling Chinook Salmon	94.04 (0.91)	1.20	82.98	40% / 39.8%

Dam	Year	Species	Dam Passage Survival (percent with Standard Error)	Median Forebay Passage Time (hours)	Spill Passage Efficiency (percent)	Spill Operation (Target / Actual)
The Dalles	2011	Yearling Chinook Salmon	96.00 (0.72)	0.97	83.1	40% / 43.1%
The Dalles	2011	Steelhead	99.52 (0.83)	0.81	89.1	40% / 43.1%
The Dalles	2012	Subyearling Chinook Salmon	94.69 (0.59)	1.08	78.39	40% / 40.4%
John Day	2011	Yearling Chinook Salmon	96.66 (1.03) 97.84 (1.07) 96.76 (0.71)	2.0 1.5 1.42	61.2 66.4 63.68	30% / 30% 40% / 40% Season-wide
John Day	2011	Steelhead	98.36 (0.90) 98.97 (0.96) 98.67 (0.61)	4.3 3.2 2.91	61.2 66.4 62.78	30% / 30% 40% / 40% Season-wide
John Day	2012	Yearling Chinook Salmon	96.73 (0.65)	1.15	74.56	30% / 37.1% 40% / 37.1%
John Day	2012	Steelhead	97.44 (0.28)	2.39	74.52	30% / 37.1% 40% / 37.1%
John Day	2012	Subyearling Chinook Salmon	94.14 (0.31)	1.02	69.62	30% / 37.9% 40% / 37.9%
John Day	2014	Subyearling Chinook Salmon	91.96 (0.74) 91.31 (0.77)	2.28 1.91	55.52 71.26	30% / 30% 40% / 40%
McNary	2012	Yearling Chinook Salmon	96.16 (1.40)	1.76	72.46	40% / 50.9%
McNary	2012	Steelhead	99.08 (1.83)	1.78	83.15	40% / 50.9%
McNary	2012	Subyearling Chinook Salmon	97.47 (1.14)	1.77	78.32	50% / 61.6%
McNary	2014	Yearling Chinook Salmon	96.10 (1.27)	1.73	71.40	40% / 52.6%
McNary	2014	Steelhead	96.98 (1.36)	2.57	84.33	40% / 52.6%
McNary	2014	Subyearling Chinook Salmon	92.39 (1.80)	2.22	53.80	50% / 48.8%
Lower Monumental	2012	Yearling Chinook Salmon	98.68 (0.90)	2.35	78.89	Gas Cap (26 kcfs) / 29.7 kcfs
Lower Monumental	2012	Steelhead	98.26 (0.21)	2.17	65.85	Gas Cap (26 kcfs) / 29.7 kcfs
Lower Monumental	2012	Subyearling Chinook Salmon	97.89 (0.79)	2.60	83.56	17 kcfs / 25.2 kcfs
Lower Monumental	2013	Subyearling Chinook Salmon	92.97 (1.05)	2.99	89.10	17 kcfs / 19.8 kcfs
Little Goose	2012	Yearling Chinook Salmon	98.22 (0.76)	2.58	65.28	30% / 31.8%
Little Goose	2012	Steelhead	99.48 (0.81)	2.67	56.09	30% / 31.8%
Little Goose	2012	Subyearling Chinook Salmon	95.08 (0.97)	2.80	72.49	30% / 38.5%
Little Goose	2013	Subyearling Chinook Salmon	90.76 (1.39)	3.66	76.83	30% / 30%

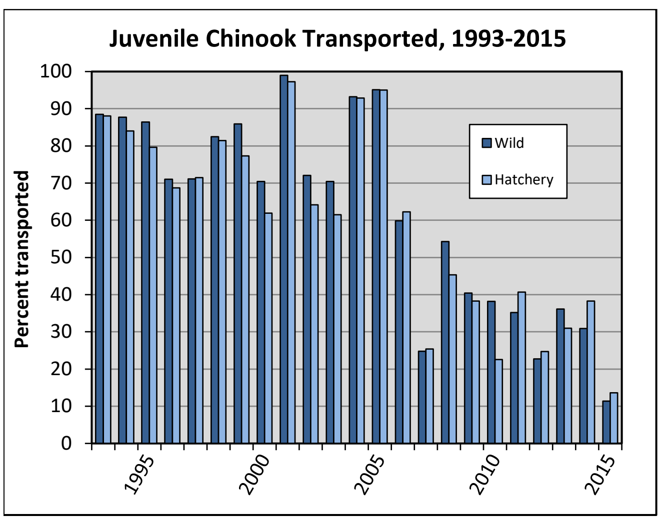
Fish Transportation and Barging

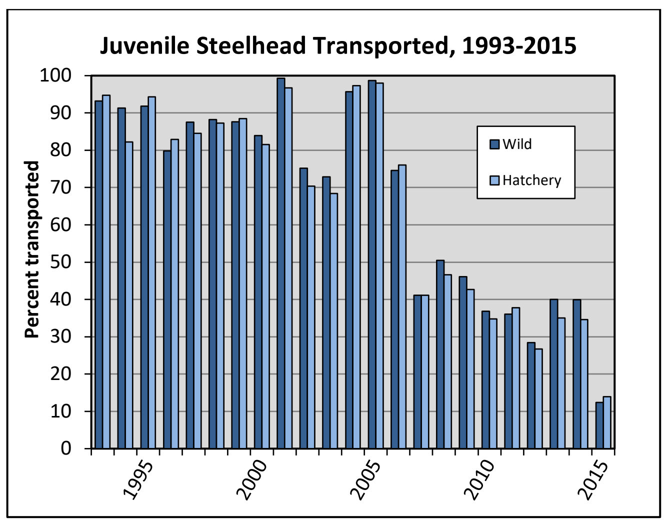
Hatchery and wild juvenile salmon and steelhead that migrate through the Snake and Columbia rivers to the ocean can migrate "in river" or they can be collected and transported. Juvenile fish transportation is an ongoing program to improve fish survival by collecting fish from juvenile bypass facilities at Lower Granite, Little Goose, and Lower Monumental dams and transporting them by either barge or truck to release sites below Bonneville Dam.

Currently, fish transport operations are adaptively managed on an annual basis. The timing and conditions for fish transportation are based on annual monitoring, comparing adult returns to Lower Granite Dam of transported fish versus fish that migrated in-river. In general, evaluation of migration is showing that Chinook return as adults 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 2015, in an ongoing effort to balance effects of transportation between species, the Action Agencies, in coordination with the regional sovereigns, reviewed transportation and in-river information. Following this, the Action Agencies began collection for transport on May 1 at Lower Granite Dam, Little Goose Dam, and Lower Monumental Dam. Prior to May 1, juveniles collected at Snake River dams were bypassed back to the river.

Estimated percentages of non-tagged spring/summer Chinook salmon juveniles that were transported during the entire 2015 season were 11.4 percent for wild fish and 13.6 percent for hatchery fish. For non-tagged steelhead, estimated percentages transported were 12.4 percent for wild fish and 13.9 percent for hatchery juveniles. These transport percentages are considerably lower than for any other year in the record (Figures 14 and 15). For comparison, the corresponding numbers for 2014 were 30.9 percent for wild Chinook, 38.3 percent for hatchery Chinook, 39.9 percent for wild steelhead, and 34.6 percent for hatchery steelhead. The low transport percentages appear to be the result of two factors. First, a greater than normal proportion (i.e., roughly 50 percent) of yearling Chinook and steelhead juveniles were already past Lower Granite Dam by the time transport started on May 1. Second, after transport began, the proportion of river flow that was spilled at the dams with collection facilities was higher than usual (due to low Snake River flows) so that the proportion of juveniles that entered dam bypass systems and were collected for transport was lower than normal. Of the fish transported in 2015, 99.6 percent were barged, and the balance transported by truck.





Figures 14 and 15. Estimated percent of yearling Chinook salmon and steelhead, respectively, transported to below Bonneville Dam, by year, 1993–2015 (data from Faulkner et al. 2016).

Juvenile In-river and Total System Survival

Juvenile salmon and steelhead that are not transported are considered to have migrated "in-river." Empirical data are used to track the percent of fish that return as adults among those transported and those left in-river to migrate. Generally, fish are transported during periods when both Chinook salmon and steelhead show increased adult returns compared to in-river migrants. In-river survival of migrating fish has improved significantly over time as a result of operation and passage improvements at the FCRPS dams. Figure 16 shows the trend of these improvements for spring/summer Chinook salmon and steelhead. As NOAA noted in their 2014 supplemental recovery plan module on hydrosystem effects, “reach survival estimates for subyearling SR fall Chinook salmon and yearling spring/summer Chinook salmon, sockeye salmon, and steelhead all appear to be meeting, or in the case of fall Chinook salmon, sockeye salmon, and steelhead substantially exceeding [BiOp expectations].” However, although survival was higher than previous low flow years like 2001 or 2004, in 2015, survival of juvenile yearling Chinook and steelhead were considerably lower than in the immediately previous years, likely as result of low flow and high temperature conditions. As NOAA noted in their annual report on migration conditions (Faulkner et al. 2016), “The lower survival estimates in 2015 for yearling Chinook, steelhead, and sockeye were associated with a set of extreme environmental conditions and unusual operational conditions compared to past years. In general, the combination of conditions in the Snake River during the 2015 spring migration was unlike any year in our time series. Water temperatures and spill percentages reached record highs while flow was near record low.”

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 50 percent for wild Chinook, 50 percent for combined wild and hatchery Chinook, 43 percent for wild steelhead, and 49 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.

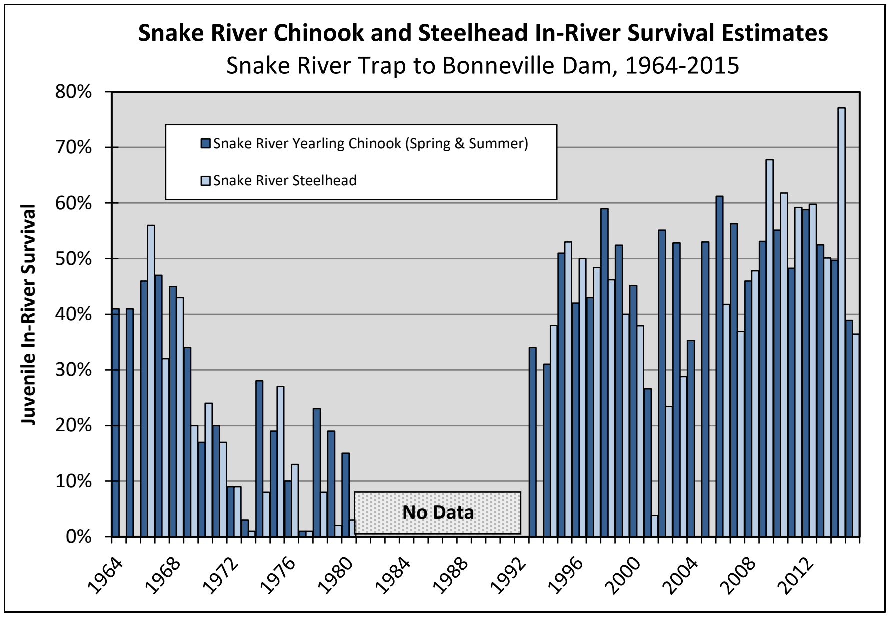
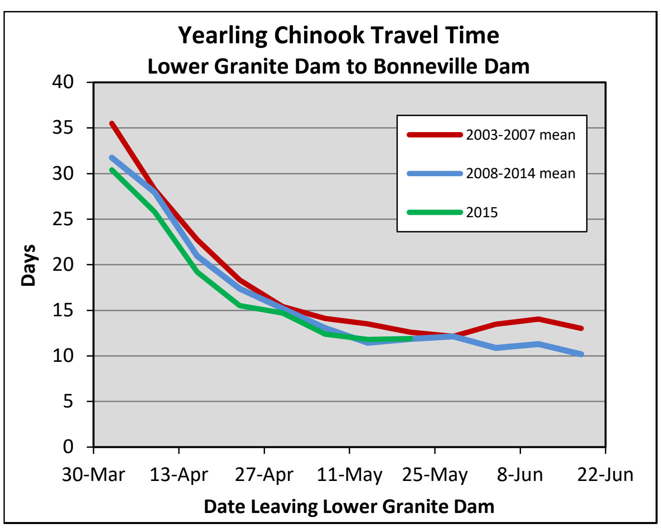
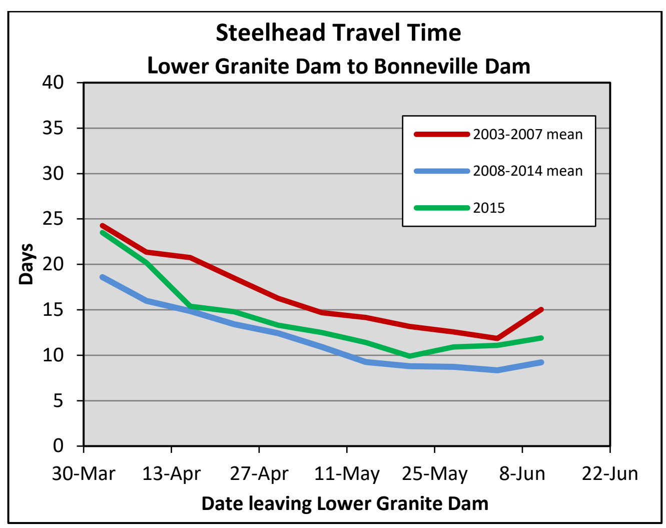


Figure 16. In-river survival estimates (hatchery and wild fish combined) for Snake River Chinook and steelhead, from the trap above Lower Granite Dam to Bonneville Dam. Survival estimates are not available for 1981 through 1992. Steelhead estimates for 2004 and 2005 are unavailable due to low PIT tag detection efficiency at Bonneville Dam. (Data from Williams et al. 2001 and Faulkner et al. 2016.) The 2014 steelhead estimate is likely biased high due to low detection probabilities at lower river sites and resulting violations of model assumptions (Faulkner et al. 2015).

Travel time for yearling Chinook and juvenile steelhead through the hydrosystem during the spring of 2015 was shorter than the 2003-2007 average for most of the migration season (Figures 17 and 18). As in previous years, the



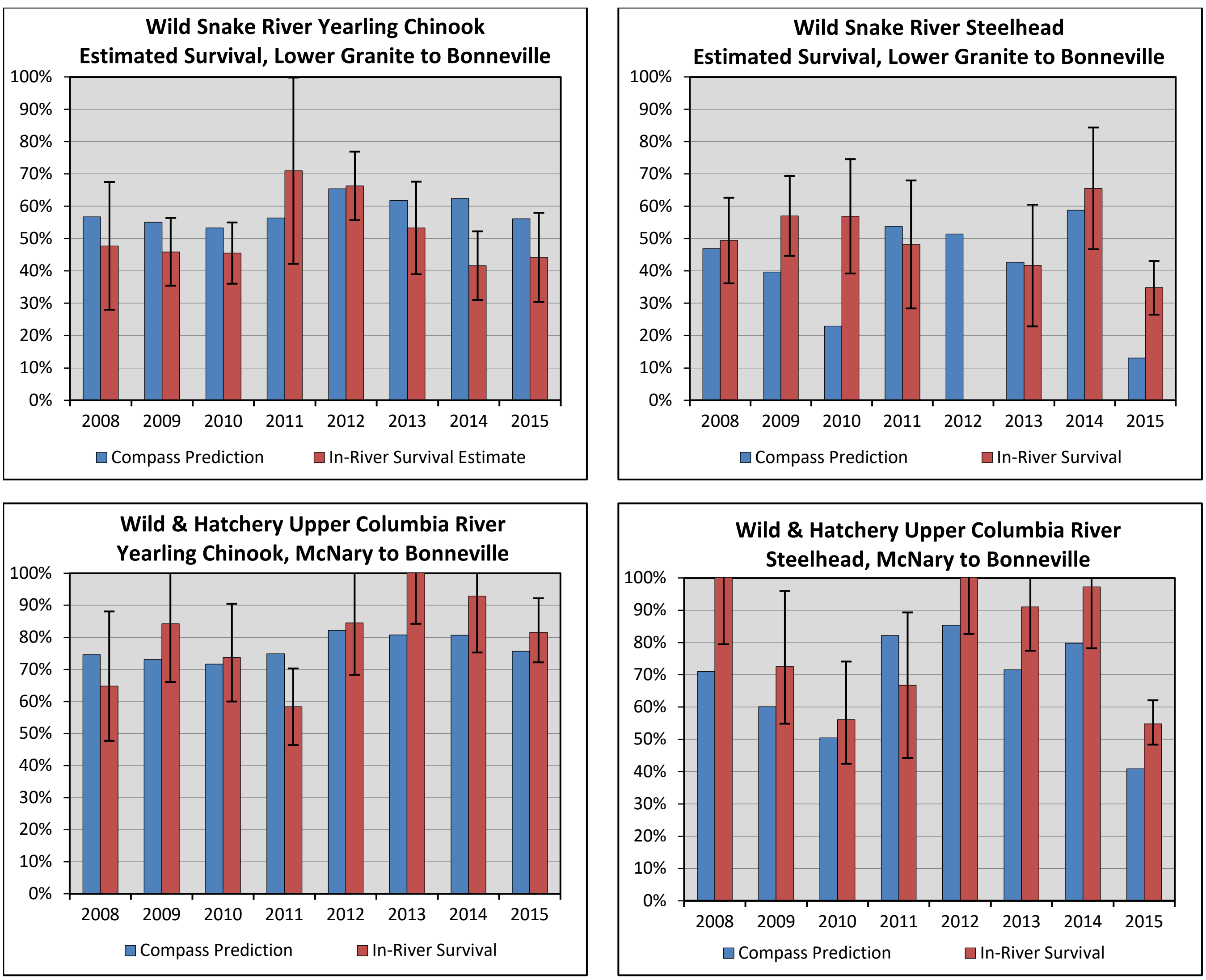


Figures 17 and 18. Median travel time from Lower Granite Dam to Bonneville Dam for weekly release groups of Snake River yearling Chinook salmon and steelhead. (Data from Faulkner et al. 2016)

difference between the 2003-2007 average and 2015 travel time was greater for steelhead than for yearling juvenile Chinook. This may indicate that juvenile steelhead, being more surface oriented, receive a greater benefit from surface passage structures than do yearling juvenile Chinook. In general, travel times have been improved, associated with the reduced delay seen from the combination of spill and spillway weirs and other surface passage routes, even in low flow years such as 2015.

The Action Agencies and NOAA included a modeled metric to estimate in-river survival performance for Snake River and upper Columbia River Chinook and steelhead. The Action Agencies empirically estimated in-river survival for 2015 (Lower Granite to Bonneville and McNary to Bonneville) and compared that with the survival estimates derived from COMPASS modeling by NOAA. For this comparison, NOAA ran the COMPASS model with survival estimates for the actions implemented at the start of the 2015 migration season using 2015 river conditions, fish migration patterns, and dam and transport operations. Figures 19–22 show the results of these comparisons.

In 2015, the PIT tag in-river juvenile survival estimate for natural-origin Snake River yearling Chinook was lower than the COMPASS estimate, while the PIT tag survival estimate for natural-origin and hatchery upper Columbia River yearling Chinook was higher than the COMPASS estimate, with neither difference being statistically significant. However, the PIT tag estimates for natural-origin Snake River steelhead and for natural-origin and hatchery upper Columbia River steelhead were higher than the COMPASS estimates, and the differences were



Figures 19, 20, 21, and 22. 2008–2015 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)

statistically significant. The results presented in Figures 19-22 indicate the benefits from the hydro operation, passage improvements, and predation deterrent actions implemented to date are generally accruing at least as well as expected in the BiOp analysis.

Snake River Kelt Management

Kelts are steelhead that survive to spawn again in subsequent years. The goal of kelt management actions in the Snake River is to improve survival and abundance 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 to spawn in their natal streams.

Photo of reconditioned Snake River B-run kelt at Dworshak Hatchery in 2014

In order to implement the objectives of the Snake River kelt program, BPA and the Corps completed the 2015 Kelt Management Plan (KMP) supplement (BPA and ACOE 2015). The 2015 version of the KMP built upon the framework of previous plans, but also identified future direction through the remainder of the BiOp (i.e., through 2018). The 2015 KMP reviews the goals of the plan and summarizes progress on reconditioning efforts. The 2015 KMP and previous years' plans can be found at: *https://www.salmonrecovery.gov/Hatchery/kelt-reconditioning*.

In 2015, Snake River B-Run kelts that were collected in 2014 were reconditioned at Dworshak National Fish Hatchery. Twenty-four reconditioned wild female B-run kelts were released to the Columbia River below Bonneville Dam in December of 2015 (Table 3). There were 21 remaining fish that were determined to not be ready to spawn and were retained for an additional year of reconditioning for release in 2016. In 2015 a total of 140 out-migrating B-run kelts were collected at the juvenile bypass facility at Lower Granite Dam and at the Fish Creek weir. Developing and improving opportunities to collect out-migrating B-run steelhead will continue to be a priority.

Table 3. Annual releases of reconditioned Snake River steelhead kelts. Percent survival to release is highly variable and largely dependent on the condition of the kelts at collection. In 2015 and 2016, the program released only those kelts that were ready to spawn, and retained other kelts for an additional year of reconditioning.

Year	Number Collected	Survived Reconditioning	% Survival	Number Released
2011	111	2	1.8%	2*
2012	124	10	8.1%	10*
2013	134	69	51.5%	69
2014	122	37	30.3%	36
2015	140	43	30.7%	24
2016	225	142	60.7%	TBD
*Water quality issues at Dworshak NFH contributed to losses in 2011 and 2012				

As part of further efforts to develop the reconditioning program, CRITFC and the Nez Perce Tribe produced a Draft Reconditioning Master Plan for review in 2015 that recommends the long-term facility needs of the program. The master plan was submitted to the Northwest Power and Conservation Council in the spring of 2016.

As in recent years, the short-term reconditioning/transport strategy was not implemented in 2015. In-river migration and reconditioning strategies are currently prioritized over the transportation strategy when there is a shortage of kelts available for full program implementation. The Action Agencies may resume transportation when the number of collected kelts exceeds the capacity of reconditioning programs.

Several categories of reconditioning research were continued in 2015 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. To assess measures to increase in-river survival of steelhead kelts and overwintering adult steelhead, two downstream passage studies were conducted at McNary Dam in 2014 and 2015. The 2014 study evaluated the survival of adult steelhead that pass through a turbine, and a spillway weir at McNary Dam. Survival (48-hr) of balloon-tagged adult steelhead for the turbine was 90.7 percent and for the spillway weir was 97.7 percent (Normandeau 2014). A second study assessed adult steelhead downstream passage distribution across passage routes at McNary Dam. During the study period when turbine intake screens were installed, TSW operation resulted in fewer adults passing via turbines and more fish passing the dam overall compared to no- spill treatments. Other passage trends were suggestive of fish being drawn away from guided passage by TSW operation, though none of those other trends led to a statistically significant difference among treatments. The increase in downstream passage by adults during TSW_Spill treatments suggests that a number of fish upstream of McNary Dam were not actively passing the dam during No_Spill treatments (Ham et al. 2015).

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 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” to address impacts of the hydrosystem that are not addressed from changes in operations or the dams themselves. These “off-site” actions typically address impacts to fish not caused by the hydrosystem, but are things the Action Agencies can do to improve the overall conditions for fish that are impacted by the hydrosystem.

Tributary Habitat Actions

The hundreds of tributary habitat improvement actions implemented or in various stages of development represent a mature habitat program. A growing list of habitat improvement actions implemented includes flow acquisition, riparian enhancement, improved instream complexity, removal of passage barriers, and improved access to stream habitat. Improved planning and evaluation of current conditions has resulted in a strategy focused on ecological concerns/limiting factors and the needs of fish that are being addressed with projects of increased size and complexity as compared to prior decades.

In implementing the tributary habitat program, the Action Agencies consult with local technical teams on the current conditions of habitat and on design details of actions intended to improve conditions for fish. Improvements to limiting factors expected to result from these actions are estimated by expert panels. Based on the expert panels’ estimates of changes to habitat functions, the Action Agencies calculate habitat quality improvements (HQIs), which correspond to survival improvements, expected to result from implementation. The process uses the Collaboration Habitat Workgroup Method that was developed during the remand collaboration informing the NOAA Fisheries 2008 FCRPS BiOp (incorporated in whole in the NOAA Fisheries 2014 FCRPS Supplemental BiOp; see *http://www.usbr.gov/pn/fcrps/habitat/panels/index.html*).

Summary of Tributary Habitat Accomplishments

Accomplishments through 2015 are presented and summarized below. Flow protection, barrier removal, and habitat enhancement are just some of the tributary habitat improvements delivering benefits to listed salmon and steelhead. A complete list of actions and metrics by population is included in Section 2, Appendix A. Below are some examples of improvements and the cumulative habitat metrics that have been delivered over time.

Protecting and Improving Instream Flow

The Action Agencies support water transactions through a dedicated program of funding. This program has resulted in increased flows to streams historically impacted by water withdrawals. For example, in 2015 the Methow Valley Irrigation District Instream Flow Project was completed after twenty years of negotiation and alternative development. The Twisp River Diversion was removed and irrigation water is now supplied by community and individual wells. The result is increased instream flow in the Twisp River by a minimum of 11 cfs or about a 40 percent increase in summer flows.

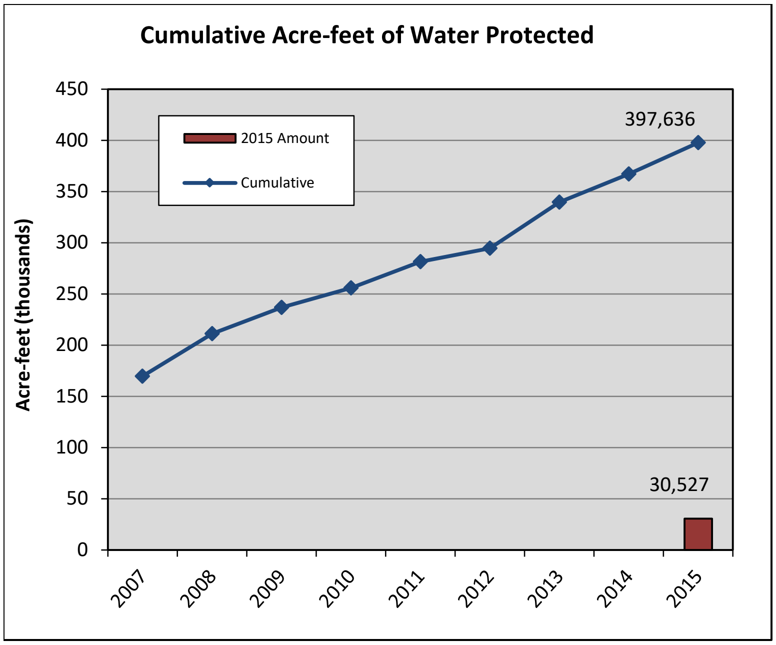


Figure 23. Water secured and protected, in acre-feet of instream flow, 2007–2015. Cumulative acre-feet/year can include annually renewed water leases.

Improving Habitat Complexity

Instream habitat actions that improve complexity have benefitted a number of salmon and steelhead populations. Where habitat complexity is improved, we have routinely seen increased fish use almost immediately. After science-based planning and evaluation identified limitations in complex rearing habitat several actions to enhance floodplain and riparian areas and create more fish habitat by the placement of large wood were implemented. One action in the Middle Fork John Day River in Oregon improved complexity and floodplain connectivity. The Nature Conservancy (TNC) Channel Reconnect Project involved placement of 22 log structures throughout the existing channel, removal of rock barbs and rip rap, and the placement of boulder structures to increase channel roughness and encourage bed deposition. In addition to the structures that were put in place, several levees were removed to open access to two side channels, thus increasing floodplain connectivity.

Figure 24. TNC Channel Reconnect Project (before): Rock barbs and riprap to be removed.

Figure 25. TNC Channel Reconnect Project (after): Log jams placed on alternating sides of the river. These increase habitat complexity, providing shelter for fish.

Figure 26. Catherine Creek, RM 44, Phase 3 (before): Pre-project condition near the lower portion of this project. The broad, shallow stream provided little cover and exposed fish to warmer temperatures.

Figure 27. Catherine Creek RM 44, Phase 3 (after): Showing large woody debris and increased habitat complexity.

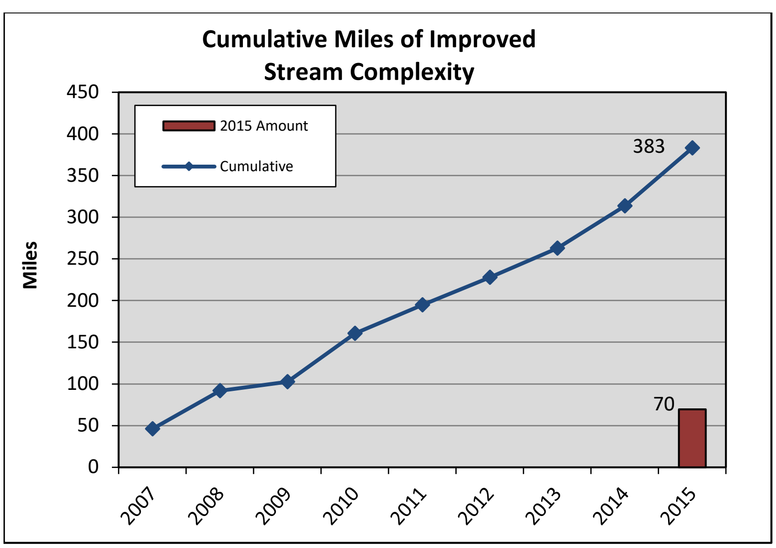


Figure 28. Cumulative miles of improved stream complexity, 2007–2015.

The instream portion of the Catherine Creek River Project was completed during the summer of 2015. This part of the project was designed to increase stream length and channel complexity, and create side channels for juvenile rearing. Through the placement of large wood structures, constructed riffles, and riparian planting this project improves habitat complexity over the course of one mile. This action was "phase three" of a five-phase project within a four-mile section of Catherine Creek. The location was considered among "the best" places to work because it is a primary area for Chinook spawning and rearing.

These and other actions contributed to progress in improving stream complexity, as shown in Figure 28 displaying annual and cumulative metrics.

Riparian Area Improvement and Protection

Unlike flow restoration or barrier removal, which deliver immediate benefits to fish, improvements from riparian revegetation generally accrue over time (Roni et al. 2014). As the features of habitat mature and improve so will conditions for fish. In addition to improving physical habitat, these actions also improve water quality and enhance forage resources. See Figure 30 for annual and cumulative acres of habitat improved.

Figure 29. Riparian area improvement and protection along Catherine Creek in the Grande Ronde basin. The blue arrow shows the alignment of the straightened channel prior to restoration.

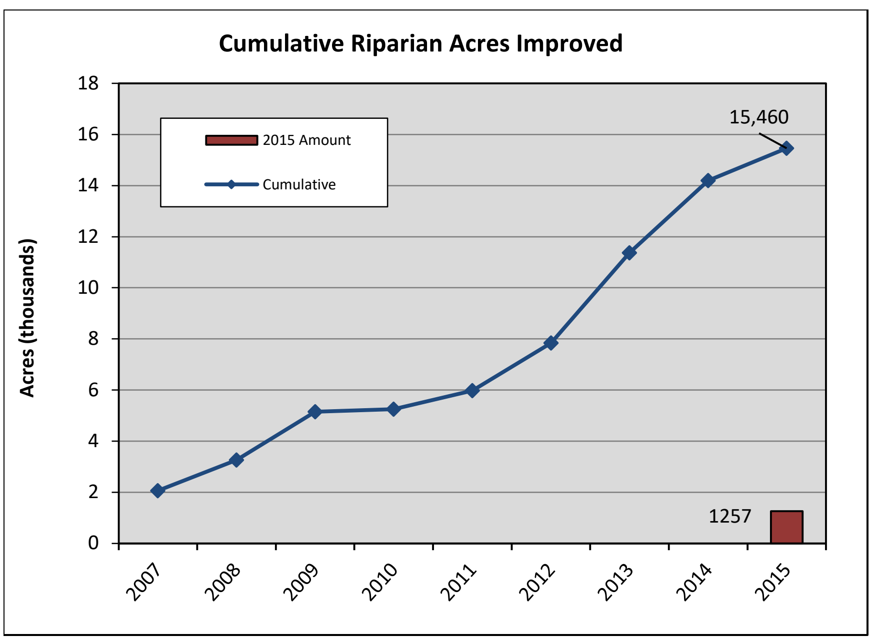


Figure 30. Cumulative acres of riparian habitat improved, 2007–2015.

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 2015, the Action Agencies funded programs in Oregon and Idaho that fabricate screens. In 2015 in the Methow Valley, the Action Agencies with Trout Unlimited, The Methow Conservancy, the Methow Salmon Recovery Foundation, and others converted the Methow Valley Irrigation District West irrigation diversion system to a groundwater fed system, thus eliminating the diversion and the fish screen (Figures 31 and 32). The action has a direct survival benefit because it eliminates entrainment and mortality associated with water withdrawal.

Figure 31. Reducing Fish Entrainment: Methow Valley Irrigation District "pushup" diversion dam prior to permanent removal.

Figure 32. Reducing Fish Entrainment: After removal of Methow Valley Irrigation District "pushup" diversion dam.

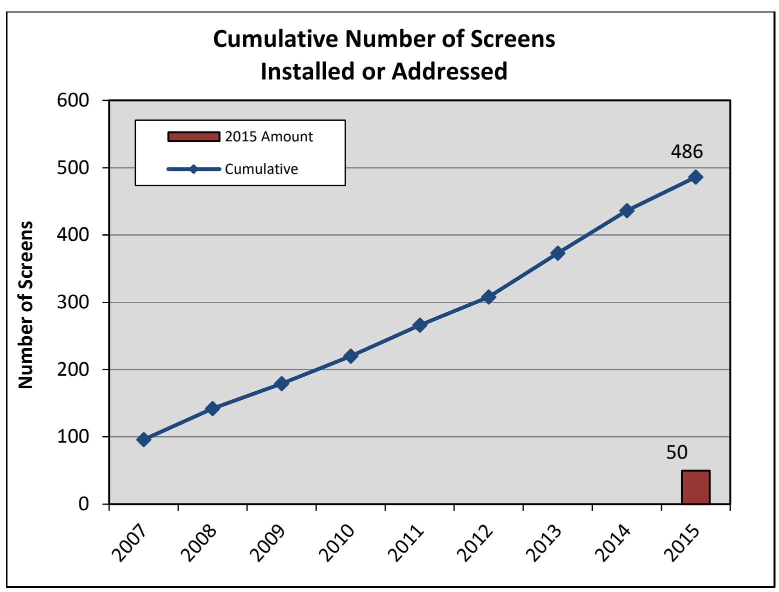


Figure 33. Cumulative number of fish screens installed or improved, 2007–2015.

Figure 34. Pole Creek Diversion Replacement (before): The old diversion structure was a barrier to fish Passage. Idaho Department of Water Resources (IDWR) agreements kept a minimum flow of 17 cfs.

Figure 35. Pole Creek Diversion Replacement (after): The new diversion structure is a low head rock weir that spans the channel and provides water surface elevation high enough to fill the new ditch without inhibiting fish movement.

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 (Figures 34 and 35). Culvert replacement and barrier removal have some of the most immediate benefits to fish because they quickly restore access to habitat. The Pole Creek Diversion Replacement, a multi-faceted project in the Upper Salmon in 2015, removed a passage barrier and installed a fish screen, making 4.7 miles accessible to the headwaters.

Tributary Habitat Improvement Metrics by ESU/DPS

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 2007–2015 in Table 4 by ESU/DPS and are displayed in the metrics charts above (Figures 23, 28, 30, 33, and 36). More details for specific populations can be found in Section 2, under RPA Action 35 and in Appendix A.[6]

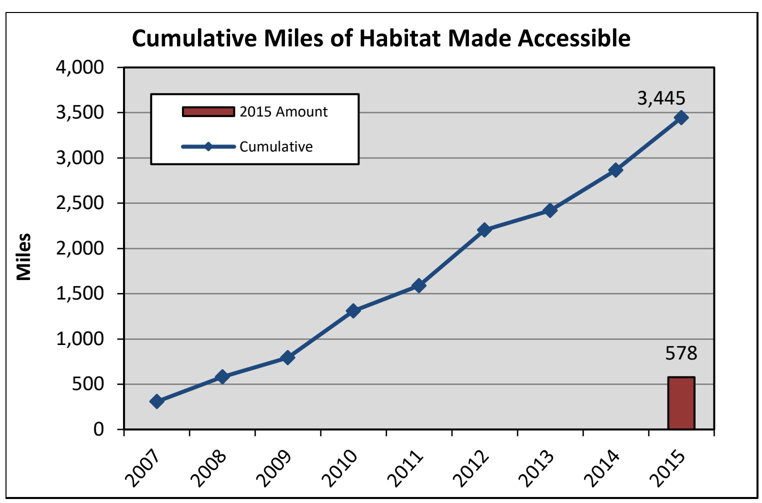


Figure 36. Cumulative miles of habitat made accessible, 2007–2015.

[6] *The Action Agencies identify actions and the extent of treatment in terms of number of acres restored, riparian miles restored, amount of flow restored, etc. Expert panels estimate how implementation of these actions will change the function of limiting factors, and this change in habitat function is then converted, by the Action Agencies (using the method developed by the Collaboration Habitat Workgroup), into an overall change in habitat quality and associated survival improvement.*

Table 4. 2007–2015 Tributary Habitat Improvement Metrics by ESU/DPS. *

Habitat Improvement Metric	Snake River Spring/ Summer Chinook	Snake River Steelhead	Upper Columbia River Spring Chinook	Upper Columbia River Spring Steelhead	Middle Columbia River Steelhead
Acre-feet/year of water protected	58,854.3	58,854.3	23,708.8	39,908.6	94,135.5
Acres protected	2,203.5	2,303.5	283.5	250.0	42,823.5
Acres treated	5,095.5	6,210.3	356.6	1,435.0	7,488.7
Miles of enhanced or newly accessible habitat	980.0	1,036.9	110.4	201.0	1,857.6
Miles of improved stream complexity	142.1	164.6	21.8	28.2	157.5
Miles protected	140.6	179.3	8.32	11.2	1,139.4
Screens installed or addressed	69	69	10	82	265

* Note: Some projects benefit multiple species. In those instances, therefore, metrics by species shown above include numbers for both steelhead and Chinook ESUs/DPSs present in the same watershed.

Estuary Habitat Actions

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. Research demonstrates 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, 2012, 2013). The Action Agencies' projects in the estuary are focused on restoring this important estuarine habitat for the benefit of multiple species of listed juvenile salmon and steelhead.

Implementation of the habitat program in the lower Columbia River and estuary continues to improve over the course of the BiOp period. Efforts in 2015 resulted in a total of 3.4 Ocean Survival Benefit Units (SBUs) and 1.2 Stream SBUs across 7 projects. 2016 efforts yielded 3.7 Ocean SBUs and 1.2 Stream SBUs across another six projects. In 2015 and 2016 the Action Agencies continued to implement the strategies outlined in the Columbia Estuary Ecosystem Restoration Plan documents (BPA and ACOE 2014, Johnson et al. 2014). Below are examples of most significant habitat improvements in the estuary in 2015 and 2016.[7]

Sauvie Island North Unit Phase 3

The Columbia River Estuary Study Taskforce (CREST), a partner organization in the estuary, implemented the third phase of a project intended to restore fish habitat and natural hydrology in the North Unit of the Sauvie Island Wildlife Area, northwest of Portland, Oregon. The project objective was the creation of an accessible mosaic of sloughs, wetlands, and back swamps that supports juvenile salmonid use within the North Unit (Figures 37 and 38). Phase Three included the removal of three water control structures to return full hydrologic access to the Cunningham Lake area. The marsh plain was also scraped down in strategic locations to increase frequency and duration of inundation, benefitting native wetland vegetation species. Other improvements to native plant communities included invasive species control and native plantings. Since 2013 the project has resulted in 329 acres of restored wetland and channel habitats.

[7] *While this Comprehensive Evaluation nominally covers through 2015, since 2016 project information and ERTG scores were available by the time of release of this report, the Action Agencies are providing information on those 2016 projects to demonstrate the continued implementation of their estuary efforts.*

Figure 38. Removal of barrier noted above, regrading of channel and installation of channel-spanning bridge to allow for full tidal flow and fish access to North Unit wetlands and channels.

Figure 37. Pre-construction photo of culvert on South Slough, restricting access to North Unit wetlands.

LaCenter Wetlands

The Lower Columbia Estuary Partnership reconnected approximately 453 acres of floodplain habitat across two large tracts of land on either side of the East Fork Lewis River. Actions included removing a water control structure, improving historic channel structure, lowering, and removing levees to allow for greater connectivity to the East Fork Lewis River, and vegetation enhancement to foster a native plant community.

Figures 39 and 40. Pre and post-construction photos of a regraded, revegetated channel and floodplain in the LaCenter wetlands project. Pre-construction photo on the left is of a non-native monoculture of Reed Canary Grass. Post-construction photo on the right displays greater channel complexity, and greater opportunity for floodplain inundation.

Buckmire Slough Phase 1

CREST successfully constructed the 65-acre first phase of the Buckmire Slough project. Project actions were focused on the removal of two berms and collapsed culverts and the installation of a channel-spanning bridge across Lake River. Additional phases will involve removal of additional fish passage barriers on Lake River, and, in coordination with Washington Department of Fish and Wildlife, floodplain reconnection from the mainstem Columbia River, slated for completion in 2018.

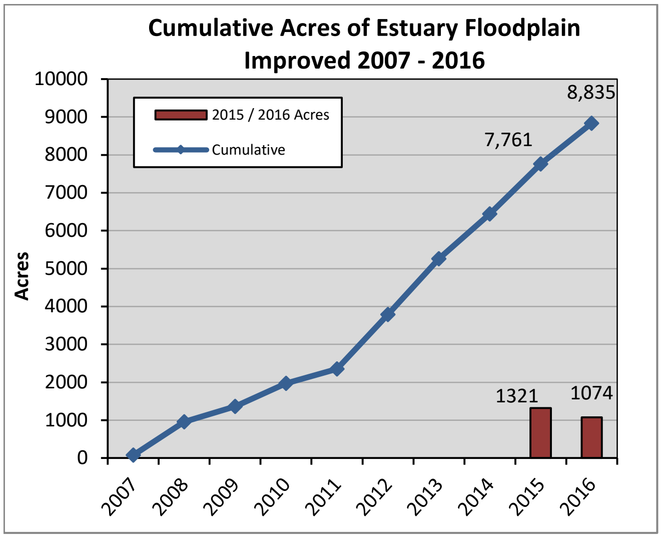
Figures 41 and 42. Pre-construction photo of Barrier #2 on the left, spanning the channel, prohibiting flow. Post construction photo on the right with channel spanning bridge and full reconnection of the channel, allowing for daily tidal exchange and fish access.

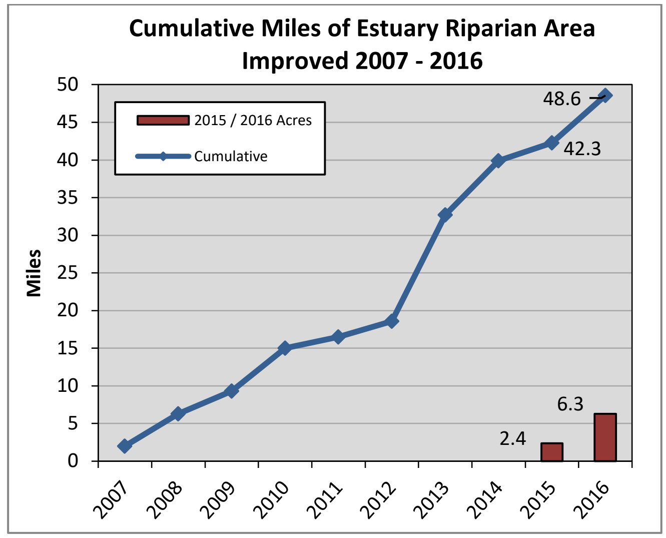
In 2015, the Action Agencies completed on-the-ground habitat actions for seven projects in the estuary, and another six projects were completed in 2016. (See Section 2, Appendix B for status of projects.) In 2015, these projects yielded 3.3 Ocean SBUs and 1.2 Stream SBUs by restoring a total of nearly 1,321 acres throughout the Columbia River estuary (Table 5). The 2016 projects yielded 3.7 Ocean SBUs and 1.2 Stream SBUs. In addition to restoration actions, protecting land under permanent conservation easements further supports habitat and fish conservation in the short and long term, both by enabling future active restoration and by allowing landscape processes to passively restore the site.

As shown in Figures 43 and 44, the 1321 acres protected and restored in 2015 and the 1074 acres protected and restored in 2016 bring the BiOp period cumulative totals through 2016 to over 8800 acres. Projects with full hydrologic reconnection, allowing increased inundation and more wetland habitat, made up the largest proportion of the actively restored acres. The Action Agency restoration strategy has given priority to full hydraulic reconnection given the high biological benefits associated with these types of projects. The other types of restoration described in Table 5 continue to be useful when developing a comprehensive suite of actions at a site and when full reconnection is not possible for social or technical reasons.

Table 5. Summary of estuary habitat restoration metrics, 2015. "CRE" refers to an action type described in NOAA Fisheries' "*Columbia River estuary ESA recovery plan module for salmon and steelhead*" (NMFS 2011).

Action	Acres
Protect riparian areas (CRE 1.3)	0
Restore off-channel habitat (CRE 9.4)	43
Restore full hydrology/access (CRE 10.1)	634
Improve hydrology/access (CRE 10.2)	256
Improve access (CRE 10.3)	0
Reduce invasive plants (CRE 15.3)	343
Use dredged materials beneficially (CRE 6.3)	0
Land Acquisition (CRE 9.3)	46
Total	**1321**





Figures 43 and 44. Cumulative acres of estuary floodplain improved; and cumulative miles of estuary riparian areas improved, respectively, 2007–2016.

Cumulative Implementation

Through 2016, the Action Agencies have implemented estuary habitat actions to achieve a total of 18.2 Ocean and 6.9 Stream SBUs (Figure 45). The Action Agencies also continued to plan and develop additional projects for future implementation to benefit ESA-listed salmon and steelhead, drawing on project opportunities identified by implementation partners and vetted through the collaborative prioritization process, which evaluates expected biological benefits, project costs, and implementation feasibility.

The priorities and biological values of actions in the estuary have shifted significantly since 2008, increasing project costs and complexity accordingly. As an example, after evaluation, the Action Agencies determined the benefits of pile dike removal were uncertain, and such actions were dropped from the program. As another example, SBU scores for stream-type fish were lowered, resulting in additional work needed to meet the BiOp targets. As a result, from 2012 to present the estuary program has focused on a subset of the CRE actions from the *Columbia River Estuary ESA recovery module* (NMFS 2011), which are the essential actions for successfully restoring floodplain ecosystems. Reconnecting, either fully or partially, hydrologic access (CRE 10.x), restoring off-channel habitat (CRE 9.4), and reducing invasive plants (CRE 15.3), are the fundamental components of all estuary restoration projects. Projects of greater size and habitat complexity are generally considered to be of highest value and priority. However, such projects can be more challenging to design and construct. The Columbia Estuary Ecosystem Restoration Program (CEERP) annually updates its strategy, reviewing new science and completed projects, to ensure that any refinement in approach, to any one or more of these habitat restoration actions, is incorporated into future projects.

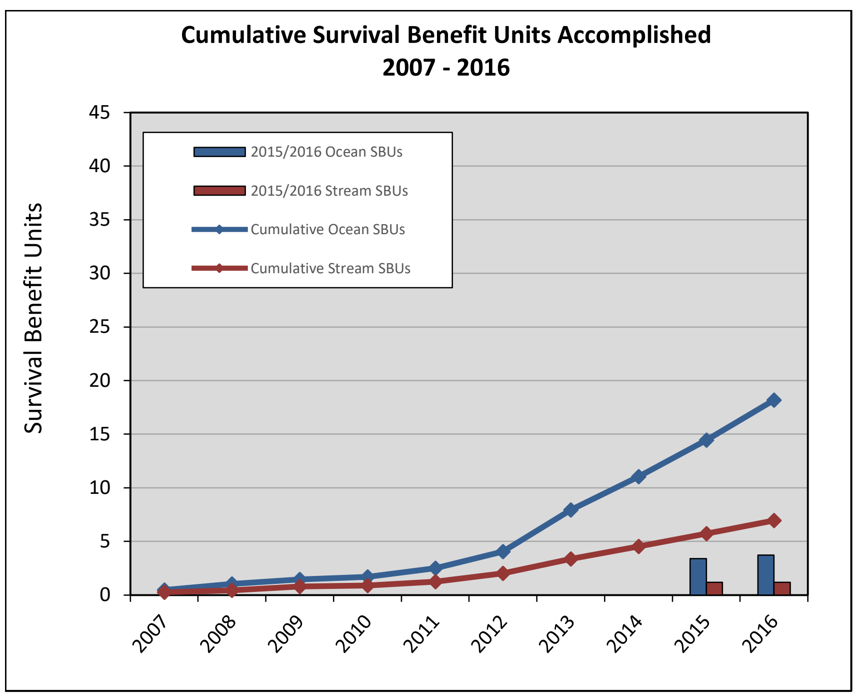


Figure 45. Cumulative survival benefit units (SBUs) accomplished, 2007–2016.

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 and other hatcheries to support tribal, commercial and sport harvest (Figure 46). Many of these hatchery fish are also part of the listed ESU/DPS, providing essential genetic resources and enhancement potential. In order to ensure that these programs advance and do not impede recovery of naturally spawning ESA-listed salmon and steelhead, the Action Agencies worked with hatchery operators to prepare updated hatchery and genetic management plans (HGMPs) for these facilities and programs, which have all been submitted to NOAA Fisheries. The HGMPs identify operations to meet production requirements and to reduce or eliminate detrimental genetic and ecological effects on listed species.

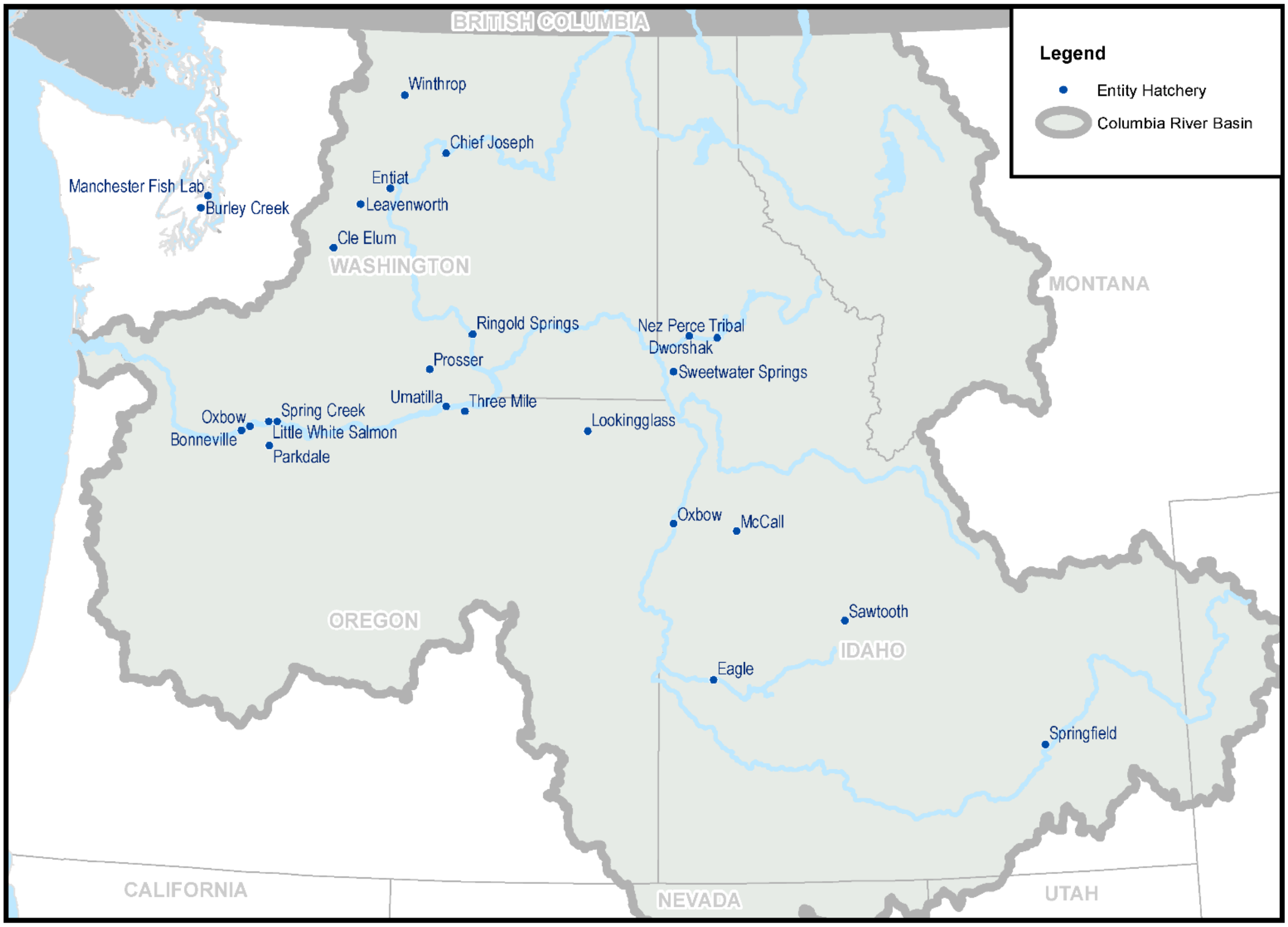


Figure 46. Action Agency-funded anadromous fish hatcheries providing off-site mitigation for FCRPS dams.

By the close of 2014, the Action Agencies had reviewed and commented on draft HGMPs for all of the 45 Action Agency-funded hatchery programs, 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. No further changes occurred in 2015 as the Action Agencies await consultation with NOAA Fisheries.

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.

Reclamation continued funding collection of local broodstock and managing returning adult steelhead for the Methow Upper Columbia steelhead program. The last group of summer steelhead to be raised in a 1-year rearing cycle were released in 2015. Local broodstock collection in 2015 was sufficient to meet hatchery needs despite difficult high water conditions caused by an unusually early localized runoff event. USFWS continued to manage returning Winthrop National Fish Hatchery-produced, Wells Hatchery, and unknown hatchery-origin steelhead on the spawning grounds in 2015. All hatchery-produced steelhead collected at the hatchery or via angling were removed from the naturally spawning population.

BPA continued to fund projects reconditioning upper and middle Columbia River kelts, steelhead that survive to spawn again in subsequent years. Kelt reconditioning as a conservation tool is intended to enhance populations that have suffered decline. A near-term improvement in productivity can be a means to offset long and short-term demographic perils and minimize loss of genetic and/or life history diversity. Kelt reconditioning programs can work in conjunction with restoration or remediation efforts. Re-establishment or enhancement of repeat spawning in listed steelhead populations can improve productivity, diversity and demographic stability. Since 2008, the Action Agency funded kelt reconditioning projects have successfully reconditioned and released over 2,300 repeat spawning steelhead in the Upper Columbia, Mid-Columbia and the Snake River basins.

The Action Agencies also continued to fund safety-net programs to reduce the extinction risk of at-risk populations of ESA-listed Snake River spring/summer Chinook and Snake River sockeye salmon. By 2015, BPA had phased out funding for Snake River spring/summer Chinook as safety-net programs because the programs successfully met their returning adults goals. The programs continue to be funded as conservation programs to support Upper Grande Ronde, Lostine River, Catherine Creek and Johnson Creek populations.

The Snake River Sockeye Salmon Captive Broodstock Program preserves this critically 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, 6,275 adults from the program have returned to Idaho's Redfish Lake or to the Sawtooth Hatchery weir on the upper Salmon River (Figure 47). In 2015, due to unusually high air and water temperatures, including in the Salmon River and its tributaries, only 56 adult sockeye returned in-river to the Salmon River sub-basin. Emergency trap and haul procedures were implemented at Lower Granite Dam and 51 adult sockeye were collected. A genetic assessment of the collected adults revealed that 35 were assigned as Snake River Sockeye (natural origin = 3, hatchery origin = 32) and the remaining 16 were determined to be from Wenatchee or Okanogan stocks. Despite the low returns to the Salmon River, the safety-net program proved to work as intended. Using a combination of captive brood (1,430 fish) and natural origin (82 fish) adults, the program was able to achieve its increased production goals of approximately 750,000 brood year 2015 smolts (i.e. increase production associated with Springfield Hatchery) and was still able to release captive adults to spawn naturally into Redfish Lake (494 fish) and Pettit Lake (93 fish).

As a follow up to the poor river and tributary conditions in 2015 and the need to implement an emergency trap and haul procedure for Snake River sockeye at Lower Granite Dam, NOAA Fisheries, in consultation with Action Agencies and co-managers, developed an after-action report outlining the lessons learned and future implementation strategies if such river conditions are observed again (NOAA Fisheries 2016).

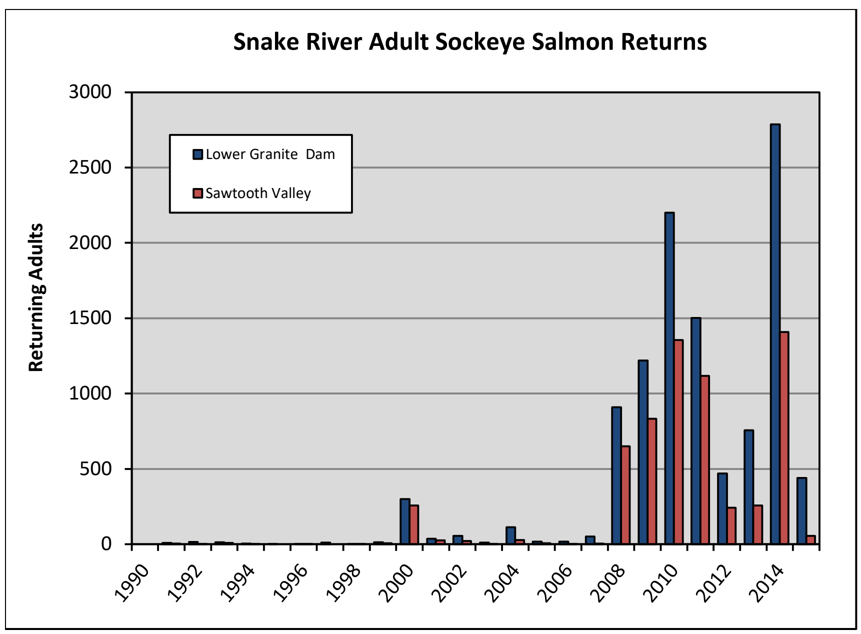


Figure 47. Adult sockeye salmon returns to Lower Granite and to the Redfish Lake Creek or Sawtooth Hatchery weirs on the upper Salmon River, Idaho, 1991–2015.

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, linked through a common NOAA biological analysis. 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. Terminal area 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

Five main predator species are major causes 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 middle Columbia region, but at lower numbers. 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. The Action Agencies efforts to manage predation by sea lions focused on non-lethal deterrent actions at Bonneville Dam, while NOAA Fisheries and others take the lead on lethal removal options and permits and the broader issue of predation from the mouth of the river upward.

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 and the Columbia Basin, 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 2015, the Action Agencies continued these efforts to control specific predators and improve survival of juvenile fish.

Avian Predation

Caspian Terns in the Estuary

The Action Agencies have created Caspian tern nesting habitat outside of the Columbia Basin to allow a reduction in the amount of nesting habitat on East Sand Island, decreasing the number of birds there and thereby decreasing predation in the estuary. In 2015, the Corps completed construction of 1.83 acres of nesting habitat in the USFWS Don Edwards National Wildlife Refuge (NWR) in South San Francisco Bay. As a result, for the 2015 breeding season a total of 7.63 acres was available to terns at seven created sites in southern Oregon, northern California, and San Francisco Bay. These sites are listed in Table 6 below. An estimated combined total of 1,059 breeding pairs of Caspian terns attempted to nest at five of these islands in southern Oregon and northern California in 2015 (Collis et al. 2015), a considerable increase over 2014 and almost as many as in the record year of 2013. An additional estimated 224 pairs attempted to nest at the San Francisco Bay site (Hartman et al. 2016).

Table 6. Status of Caspian Tern Nesting Islands for the 2015 Breeding Season (Collis et al. 2015).

Location	Acres Available in 2015	Completion Date	Social Attraction	Watered
Fern Ridge Reservoir (OR)	1.0	Feb 2008	Yes	Yes
Crump Lake (OR)	1.0	Mar 2008	No	No
East Link Unit, Summer Lake Wildlife Area (OR)	0.5	Dec 2008	Yes	Yes
Dutchy Lake, Summer Lake Wildlife Area (OR) *	0.0	Feb 2009	NA	NA
Sump 1B, Tule Lake NWR (CA)	2.0	Aug 2009	Yes	Yes
Gold Dike Unit, Summer Lake Wildlife Area (OR)	0.5	Sep 2009	Yes	Yes
Orems Unit, Lower Klamath NWR (CA)	0.0	Sep 2009	No	No
Sheepy Lake, Lower Klamath NWR, (CA)	0.8	Feb 2010	No	Yes
Malheur Lake, NWR (OR)	1.0	Feb 2012	Yes	Yes
Don Edwards NWR, San Francisco Bay (CA)	1.83	Feb 2015	Yes	Yes
*Island removed in 2012. No management or monitoring in 2014.				

Due to the increase in the acreage of alternative nest sites, the area made available for tern nesting at East Sand Island in 2015 was reduced to 1.0 acre, the minimum size considered in the Caspian Tern Management Plan, and a substantial reduction from the 1.55 acres made available in 2014.

Despite the decrease in nesting area made available, the Caspian tern colony on East Sand Island consisted of about 6,240 breeding pairs in 2015, nearly identical to the estimated 6,270 pairs present in 2014 (Figure 48). This is a decrease from the estimate of 7,400 pairs in 2013, and is the smallest colony size recorded at East Sand Island since the initiation of reductions in tern nesting habitat on the island in 2008, when the colony numbered over 10,000 breeding pairs. However, this remains above the target colony size of 3,125 breeding pairs set forth in the Tern Environmental Impact Statement and Record of Decision. Average nesting density in 2015 was 1.32 nests/m^2 within the 1.0 acre core colony area. This is the highest Caspian tern nesting density recorded on East Sand Island, well above the 1.06 nests/m^2 in 2014 and 1.17 nests/m^2 seen in 2013. The Caspian tern colony on East Sand Island produced roughly 3,700 fledglings in 2015, an average of about 0.59 young raised/breeding pair. This nesting success rate is higher than the average for the 2010–2014 period, but substantially lower than the average for the 2000–2009 period.

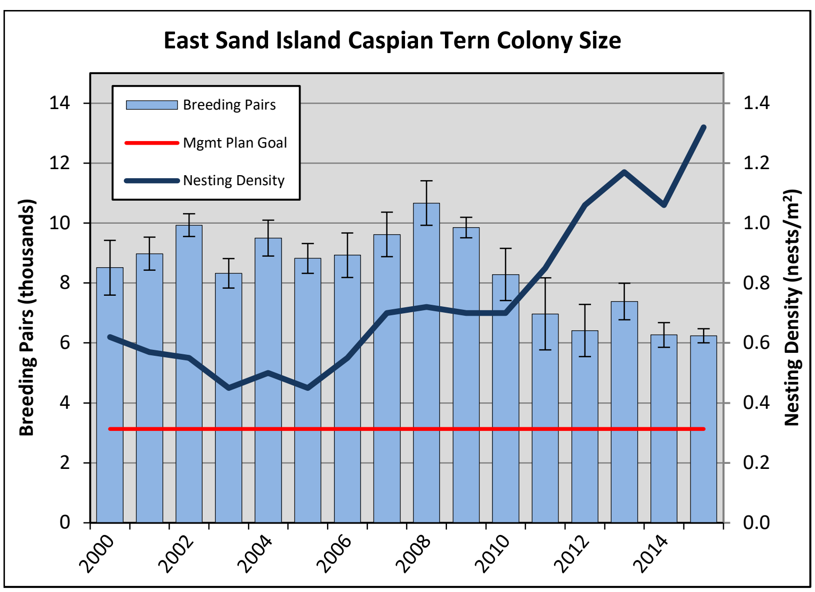


Figure 48. Abundance of Caspian terns on East Sand Island, 2000–2015. Error bars represent 95% c.i. The red line represents the lower limit of the target colony size specified in the Caspian Tern Management Plan (3,125 to 4,375 nesting pairs). (Data from Roby et al. 2016.)

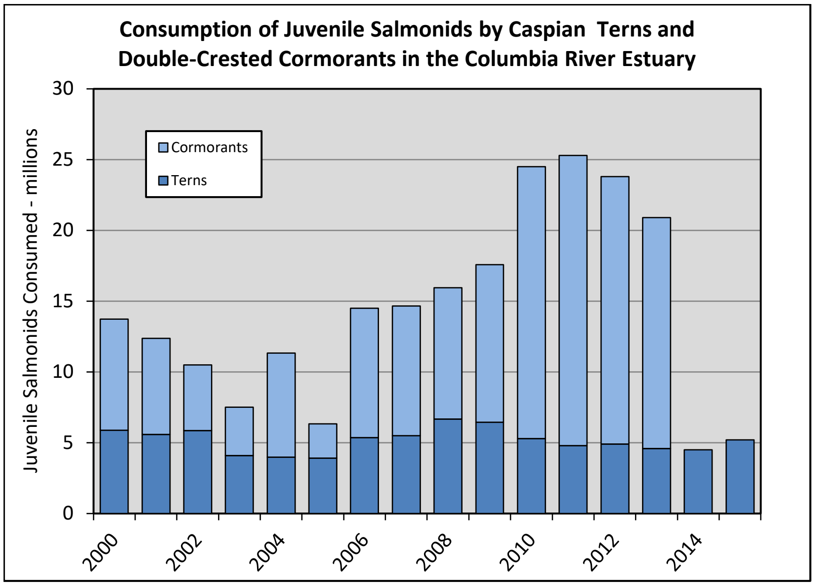


Figure 49. Consumption of juvenile salmonids in the Columbia River Estuary, 2000–2015. Estimates of total cormorant consumption of juvenile salmonids in 2014 and 2015 were not available at time of writing. (Tern data and 2003–2013 cormorant data from Roby et al. 2016. Cormorant data 2000–2002 from K. Collis, pers. comm.)

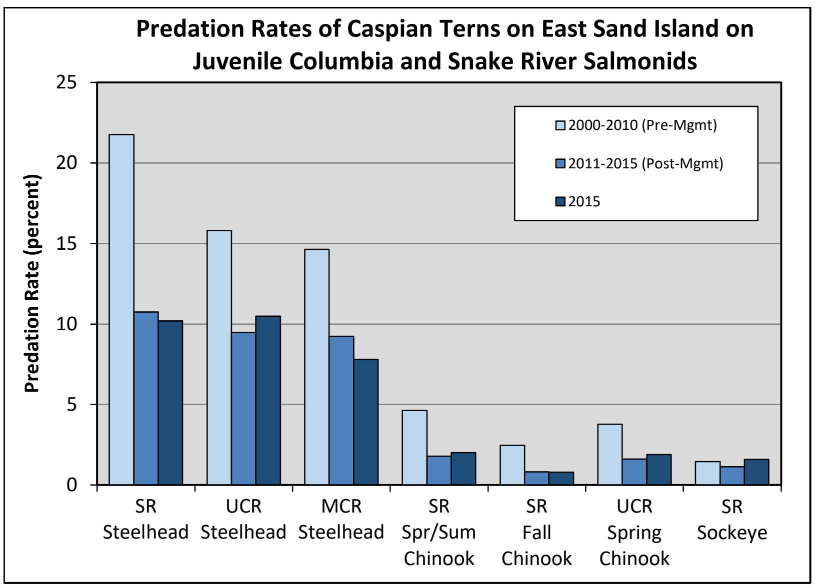


Figure 50. Predation rates of Caspian terns on East Sand Island on listed Columbia and Snake River salmonids. (Data from Evans et al. 2016.)

The average proportion of juvenile salmon and steelhead in the diet of Caspian terns during the 2015 nesting season was 38 percent, slightly higher than the 31 percent average over the previous 15 years. The estimated total smolt consumption by Caspian terns nesting at East Sand Island in 2015 was 5.2 million (95 percent c.i. = 4.6–5.9 million), not significantly different from total annual smolt consumption during 2011–2014 (Figure 49). In 2015, similar to previous years, Caspian tern predation rates were 5–10 times higher on populations of steelhead smolts (8.6–11.4 percent, depending on DPS) compared with populations of salmon (0.9–1.6 percent depending on ESU). Predation rates on specific populations of salmonids (ESUs/DPSs) by Caspian terns in 2015 were similar to those observed during 2011–2014, but, with the exception of Snake River sockeye, were considerably lower than the average for the 2000–2010 pre-management era (Figure 50). For example, predation by Caspian terns averaged 21.8 percent from 2000 to 2011 prior to management actions while after initiation of management actions, from 2011 through 2015, average predation rates by terns on Snake River steelhead averaged 10.7 percent.

Similar to previous tern nesting habitat reductions on East Sand Island, reducing the tern area from 1.5 acres to 1 acre did not substantively reduce the number of terns nesting on the island. However, there were promising indicators that suggest that over time, more terns may opt to nest elsewhere. The habitat created at Don Edwards National Wildlife Refuge attracted 224 nesting pairs in its first year and the created sites in southern Oregon and northern California attracted nearly as many terns as the 2013 record year, despite drought conditions in that region. Given time, nesting terns may continue to spread out along these West Coast habitats, resulting in a reduction in the number of terns on East Sand Island. In any case, estuary tern management actions taken to date have clearly reduced the Caspian tern predation rate on juvenile salmonids when comparing pre- and post-management years (Figure 50).

Cormorants in the Estuary

In 2015, the colony consisted of about 12,150 breeding pairs, down from the 13,626 pairs recorded in 2014 and the 14,916 pairs seen in 2013, but higher than the average annual estimate of 11,809 for 2000–2013 (Figure 51). Predation rates on some ESUs in 2015 were the highest recorded since the colony was first scanned for PIT tags in 1999 (Figure 52). For example, the estimated rate of predation by East Sand Island Double-crested cormorants on Snake River spring/summer Chinook in 2015 was 14.5 percent (95 percent c.i. = 10.5–22.4 percent), even higher than the previous record 2014 estimate of 8.5 percent (95 percent c.i. = 6.1–13.2 percent) and roughly 3–15 times higher than those recorded during 1999–2013 (about 0.9–6.8 percent). Analysis indicates that Double-crested cormorants consume juvenile salmonids in proportion to their relative availability, with the highest predation rates in May, when the largest numbers of PIT-tagged smolts were available in the estuary (Evans et al. 2016).

After conducting its NEPA process, the Corps published its *Double-Crested Cormorant Management Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary: Final Environmental Impact Statement* in the Federal Register on February 6, 2015, and on March 19, 2015, the Corps' Record of Decision was signed. The alternative selected for the recommended management plan included a combination of culling adult birds and oiling eggs. In March 2015 the Corps applied for a depredation permit from USFWS and received a one-year depredation permit on April 13, 2015 for Double-crested cormorant culling and egg oiling. The Corps completed the first year of implementation in 2015, with 2,346 adults culled and the eggs in 5,089 nests oiled. However, almost all of the culling took place after the end of the juvenile salmonid out-migration, so the 2015 management actions would have almost no effect upon the 2015 predation rate (Evans et al. 2016).

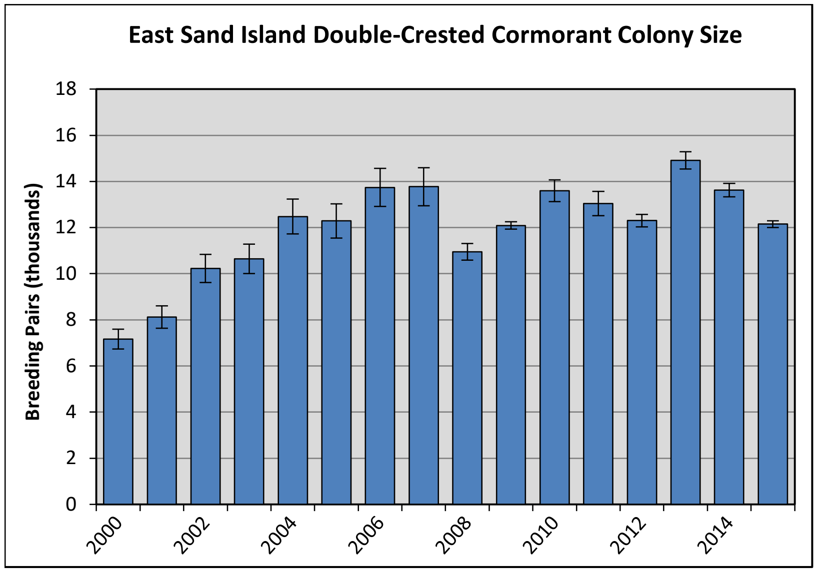


Figure 51. Abundance of double-crested cormorants on East Sand Island, 2000-2015. Error bars represent 95% c.i. (Data from Roby et al. 2016)

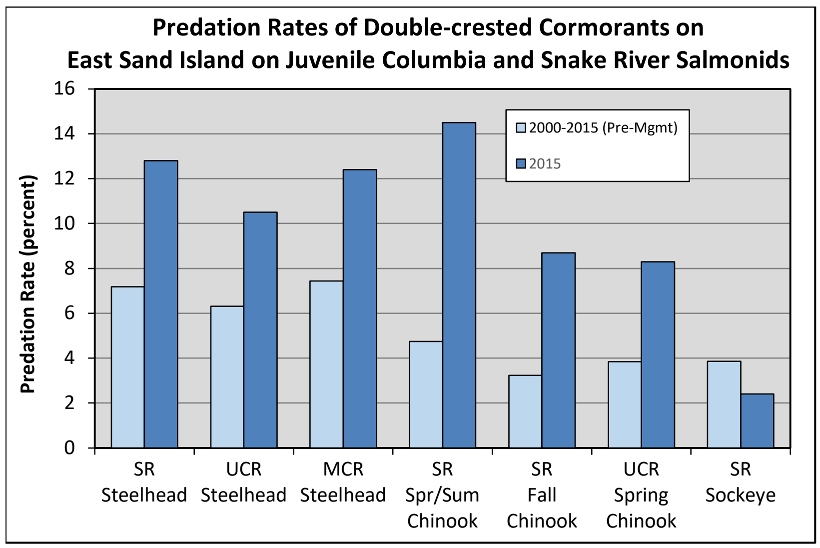


Figure 52. Predation rates of double-crested cormorants on East Sand Island on listed Columbia and Snake River salmonids. (Data from Evans et al. 2016.)

Inland Avian Predation

In 2015, the Action Agencies continued implementation of the Inland Avian Predation Management Plan (IAPMP). The IAPMP is a 5-year, phased, habitat-based management plan primarily addressing Caspian tern predation within the Columbia River Basin upstream of Bonneville Dam. 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 Goose Island (Reclamation-owned lands in Potholes Reservoir near Othello, Washington), where a Caspian tern colony was preying heavily on Upper Columbia River steelhead. IAPMP implementation Phase I actions in 2014 by the Corps and Reclamation focused primarily on dissuading Caspian terns from Goose Island through use of rope, flagging, and active hazing, and on developing Caspian tern nesting habitat at the USFWS Don Edwards NWR. With completion of the Don Edwards NWR nesting habitat in February, 2015, the Corps and Reclamation implemented Phase II dissuasion actions at both Goose Island and at Crescent Island in the McNary Dam reservoir. Implementation of the IAPMP is already yielding encouraging results, as shown in Table 7. Management efforts in 2014 and 2015 reduced the Goose Island colony predation rate on Upper Columbia River steelhead from a 2007-2013 average of 15.7 percent to 2.9 percent in 2014 and 1.5 percent in 2015, and the predation rate on listed Upper Columbia River Spring Chinook from a 2009-2013 average of 2.6 percent to 0.6 percent in 2014 and 0.1 percent in 2015. Those efforts also reduced the Crescent Island colony predation rate to less than 0.1% per ESU (Collis et al. 2016). However, during 2015 the historically small Caspian tern colony on Blalock Island in John Day Dam reservoir increased in size, offsetting a substantial amount of the benefits realized by reduction of the colonies on Goose Island and Crescent Island.

Table 7. Estimated ESU/DPS-specific predation rates, in percent, by Caspian terns from Goose Island in Potholes Reservoir and from Crescent Island in McNary Reservoir. Management actions began in 2014 at Goose Island and in 2015 at Crescent Island. (Data from Collis et al. 2016)

Year	Upper Columbia River Steelhead	Upper Columbia River Chinook	Snake River Steelhead	Snake River Spr/Sum Chinook	Snake River Fall Chinook	Snake River Sockeye
Goose Island						
2007–2013 average (before management)	15.7	2.6	0.1	<0.1	0.1	0.2
2014–2015 average (after management)	2.2	0.4	0.1	<0.1	<0.1	<0.1
Crescent Island						
2007–2014 average (before management)	2.4	0.5	3.9	0.7	0.9	1.1
2015 (after management)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

The Corps' avian deterrent program at the eight lower Columbia and lower Snake River hydroelectric facilities continued to be addressed through the Fish Passage Operations and Maintenance group and was included in the Fish Passage Plan as called for by the RPA.

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, through the Northern Pikeminnow Sport Reward Fishery, to provide the majority of the catch of northern pikeminnow. In 2015, the BPA monetary reward for the catch of this predator was increased to a higher level than the one initiated in 2004. The increased reward structure helps sustain higher catches; the 2015 catch was 200,114 fish, over 20 percent more than the catch in 2014 (Figure 53). The increased reward also helped increase the exploitation rate in 2015 (Figure 54).

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 7,693 northern pikeminnow were caught at those locations in 2015.

In 2015, the exploitation rate on northern pikeminnow was 17.2 percent (Figure 54). This rate was based on a total catch of

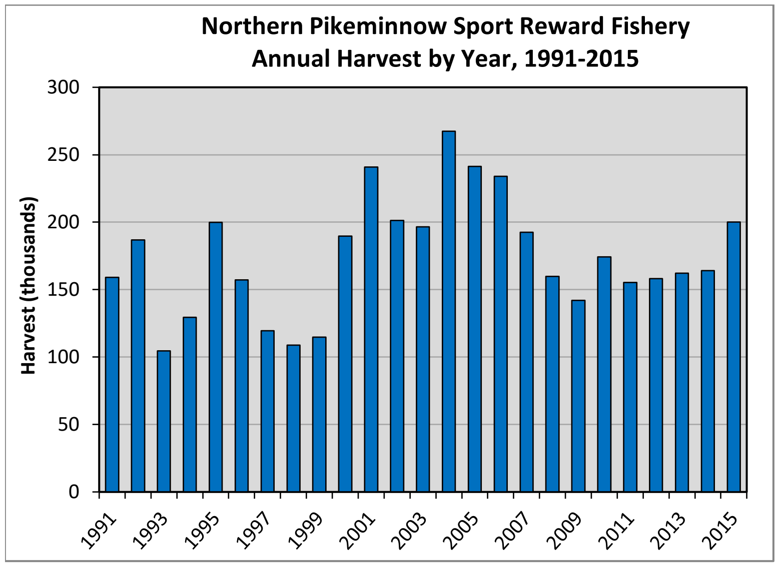


Figure 53. Northern Pikeminnow Sport Reward Fishery catch by year, 1991-2015.

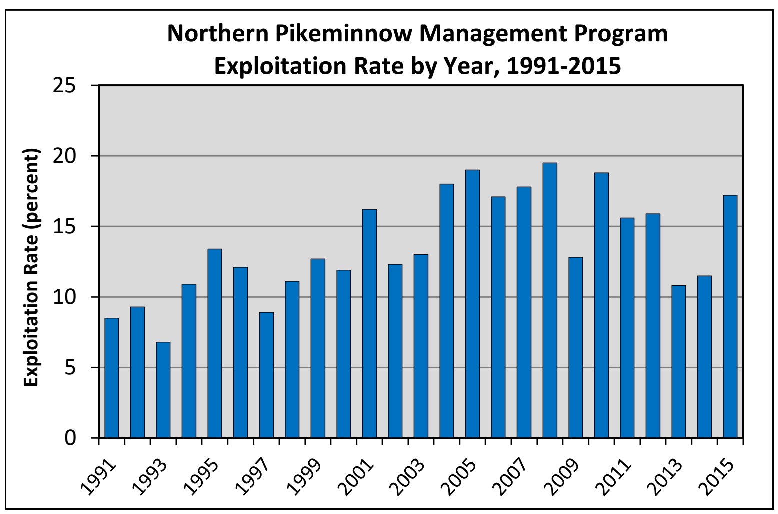


Figure 54. Northern Pikeminnow Management Program exploitation rate by year, 1991-2015. Exploitation rate is based on the total catch from both the Sport Reward Fishery and the dam angling program.

207,807 from the sport reward fishery and the dam angling program.

The NPMP has removed more than 4.5 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 3 to 5 million juvenile salmon annually that otherwise would have been eaten by this predator.

Sea Lions at Bonneville Dam

In recent years, California sea lions (CSLs) and Steller sea lions (SSLs), 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 on adult spring Chinook salmon, winter steelhead, Pacific lamprey, and white sturgeon. Initially, sea lions would arrive at Bonneville in middle to late February, and leave by the first week in June. However, in recent years some SSLs have started to arrive during the fall months to prey upon adult fall Chinook and coho salmon, steelhead, and white sturgeon.

Photo of sea lion with salmon

Corps biologists began gathering data on sea lion presence and predation at the dam in 2001. In 2015, the total number of different pinnipeds seen at Bonneville Dam increased considerably, from 137 in 2014 to 264 in 2015. Nearly all the increase was due to CSLs (Figure 55).

The number of fish eaten by sea lions reached an initial peak in 2010, declined somewhat in 2011 through 2014, but increased considerably in 2015 (Figure 55 and Table 8). In 2015, estimated (expanded) consumption was 9,981, about 4.0 percent of all salmonids counted at Bonneville Dam from January 1 through May 31. Salmon and steelhead consumption by SSLs had increased in the last several years, with SSLs responsible for approximately half of the total consumption in 2013. However, with the increase in the number of CSLs seen at Bonneville in 2014 and 2015, CSLs were responsible for 78 percent of the estimated minimum salmonid fish catch during the 2015 monitoring season.

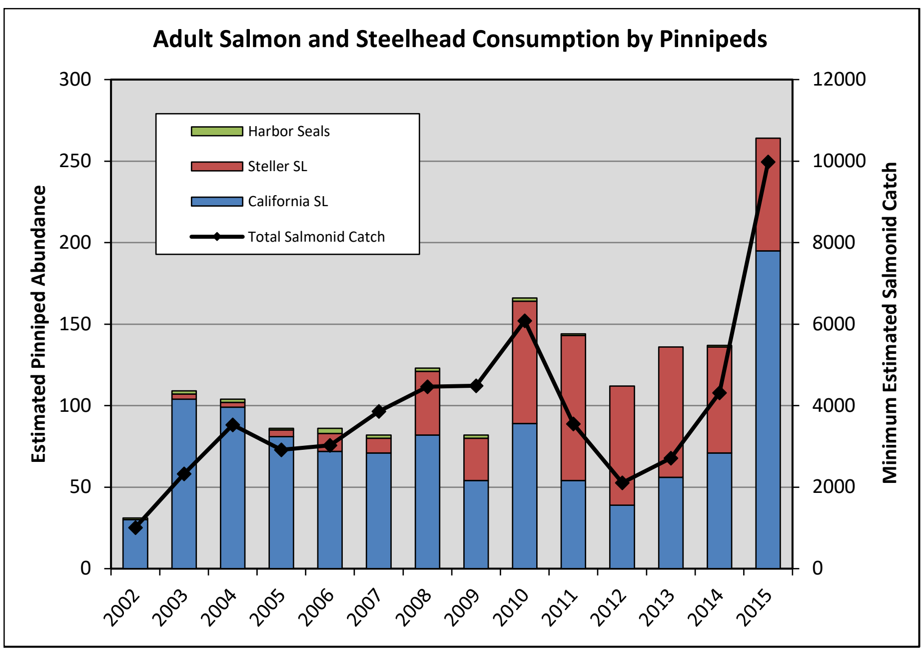


Figure 55. Estimated minimum number of adult salmon and steelhead consumed by pinnipeds and estimated total number of pinnipeds seen at Bonneville Dam January 1–May 31, from 2002 to 2015. In 2005, regular observations did not start until March 18. Pinnipeds observed included California sea lions, Steller sea lions, and harbor seals. Data from Fish Field Unit 2016.

Table 8. 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 2015. 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. Data from Fish Field Unit 2016.

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–May 31)	Estimated consumption	Percent of run (Jan. 1–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	3.6	2,920	3.4
2006	105,063	3,023	2.9	3,520	3.4
2007	88,474	3,859	4.4	4,507	5.1
2008	147,558	4,466	3.0	5,099	3.5
2009	186,056	4,489	2.4	5,134	2.8
2010	267,127	6,081	2.3	6,542	2.4
2011	223,380	3,557	1.6	3.970	1.8
2012	171,665	2,107	1.2	2,382	1.4
2013	120,619	2,714	2.3	2,954	2.4
2014	219,929	4,314	2.0	4,746	2.2
2015	239,326	9,981	4.0	10,859	4.3

The objectives of the Corps' pinniped activities 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, steelhead and other fish; and 4) evaluating the effectiveness of hazing and other deterrent measures.

In 2015, the Corps again contracted with U.S. 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 began on March 18 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), rubber buckshot, and underwater "seal bomb" percussive devices. 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 2015, 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 in the tailrace 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.

In 2015, ODFW and WDFW operated four floating sea lion traps in the Bonneville Dam tailrace as they have for the past several years. All SSLs captured were released back to the tailrace without further handling. A number of CSLs, already branded, were recorded and released without further handling. A total of 131 CSLs were trapped, branded and released between April 6 and May 22. Another 32 CSLs, having been trapped in previous seasons and on the list of 94 individuals authorized for permanent removal from the population, were captured and removed by state personnel. Of these, 2 were sent to zoo facilities and 30 were euthanized. In addition, 2 CSLs and 1 SSL died in accidents involving the traps.

Research, Monitoring, Evaluation, and Adaptive Management

The Action Agencies implement an extensive Research, Monitoring, and Evaluation (RME) Program that generates data critical to improve action efficiency and effectiveness through adaptive management, and supports accountability for action implementation. The Action Agencies use the best available scientific information from this program to help ensure that actions meet the BiOp and broader Northwest Power Act goals and performance standards.

RME is implemented through BPA's Fish and Wildlife Program, the Corps' Anadromous Fish Evaluation Program, and Reclamation's technical assistance activities. The Action Agencies coordinate with other state, federal, and tribal aquatic habitat and ESA-listed salmon and steelhead monitoring programs, and state and tribal constituents through several forums including the Pacific Northwest Aquatic Monitoring Partnership.

The Action Agencies carry out RME for fish population status, hydrosystem, tributary habitat, estuary/ocean, harvest, hatchery, predation, and regional coordination and data management. Refer to Section 2 of this CE for a complete list of Action Agency funded RME projects. Summaries of significant results are included in the sections below. Additional project details, sponsor reports, and a PDF compilation of all 2015 RPA subaction reports can be found at: *http://www.cbfish.org/BiologicalOpinionAction.mvc/Index/2015/BiOpRpaStatus*.

Fish Status and Trend Monitoring

As part of its hydro mitigation efforts, BPA funds a substantial amount of the salmon and steelhead fish status and trend monitoring in the mid and upper Columbia Basin. The fish status and trend monitoring program includes data collection for listed and non-listed fish, including 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 to assess progress on the region's rebuilding targets, BiOp contingency triggers, and other purposes. Fish status is also a useful indicator in prioritizing and evaluating tributary and estuary restoration actions, hatchery management actions, predation management, and harvest management.

The fish status and trends monitoring actions primarily focus on 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"), hatchery production and related monitoring, and adult and juvenile salmon passage and survival through the hydrosystem.

Significant Results

- Long-term trends of spawner abundance show that since listing, the majority of species have improved based on an assessment of average annual population growth (Lambda). While ocean conditions are a dominant factor in fish survival, other landscape factors, including contributions from the Action Agencies hydro and habitat projects, also play an important role.
- Natural Spawner Escapement: Since 2001, natural-origin adult escapement trend has increased for the majority of species evaluated (BPA Project 1983-350-03). Using the 4-year change in the 5-year geometric mean highlights the significant improvements in spawner abundance that have occurred during the latter part of the current BiOp period. Short term patterns are a result of multiple factors including ocean conditions.
- Fish RME results demonstrated that degraded Umatilla River habitat accounts for an estimated 85 percent of the mortality of summer steelhead and spring Chinook salmon during adult migration, spawning, rearing and juvenile migration in the Umatilla River drainage. These results highlighted the value of restoring critical juvenile rearing and overwintering habitat for improving conditions for these fish, and were incorporated into the habitat prioritization for the off-site habitat work funded by BPA. (Project 1990-005-01 - Umatilla Basin Natural Production Monitoring and Evaluation)

Hydro RME

RME actions are conducted in the FCRPS to evaluate compliance with survival and performance standards 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 actions 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.

Given the lead time needed to put a dam survival study in place, there were no individual dams studied in 2015. Although there were no individual dams studied in 2015, ongoing monitoring of travel time and survival through the entire hydrosystem continued, the results of which are discussed below.

Significant Results for 2015

- 2015 Juvenile Salmon and Steelhead Migration Conditions: Faulkner et al. (2016) summarized the 2015 migration conditions as follows: "The lower survival estimates in 2015 for yearling Chinook, steelhead, and sockeye were associated with a set of extreme environmental conditions and unusual operational conditions compared to past years. In general, the combination of conditions in the Snake River during the 2015 spring migration was unlike any year in our time series. Water temperatures and spill percentages reached record highs while flow was near record low. In terms of flow, 2015 was most like 1994, 2001, and 2007. In terms of spill percentages, 2015 was most like 2008 and 2010. In terms of water temperature, there are no comparable years in our times series due to the highs reached later in the migration period."
- Smolt travel time: In 2015, as noted above, flows were low, and the mean percentage spill at dams with fixed spill targets such as Bonneville and Lower Granite were much higher than average. Travel times for both Chinook and steelhead between Lower Granite Dam and Bonneville Dam were longer in 2015 than in some recent years (2008-2014), but still shorter than the long-term average (1998-2015) and shorter than most other low-flow years (See discussion and figure 1-3 in Faulkner et al. 2016). This suggests that structural and operational changes in the hydrosystem have effectively decreased fish travel times relative to water travel time.
- Smolt Survival: Unfortunately, the improved travel time observed in 2015 compared to other low flow years only translated moderately improved in-river survival compared to equivalent warm/low-flow years such as 2001 and 2004, particularly for steelhead. As noted in Faulkner et al. (2016):
    - For combined hatchery and wild Snake River yearling Chinook salmon, estimated survival through the entire hydrosystem, from the Snake River Trap to Bonneville tailrace, was 38.9 percent, in 2015. This estimate was the third lowest out of 17 years with observations (1999-2015), and below the long-term average of 49.4 percent.
    - For combined hatchery and wild Snake River steelhead, estimated survival through the entire hydrosystem was 36.4 percent in 2015. This estimate was below the long-term mean of 45.1 percent and was the fourth lowest estimate in the time series.
    - For sockeye salmon originating in the Snake River Basin, estimated survival from Lower Granite to Bonneville Dam was 37.3 percent in 2015. This estimate was low, but there are five lower estimates in the time series for sockeye through that reach. Similarly, for sockeye originating in the Upper Columbia Basin, estimated survival between Rock Island and Bonneville Dam was 34.0 percent.
- Juvenile Transport: In 2015, the fraction of untagged yearling Chinook and steelhead transported was the lowest in over 20 years, in part because a larger than average percentage of outmigrating smolts had passed the lower Snake Dams by late April before transportation started on May 1; 58 percent of wild and hatchery Chinook and 48 percent of steelhead had already passed Lower Granite Dam. In 2015, the percentage of water spilled was the highest realized in recent years. As a consequence, a small fraction of the spring-migrating species were transported: 11.4 percent wild / 13.6 percent hatchery-origin yearling Chinook and 12.4 percent wild / 13.9 percent hatchery-origin steelhead.
- Transportation of Snake River Fall Chinook: The effects of transportation on Snake River fall Chinook salmon are being evaluated by the CSS and by NOAA Fisheries. Final analysis is still awaiting the return of all adult Chinook salmon that were tagged for the study as juveniles. NOAA analysis comparing SARs of Snake River fall Chinook that outmigrated through bypass systems at the dams to SARs of fish that were transported is showing that the timing of migration and transport is important. In general, the bypassed fish had higher survival relative to transporting juvenile fall Chinook salmon prior to June 15. However, after that date the transport strategy produced higher SARs than fish which were collected and returned to the river (Smith et al. 2014). Preliminary results from the 2015 CSS report continue to show that the benefit to fall Chinook is highly variable between years, release location, and hatchery/wild status.
- Adult Passage: River conditions in 2015 highlighted that the effectiveness of adult passage through fish ladders is affected when differences in water temperature occur within ladders and between the ladder entrances and exits and the river. This effect of temperature differentials within the fish ladders will be addressed as warranted. Interim pumps were installed in the forebay at Lower Granite Dam in 2014 and 2015 (and permanent pumps were installed in 2016).

- Overwintering Adult Steelhead and Steelhead Kelt Passage: A hydroacoustic study of spillway weir passage for adult steelhead (including kelts) was conducted at McNary Dam during late 2014 and early 2015. The study found that with fish guidance screens in place in the turbine units, operation of the spillway weirs resulted in statistically significant increases in the proportion of fish passing the dam by non-turbine routes and the total number of fish passing the dam (Ham et al. 2015).

Tributary Habitat RME

The Tributary Habitat Research Monitoring and Evaluation program is directed toward identifying factors that limit fish survival (limiting factors) and the effect that habitat conditions and actions have on fish survival and productivity. Habitat monitoring further helps to understand the effects of climate change on species. Information collected is used to identify and prioritize habitat improvement projects and substantiate progress toward targeted improvements for specific fish populations, as well as to summarize the range of fish benefits observed from habitat actions. Work performed in intensively monitored watersheds (IMWs) and fish population monitoring, in the Integrated Status and Effectiveness Monitoring Program (ISEMP 2003-*017-00*) and Columbia Habitat Monitoring Program (CHaMP 2011-006-00) projects, continues to conduct evaluations and modeling that may contribute to habitat planning for the duration of the NOAA Fisheries 2008 FCRPS BiOp and 2014 FCRPS Supplemental BiOp. In addition, habitat action effectiveness monitoring (completed in numerous projects including BPA Project Action Effectiveness Monitoring (AEM) Programmatic 2016-001-00) continues to assess project benefits and support 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 trend and action effectiveness monitoring and research are used to develop and support fish habitat relationships.

Research and monitoring are also illustrating how, in several watersheds and for many populations, density dependence may limit fish numbers and survival. In other words, carrying capacity of some habitats can be limiting. Density dependent effects have been identified and evaluated by NOAA in the 2014 BiOp and assessed by the Independent Science Advisory Board. The ISAB's synthesis of density dependence studies (ISAB 2015) concluded that:

> "[M]any salmon populations throughout the interior of the Columbia River Basin are experiencing reduced productivity associated with recent increases in natural spawning abundance, even though current abundance remains far below historical levels. Density dependence is now evident in most of the ESA-listed populations examined and appears strong enough to constrain their recovery".

Summaries of tributary habitat research and monitoring demonstrate the importance of freshwater habitat for various life stages of salmon, the negative impacts of human activities on habitat quality and salmon carrying capacity and growth, relationships between habitat and fish, the significance of habitat improvements in light of climate change, and the effects related to specific actions (Roni et al. 2014, BPA 2014, ISAB 2007, NOAA Fisheries 2014). Monitoring has demonstrated that habitat actions have proven valuable to both improving fish utilization of improved stream reaches and increasing the overall area of usable habitat and production potential.

Significant Results

- Fish Habitat Relationships: Throughout the Columbia River Basin, monitoring of habitat actions and fish habitat relationships indicate that projects implemented as part of the Action Agencies off-site work in tributary habitat commitments (see Table 5 in the RPA), are improving tributary spawning and rearing habitat, and improving growth, survival and spatial structure for numerous populations of salmon and steelhead (ISEMP/CHaMP 2015).
- Bridge Creek: In Bridge Creek, a watershed in the John Day Basin, simple, inexpensive habitat improvement actions have restored floodplain processes that result in increased base flow, increased groundwater elevation, lower groundwater and surface water summer temperatures, decreased sediment loads, and increased habitat complexity (i.e., more frequent and deeper pools). In turn, these habitat changes have led to increased density, growth, production, and survival of juvenile steelhead, compared to a reference stream. In most cases, steelhead responses to habitat changes were large. In the case of Murderer's Creek, in the

John Day basin in Oregon, juvenile abundance increased 139 percent, survival increased 52 percent, and productivity increased 175 percent (ISEMP/CHaMP 2015). Work in 2014 by CHaMP and ISEMP showed that installation of instream support structures led to the building of beaver dams on over half of the support structures installed, as well as a 300 percent increase in the number of natural beaver dams within the study area. Results demonstrate the positive effects of beaver dams on significantly reducing instream incision. Future evaluations in the Bridge Creek watershed will include evaluating smolts per spawner, SARs, and spawner-to-spawner ratios (BPA Project 2003-017-00).

- Lemhi: In the Lemhi River IMW (Salmon River Basin, ID) a primary focus of the IMW is to re-establish tributary connectivity to increase habitat access for fish within the 31 tributaries to the Lemhi River. Preliminary results illustrate a shift in the influence that limited habitat quantity and quality have on the fraction of presmolt spring/summer Chinook emigrating from the Lemhi. Since restoration, estimates of this influence are at approximately 70%, compared to a roughly 90% reduction prior to restoration efforts. Reconnected tributaries have documented use for rearing by juvenile Chinook salmon. Several of these, Little Springs Creek in particular, have also shown to provide a survival benefit as refuge habitat when summer low flows are low and/or mainstem temperatures are high. Upcoming restoration actions will target areas downstream of spawning habitat to improve summer and winter capacity (BPA Projects CHaMP/ISEMP; Chris Jordan, pers. comm., 11/30/2016).
- Methow River: Methow River monitoring data continue to show increased abundance of juvenile Chinook and steelhead in the Whitefish Island side channel restoration area compared to pre-restoration abundance levels (Reclamation, unpublished data). USGS aquatic productivity model results have matched empirical data regarding fish, invertebrate, and periphyton biomass levels in those sampled areas of the Methow River basin. Further, the findings of the model simulations lend support to the ongoing habitat improvement efforts that use the addition of large woody structures and side channel reconnection as a strategy to benefit juvenile Chinook and steelhead.

  The model is currently being tested to evaluate and prioritize habitat improvement alternatives for an ongoing project in the Methow basin the results of which will contribute to a higher quality final habitat improvement project design. Finally the model will use data from twelve CHaMP sites within the Methow basin to run simulations to gain insight into fish production limiting factors. Those results can be used to aid in determining appropriate site specific habitat improvement actions.
- Okanogan Basin Monitoring: Monitoring has benefitted steelhead populations in the Okanagan subbasin by informing specific restoration actions and prioritizing restoration and enhancement efforts. Steelhead spawning surveys have provided a means to document spawning distribution, timing, and an estimate of escapement in years when spring runoff occurs post-spawning. Defining the physical location of redds has helped to inform managers about the location of habitats being used for spawning and allow for tracking of spatial status and trends through time. Spatial distribution of redds has also been important when considering locations for restoring and/or protecting habitat. Detailed percent-natural-origin information has been provided and every attempt has been made to ensure that these estimates are as accurate as stated methods currently allow. In the absence of Okanagan Basin Monitoring and Evaluation Program monitoring efforts, very little empirical information would exist on the Okanogan subbasin. Future monitoring will continue to support validation of trends, while some modifications of protocols may be needed to evaluate identified uncertainties.
- Data Sharing: CHaMP and the U.S. Forest Service's PACFISH/INFISH Biological Opinion (PIBO) monitoring program have worked together to complete pilot efforts in data sharing including development of common habitat metrics between the two programs. Efforts included expanding the CHaMP database to store and process PIBO metrics. Completion of the pilot phase included the two programs interchanging stream temperature, pool frequency, and large woody debris frequency. Other metrics could be evaluated in future phases of data sharing efforts. Successful completion of this pilot illustrates the compatibility of large scale habitat monitoring programs in the Columbia River Basin and opens the door to the Action Agencies increased use of other habitat data sources in the future.

Estuary and Ocean RME

Research in the Columbia River estuary, plume and ocean improves our understanding of how environmental conditions affect salmon and steelhead survival. The CEERP includes a monitoring framework that annually incorporates the newest data and findings to inform and/or reinforce the habitat restoration and monitoring strategies. The research and monitoring results, focused on the biological response of ecosystems and juvenile salmonids to habitat restoration actions, are reviewed by the Expert Regional Technical Group, project sponsors, and the Action Agencies to ensure the habitat restoration and monitoring strategies are well informed of the latest information on juvenile salmonid presence/abundance, ecosystem response, and the individual and cumulative effects of the estuary restoration program.

Significant Results

Ocean and Plume

- Growth rates and Prey Resources: The diets, feeding intensity, and condition of yearling Chinook salmon caught in May and June of 2015 reflected a diet of warm ocean prey, a high proportion of empty stomachs, average stomach fullness in May and low fullness in June, and poor physical condition. Analysis of food availability and diets of juvenile salmon caught in the plume and nearshore ocean indicate trophic-mediated responses in both size of juveniles and potentially in their early ocean survival (BPA Project 1998-014-00). This data will be compared with 2016 data from the Corps Project EST-P-15-01 (Evaluating the Effectiveness of Habitat Restoration Actions in the Lower Columbia River and Estuary) to evaluate whether juvenile salmon condition in the ocean is related to a juvenile's consumption of prey and time spent in the estuary and plume.
- Ecosystem Importance: Results indicate that a combination of physical and biological processes affect the early ocean survival of juvenile salmon, but the nature and strength of these relationships varies between species, ESUs, stock groups, and life history types (BPA Project 1998-014-00).
- Early ocean entry: One study found that Chinook salmon and steelhead stocks within the Columbia basin differ in their size and timing of ocean entry. Growth rates were lower for stocks having only recently arrived in marine waters, highlighting the need to consider stock-specific early life history and the implications to survival across the entire life cycle (Weitkamp et al. 2015).
- Ocean Conditions and Diet in Subyearling Survival: Ocean conditions, including sea surface temperatures, affect different prey fields, which, in turn, affect juvenile Chinook growth and survival (Daly and Brodeur 2015). Findings suggest the importance of understanding the influence of factors outside the FCRPS on lifecycle survival.
- Stock-Specific & Origin Survival and Ocean Entry: One study found that natural-origin juvenile salmon from the upper Columbia summer/fall Chinook genetic stock group may have higher survival rates during their first year at sea than hatchery-origin salmon (Claiborne et al. 2014).
- Stock-Specific Salmon Growth & Survival: Trudel et al. (2015) collected juvenile salmon and oceanographic data from the west coast of British Columbia to Southeast Alaska from 1998 to 2012 to monitor the effects of ocean conditions on the distribution, migration, growth, and survival of Pacific salmon during their first ocean year. The relative survival of different stocks can depend upon where and when they migrate in the ocean and where and when they establish their first winter feeding grounds. Changes at the base of the food chain must be considered to fully understand the effects of ocean conditions on growth and survival (BPA Project 2003-009-00).

Estuary

- Mapping: In 2015, the Estuary Partnership used a new version of the Corps' Ecosystem Functions Model to develop statistical relationships between site hydrology (as predicted by a 2-D hydrodynamic model) and ecological parameters such as vegetation data and fish and wildlife habitat suitability. The model can be used to map flood timing and frequency of inundation under different restoration designs, and evaluate how those changes in design affect habitat for multiple species. This model can be used to inform future habitat restoration design (BPA Project 2003-007-00.)
- Action Effectiveness Monitoring and Research of Habitat Restoration Actions in the Lower Columbia River and Estuary: A delay in Congressional funding authority in 2014 and 2015 created a gap in juvenile salmonid monitoring at restored sites in the estuary. This work was re-started at the end of 2015 and sampling of fish and ecosystem responses began during the spring to fall of 2016. This data, paired with ongoing monitoring at reference sites, will provide insight into the specific causal relationships between habitat opportunity/capacity and benefits to juvenile salmon. (Corps Project EST-P-154-01.)

Summary

Although individual research projects, both in the ocean/plume and in the estuary, typically identify a need for more research and further data collection, collectively these projects improve our understanding of ecosystem processes and the ecological benefits of restoration actions. Findings from BPA and Corps RME efforts are expected to help delineate the relative contribution of the estuary and plume to the condition of juvenile salmonids, and provide evidence of the role of the estuary and plume in supporting the food web that juvenile salmon rely upon when they enter the ocean.

Harvest RME

In 2015, research to help support harvest-related RPA actions included feasibility studies for Zone 6 harvest PIT tag recoveries to help refine upstream adult survival rates. Selective fishing methods and gear continued to be evaluated. Support was also 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

- Selective Harvest: The Action Agencies continued to fund the development and implementation of selective fish gear. In 2015, the Colville Confederated Tribes select harvest yielded a total of 28,885 salmon. 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 (BPA Project 2008-105-00).
- PIT Tags: Harvest managers were again able to collect PIT tag data from commercial catch in 2015, 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).

Hatchery RME

A large number of hatchery program effectiveness and critical uncertainty research projects were implemented from 2008 through 2015 and remain ongoing. The Action Agencies have continued support of RM&E for hatchery effectiveness in the last few years, including expanded genetic studies, PIT tagging (and detection) in numerous tributaries, kelt reconditioning research, and additional studies in the Methow and Deschutes rivers. Management can be informed by the findings from monitoring and research of the effects of hatchery programs on naturally produced population viability, general effectiveness of hatchery programs, and the benefits of hatchery reform. Additionally, relative reproductive success (RRS) studies, comparing the reproductive success of hatchery-origin fish to the reproductive success of natural-origin fish, continue to provide a key indicator for hatchery program effectiveness in conserving or increasing natural populations.

Significant Results

- Genetic Tagging: Multiple BPA projects have studied salmonid genetics to advance Chinook salmon and steelhead stock identification so that eventually any natural- or hatchery-origin Chinook salmon or steelhead can be traced to its stock of origin. BPA funded research conducted by IDFG and CRITFC supports that genetic stock identification (GSI) appears to be feasible and there is sufficient genetic structuring to monitor these species at the ESU and MPG level. Additionally, GSI techniques have been developed to segregate wild runs of Snake River Spring/Summer Chinook and Snake River Steelhead by stock of origin. Parental based tagging (PBT) technologies have been developed to identify the specific hatchery stock and age of sampled hatchery fish. The development of genetic tagging for hatchery stocks, integrated with GSI for wild stocks, is cost effective compared with other methods and provides powerful tools to monitor hatchery and wild stocks throughout the Columbia River Basin. For example, these technologies will support implementation of fish population status monitoring, such as productivity and abundance, for listed populations.
- Relative Reproductive Success: Several long-term studies have been funded by the Action Agencies to estimate relative reproductive success (RRS) of hatchery-origin to natural-origin salmon and steelhead. RRS studies have been conducted for Chinook salmon in the Upper Grande Ronde, Lostine River, Catherine Creek, and Wenatchee River and steelhead in the Hood River and in the Methow Basin. These studies have attempted to address a key uncertainty for evaluating effectiveness of supplementation programs. In some cases, researchers have begun investigating mechanisms such as, body size, egg size, migration and spawning time, spawning location, and behavioral characteristics that may be contributing factors in observed

differences between hatchery and natural productivity. Through improved understanding of the mechanisms influencing success of hatchery fish, adaptive management and hatchery reform can guide conservation hatchery practices to improve success of fish that are meant to supplement the natural population in the wild.

- Fall Chinook Supplementation: Supplementation of fall Chinook salmon above Lower Granite Dam since 1996 has successfully increased overall natural and hatchery abundance escapement in the Snake River Basin from less than 1,000 adults/year in 1975 to approximately 60,000 adults in 2013, 2014 and 2015. Radio tagging, parental based tagging, redd surveys, and multistage life cycle modeling for the Snake River basin fall Chinook salmon ESU are being conducted to provide better estimates for how the fall Chinook hatchery program affects productivity of the fall Chinook salmon ESU.
- Idaho Supplementation Study: The Idaho Supplementation Study (ISS) was originally proposed to investigate whether natural-origin salmon population productivity and abundance could be boosted by supplementing populations with naturally spawning hatchery fish. The study took place over 23 years in 13 supplementation and 14 reference streams in the Clearwater and Salmon subbasins. It found that supplementation did increase redds, juvenile emigrants, and returning adults, however, productivity and abundance generally returned to pre-supplementation levels after supplementation ceased.

Predation and Invasive Species Management RME

Predation monitoring and evaluation 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

- Avian Predation Control: Implementation of the IAPMP is already yielding encouraging results. In accordance with the plan, dissuasion efforts and reductions in Caspian tern colonies are focused at strategic locations in the Columbia Plateau, with positive outcomes. For example, management efforts at Goose Island in Potholes Reservoir reduced predation on Upper Columbia River steelhead attributable to that colony from a 2007-2013 average of 15.7 percent to 2.9 percent in 2014 and 1.5 percent in 2015, and the predation rate on listed Upper Columbia River Spring Chinook from a 2009-2013 average of 2.6 percent to 0.6 percent in 2014 and 0.1 percent in 2015 (Collis et al. 2016). Double-crested cormorant management efforts on East Sand Island occurred too late in 2015 to have an effect upon the juvenile salmonid predation rate in that year (Evans et al. 2016).
- Northern Pikeminnow: Predation by northern pikeminnow is being successfully controlled, with significant ongoing salmon survival benefits. The multi-year index for estimating system-wide exploitation on northern pikeminnow greater than or equal to 250 mm fork length was calculated as 17.2 percent. The 2015 estimate was near the upper end of the range necessary to achieve project goals. 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 test for responses that offset the benefits we see from the Northern Pikeminnow Sport Reward Fishery Program (BPA Project 1990-077-00).
- Sea Lions: 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, whereas hazing efforts had only a temporary effect. Monitoring in 2015 revealed that both the total number of California sea lions seen and the minimum estimated pinniped catch of salmonids more than doubled from 2014 levels (Fish Field Unit 2016).
- Avian Predation Monitoring: In 2015, a suite of avian studies continued to document predatory bird abundance, distribution, and movement patterns in the Columbia Basin. Tern nesting density on East Sand Island increased to a level considerably higher than had been seen before. Double-crested cormorant populations have expanded and continue to have a major impact on juvenile salmon (Roby et al. 2016).

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. As part of the "off-site" mitigation to benefit regional efforts for improving conditions for fish overall, the Action Agencies continued in their support of data coordination and management efforts through funding and other commitments.

Significant Results

- PNAMP: The Pacific Northwest Aquatic Monitoring Program continued to support and improve metadata documentation through standardization of protocol and method documentation, and support coordination through visualization of monitoring efforts through the Monitoring Resources tools (BPA Project 2004-002-00).
- Data Exchange: The Coordinated Assessments process led by StreamNet (BPA Project 1988-108-04) supported development of data exchange standards for Natural Origin Spawning Adults (NOSA) for 113 of 226 ESA-listed populations to help with NOAA’s 2016 ESA status review. This process provided more data to NOAA and the AAs in a format that improved timeliness of their data assessment. While this process improved exchanges, many NOSA and juvenile production datasets for priority populations were not completed, requiring a reprioritization of effort from data managers. More work was prioritized for 2016 to complete the data exchanges for another 30 percent of the populations for NOSA data, and 100 percent of juvenile out-migrant abundance exchanges for BiOp-priority populations. For example, NOSA exchanges have not been completed for Snake River steelhead populations, and juvenile data changes for fish-out have not been completed for any population. StreamNet was tasked with additional work to track progress on data submission and availability to help with transparency and accountability of data access, which may be viewed at *http://www.streamnet.org/ca-priority-data/*.

Working with the Region

Regional Forum

The Regional Forum process was developed in 1995 and has been employed 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 middle 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.

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 NOAA Fisheries 2014 FCRPS Supplemental 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 2015, the Action Agencies met with RIOG on four occasions to discuss, review, and coordinate on 2015 spill and transport operations, operations at Lower Granite and Little Goose dams during the 2015 adult sockeye run where elevated temperatures were observed throughout the basin, and the 2014 Annual Progress Report.

Columbia Basin Fish Accords

The Columbia Basin Fish Accords are 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, the Kalispel Tribe, 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 ESA-listed fish.

Northwest Power and Conservation Council Fish and Wildlife Program

The Northwest Power and Conservation Council is an interstate compact agency of four Columbia River basin states (Idaho, Montana, Oregon, and Washington), and was established by Congress in the Northwest Power Act. The Act directs the NPCC to develop and adopt a program to “protect, mitigate, and enhance fish and wildlife, including related spawning grounds and habitat [affected by the development and operation of any hydroelectric project] on the Columbia River and its tributaries,” and furthermore the Act directs BPA to use its fish and wildlife funds in a manner consistent with the program. This *Columbia River Basin Fish and Wildlife Program* (*http://www.nwcouncil.org/fw/program/2014-12/program*) must be considered by all federal and non-federal agencies that manage, operate, or regulate hydroelectric facilities in the basin. The NPCC is required to make periodic major revisions to the program, which was done most recently in 2014.

The NPCC's *Columbia River Basin Research Plan* (*https://www.nwcouncil.org/media/29261/2006_3.pdf*) is an integral, complimentary component of its Fish and Wildlife Program, which "identifies and helps to resolve critical uncertainties that affect anadromous fish, resident fish, wildlife, and the ecosystems that support them." NPCC has initiated the process to revise the 2006 plan by updating the program's *Critical Uncertainties* (*https://www.nwcouncil.org/fw/isab/isabisrp2016-1/*). The revised research plan is anticipated in 2017.

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Abbreviations and Acronyms

BiOp	Biological Opinion, specifically, the FCRPS Supplemental Biological Opinions
BOR	Bureau of Reclamation
BPA	Bonneville Power Administration
CE	Comprehensive Evaluation
CHaMP	Columbia Habitat Monitoring Program
cfs	cubic feet per second
c.i.	confidence interval (or, for Bayesian statistics, credible interval)
COMPASS	NOAA Fisheries' Comprehensive Fish Passage statistical model
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
CREST	Columbia River Estuary Study Taskforce
CRITFC	Columbia River Inter-Tribal Fish Commission
CSL	California Sea Lion
CSS	Comparative Survival Study
DPS	distinct population segment
EDT	ecosystem diagnosis and treatment
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FCRPS	Federal Columbia River Power System
GSI	genetic stock identification
HEC-EFM	Hydrologic Engineering Center Ecosystem Functions Model
HGMP	Hatchery and Genetic Management Plan
HQI	habitat quality improvement
IAPMP	Inland Avian Predation Management Plan
ISAB	Independent Scientific Advisory Board
ISEMP	Integrated Status and Effectiveness Monitoring Program
JBS	juvenile bypass system
kaf	thousand acre-feet
kcfs	thousand cubic feet per second
KMP	Kelt Management Plan
LWD	large woody debris
Maf	million acre feet
MPG	major population group
NMFS	National Marine Fisheries Service (also known as NOAA Fisheries)
NOAA	National Oceanic and Atmospheric Administration
NOSA	natural-origin spawning adults
NPCC	Northwest Power and Conservation Council
NPMP	Northern Pikeminnow Management Program
NWFSC	NOAA's Northwest Fisheries Science Center
NWRFC	Northwest River Forecast Center

OBMEP	Okanogan Basin Monitoring and Evaluation Program
ODFW	Oregon Department of Fish & Wildlife
PBT	parental based tagging
PDO	Pacific Decadal Oscillation
PIBO	U.S. Forest Service PACFISH/INFISH Biological Opinion
PIT	passive integrated transponder
PNAMP	Pacific Northwest Aquatic Monitoring Program
Reclamation	Bureau of Reclamation
RIOG	Regional Implementation Oversight Group
RM	river mile
RME	research, monitoring and evaluation
RPA	Reasonable and Prudent Alternative
RRS	relative reproductive success
SAR	smolt-to-adult return ratio
SBU	survival benefit unit
SLED	sea lion exclusion device
SSL	Steller (or Steller's) sea lion, named after German naturalist Georg Wilhelm Steller (1709-1746)
TDG	total dissolved gas
TMT	Technical Management Team, a technical subgroup of RIOG
TNC	The Nature Conservancy
USDA	United States Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
WDFW	Washington Department of Fish & Wildlife
WMP	Water Management Plan