

*Endangered Species Act
Federal Columbia River Power System
2013 Annual Progress Report: Section 2*

**Detailed Description of Reasonable and Prudent
Alternative (RPA) Action Implementation**

Under Reasonable and Prudent Alternative (RPA) Action 2, the Bonneville Power Administration (BPA), United States Army Corps of Engineers (Corps), and the Bureau of Reclamation (Reclamation), collectively referred to as the Action Agencies; submit an annual progress report that describes the status of implementation for the previous calendar year. Section 2 describes this progress for each RPA action and Research, Monitoring, and Evaluation (RME) project information. Section 3 includes a list of projects implemented in 2013 along with their associated RPA subactions.

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Hydropower Implementation Reports, RPA Actions 4-33

This document reports on actions taken during calendar year 2013. The Hydropower RPA actions are intended to be implemented over the term of the National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries) 2014 Federal Columbia River Power System (FCRPS) Supplemental Biological Opinion¹ (BiOp). Although many of these actions were under way or being implemented during 2013, some will be implemented later in the BiOp period. For hydropower system (hydro) operations, actions are reported by water year (October through September) and through calendar year 2013 because this is consistent with the actual approach for project operations.

Table 1. Hydropower Strategy Reporting.

RPA Action No.	Action	Annual Progress Report
Hydropower Strategy 1		
4	Storage Project Operations	Prepare an annual year-end review.
5	Lower Columbia and Snake River Operations	Prepare an annual year-end review.
6	In-Season Water Management	Annual progress reports will describe Federal Columbia River Power System (FCRPS) operations for the fish passage season. There is no other physical or biological monitoring or reporting.
7	Forecasting and Climate Change/Variability	Annual progress reports will include a summary of the annual forecast review and any new, pertinent climate change information or research.
8	Operational Emergencies	Annual progress reports will describe any emergency situations and actions taken per the emergency protocols. There is no other physical or biological monitoring or reporting.
9	Fish Emergencies	Annual progress reports will describe any fish emergency situations and actions taken. There is no other physical or biological monitoring or reporting.
10	Columbia River Treaty Storage	Annual progress reports will describe actions taken to provide 1 million acre-feet (maf) of storage in treaty space. There is no other physical or biological monitoring or reporting.
11	Non-Treaty Storage (NTS)	Annual progress reports will describe actions taken to refill NTS space. There is no other physical or biological monitoring or reporting.
12	Non-Treaty Long-Term Agreement	Annual progress reports will describe actions taken to develop long-term and/or annual agreements that affect Lower Columbia River flows during the April through August period. There is no other physical or biological monitoring or reporting.
13	Non-Treaty Coordination with Federal Agencies, States, and Tribes	Annual progress reports will describe actions to coordinate NTS agreements. There is no other physical or biological monitoring or reporting.
14	Dry Water Year Operations	Annual progress reports will describe actions taken during dry water years. There is no other physical or biological monitoring or reporting.
15	Water Quality Plan for Total Dissolved Gas and Water Temperature in the Mainstem Columbia and Snake Rivers	Annual progress reports will describe actions taken to implement Endangered Species Act (ESA) commitments. There is no other physical or biological monitoring or reporting.
16	Tributary Projects	Status of the consultations for Reclamation's tributary projects will be provided in the annual progress reports.

¹ The NOAA Fisheries 2014 FCRPS Supplemental BiOp incorporates, in whole, the NOAA Fisheries 2008 Biological Opinion, the 2009 FCRPS Adaptive Management Implementation Plan, and the 2010 Biological Opinion.

RPA Action No.	Action	Annual Progress Report
17	Chum Spawning Flows	Annual progress reports will describe in-season water management actions taken during the water year, which includes part of the previous calendar year.
Hydropower Strategy 2		
18	Configuration and Operational Plan for Bonneville Project	Annual progress reports will describe status of the actions taken in the Configuration and Operational Plan (COP) and the results of the associated research, monitoring, and evaluation (RME).
19	Configuration and Operational Plan for The Dalles Project	Annual progress reports will describe the status of the actions taken in the COP and the results of the associated RME.
20	Configuration and Operational Plan for John Day Project	Annual progress reports will describe the status of the actions taken in the COP and the results of the associated RME.
21	Configuration and Operational Plan for McNary Project	Annual progress reports will describe the status of the actions taken in the COP and the results of the associated RME.
22	Configuration and Operational Plan for Ice Harbor Project	Annual progress reports will describe the status of the actions taken in the COP and the results of the associated RME.
23	Configuration and Operational Plan for Lower Monumental Project	Annual progress reports will describe status of the actions taken in the COP and the results of the associated RME.
24	Configuration and Operational Plan for Little Goose Project	Annual progress reports will describe the status of the actions taken in the COP and the results of the associated RME.
25	Configuration and Operational Plan for Lower Granite Project	Annual progress reports will describe the status of the actions taken in the COP and the results of the associated RME.
26	Chief Joseph Dam Flow Deflector	Annual progress reports will describe the status of the flow deflector construction. Note: This construction project was completed in spring 2009.
27	Turbine Unit Operations	Annual progress reports are developed by BPA.
28	Columbia and Snake River Project Adult Passage Improvements	Annual progress reports will describe the status of the actions taken.
Hydropower Strategy 3		
29	Spill Operations to Improve Juvenile Passage	Spill operations are reported annually.
30	Juvenile Fish Transportation in the Columbia and Snake Rivers	Annual progress reports will provide the number of fish collected and transported in an annual report each February.
31	Configuration and Operational Plan Transportation Strategy	Annual progress reports will describe the status of the construction and operational actions and associated RME to support the transportation strategy.
Hydropower Strategy 4		
32	Fish Passage Plan (FPP)	Not applicable.
Hydropower Strategy 5		
33	Snake River Steelhead Kelt Management Plan	Status of project implementation (including project milestones) through December of the previous year for all actions identified in implementation plans.

Hydropower Strategy 1 (RPA Actions 4-27)

RPA Action 4 – Storage Project Operations

The Action Agencies will operate the FCRPS storage projects (Libby, Hungry Horse, Albeni Falls, Grand Coulee, and Dworshak projects) for flow management to aid anadromous fish. These storage project operations will be included in the Water Management Plan. These projects are operated for multiple purposes including fish and wildlife, flood control, irrigation, navigation, power, and recreation.

The Action Agencies operated the FCRPS storage projects to provide flows to improve juvenile and adult fish survival consistent with Hydropower Strategy 1 of the BiOp as described in the 2013 Water Management Plan² (WMP) (BPA et al. 2012). In accordance with the adaptive management provisions of the 2008 BiOp, the WMP was developed to meet RPA water management actions identified in the 2008 FCRPS BiOp and the U.S. Fish & Wildlife Service (USFWS) 2000 and 2006 BiOps and describes the Action Agencies' annual plan for implementing specific operations. The 2013 WMP was developed in the fall of 2012 with full regional coordination.

The dams in the FCRPS were authorized by Congress for multiple purposes, which are implemented in a manner that is consistent with the BiOp RPA. Details of how the projects were operated to improve juvenile and adult survival are described in the following sections and shown in Figures 1 through 4. This information is presented from the start of the 2013 water year — October 2012 through December 2013. Real-time operations follow RPA Action 4 specifications as adjusted in-season with recommendations from the Technical Management Team (TMT), and oversight group consisting of regional sovereign biologists and hydrologists. Further discussion of these operations is included in the minutes of the TMT "2013 Year End Review Session" (TMT 2013). (Available at http://www.nwd-wc.usace.army.mil/tmt/agendas/2013/1212_Agenda_YER.html and http://www.nwd-wc.usace.army.mil/tmt/agendas/2013/1212_Minutes_Revision_1.pdf)

Figure 1 provides a high level summary of the operational constraints (fish operations, flood risk management power operation, other) that have been put in place and actions that are taken during the year to provide improved conditions for fish at FCRPS storage projects. Operations for purposes such as power generation occur within the constraints established for Flood Risk Management and fish operations shown in this figure.

² The WMP describes specific operations defined in biological opinions issued by the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS, also known as NOAA Fisheries) in 2008 (NMFS 2008 BiOp) and 2010 (NMFS 2010 Supplemental BiOp), and also by the U.S. Fish and Wildlife Service (USFWS) in 2000 and 2006 (USFWS 2000, 2006).

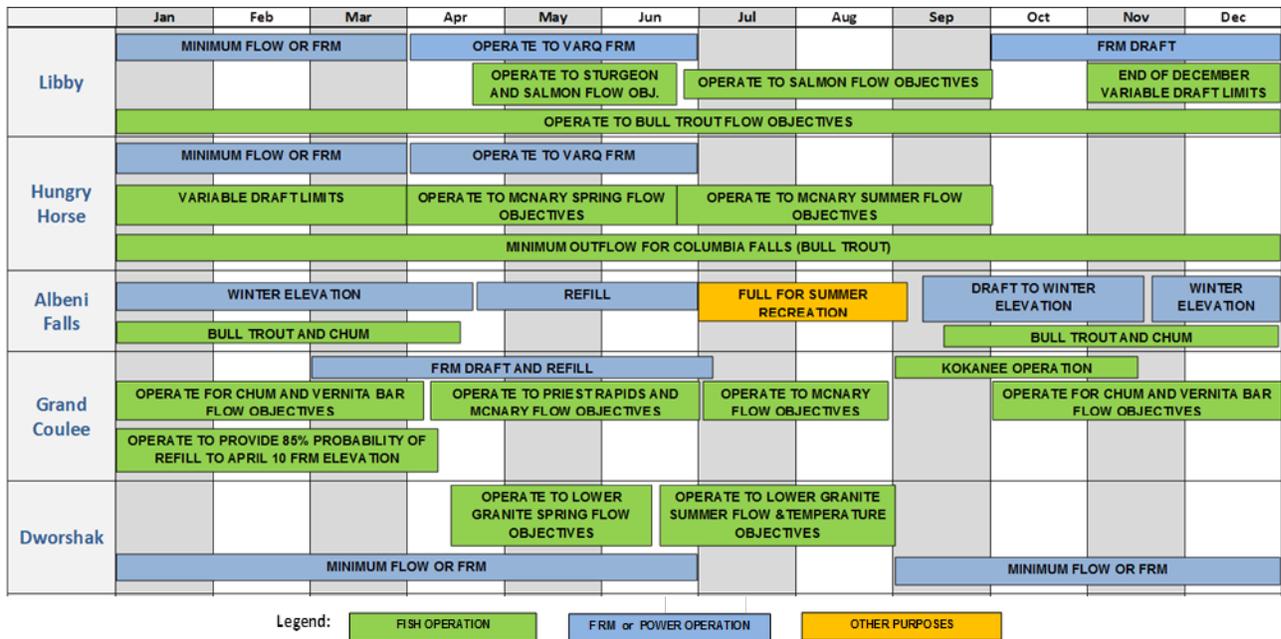


Figure 1. Storage Projects Operations Timeline.

Dworshak Dam

From October 2012 until January 5, 2013, Dworshak Dam released near minimum flows, approximately 1,600 to 1,700 cubic feet per second (cfs), except for some minor turbine unit testing. Dworshak Reservoir began January 2013 at elevation 1544.2 feet, well under flood control elevations due to lack of water inflows. Beginning on January 5th the project increased outflow to meet future flood-control targets. During January the reservoir was drafted to elevation 1540.2 feet on January 31st.

Water forecasts and snowpack were below normal through April. As a result of the below normal forecasts, except for a brief flood control release in January, the discharge from Dworshak was held at minimum through the end of March. During this period, the reservoir slowly filled to 1560.9 feet by the end of March. On April 1st the water supply forecast for April to July runoff volume was 2,036 thousand acre-feet (kaf) (76 percent of normal). The flood control requirement for the end of April based on the water supply forecast, called for the reservoir elevation at or below 1568.5 feet. To meet the flood control requirement, discharge was increased from minimum to 9.9 thousand cubic feet per second (kcfs) during April. On April 24th, the reservoir reached the Flood Control Refill Curve, which indicates the spring runoff has started and a refill operation is recommended to insure the reservoir refills. However, NOAA Fisheries requested discharge be maintained at full powerhouse level (approximately 10 kcfs) through May 7th. The request was discussed at TMT on April 24th, and May 1st, and was implemented by the U.S. Army Corps of Engineers (Corps). Due to potential impacts to refill, the discharge was reduced to 7.5 kcfs on May 8th and subsequently to 5.5 kcfs on May 11th. This operation was also coordinated at TMT on May 8th. On May 22nd the discharge was further reduced to 3.9 kcfs to insure final refill, after coordination at the May 22nd TMT meeting.

On May 30th, per the request of TMT members, the discharge was increased to 7.5 kcfs for three days, then reduced to 3.0 kcfs for three days. On June 7th, the discharge was increased to effectively pass inflow with the reservoir elevation at 1599.6 feet. The

reservoir was held full until June 30th when the summer temperature operations started. Discharges varied between 9.6 kcfs and 13.0 kcfs during the month of July. The reservoir was drafted to elevation 1568.1 feet on July 31st. During the month of August the discharge varied between 7.5 kcfs and 10.0 kcfs as the reservoir was drafted to elevation 1534.8 feet by August 31st (BiOp target is 1535 feet). Additionally, under an agreement with the Nez Perce Tribe, the Corps released 200 kaf of storage during September, targeting 1520.0 feet by September 20.

During July through mid-September, the Corps managed Dworshak Dam to regulate outflow temperatures and attempt to maintain water temperatures at Lower Granite tailwater gauge at or below 68 degrees Fahrenheit. The water temperatures were modeled using CEQUAL-W2 and weather forecasts to plan releases on a daily basis. During this time the Lower Granite Dam tailwater exceeded 68 degrees on the following dates: August 21 (6 hourly readings), August 22 (14 hourly readings), August 23 (8 hours readings), September 11 (1 hourly reading), September 15 (11 hourly readings), September 19 (18 hourly readings), September 20 (24 hourly readings), September 21 (24 hourly readings), and September 22 (19 hourly readings). While 133 hourly readings over 68 degrees Fahrenheit occurred on 9 days from July through September, the maximum hourly reading was 69.04 degrees which occurred on September 20th at 1700 hours. Due to the very warm conditions in July and August, all the Dworshak temperature management ability was exhausted by September 20th with the reservoir drafted to elevation 1520 feet.

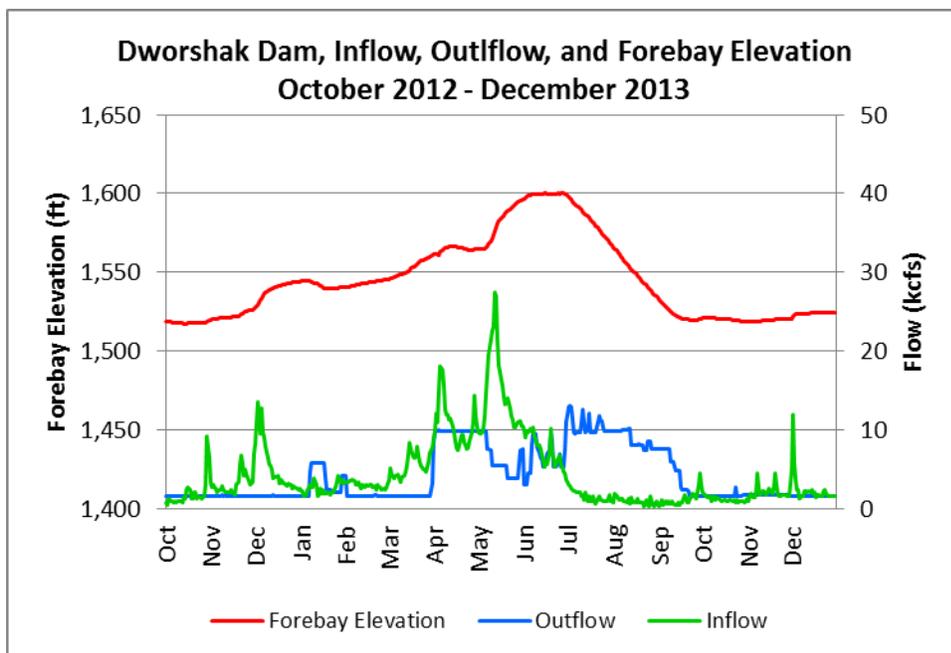


Figure 2. Dworshak Dam inflow, outflow, and forebay elevation from October 1, 2012 through December 31, 2013.

From October to December 2013, Dworshak Dam released near minimum flows between 1,500 and 1,800 cfs. It ended December 2013 at elevation 1,524.6 feet.

Libby Dam

Libby Dam started October 2012 at a pool elevation of 2448.49 feet. For October 3 through November 4 the project was at its minimum release of 4 kcfs. To reach its end of December pool elevation, Libby Dam released an average of 17.9 kcfs during the month of November.

Inflows for November were 7.1 kcfs. The end November elevation was 2435.74 feet, a draft of 14.1 feet for the month. The December water supply forecast was issued on December 7, with an April-August volume of 6238 kaf, which set the end of December required elevation to 2411 feet. The actual December 31 elevation was 2409.89 feet. December inflows averaged 5.3 kcfs, and outflows averaged 21.7 kcfs.

The January water supply forecast for Libby Dam was issued on January 8, with a volume of 6898 kaf. This increase in forecast was attributed to wet snow building in December. The forecast set the end of month required elevation to 2395.2 feet. To reach this target the releases were load shaped from two to three units for most weekdays during the month of January. January inflows averaged 3.5 kcfs, and outflows averaged 11.4 kcfs. The February water supply forecast was issued on February 4, with a volume of 6384 kaf. The forecast reduction in volume was due to a very dry January with half of the normal precipitation. The February forecast set the end of month required elevation to 2404.3 feet, which was 9.1 feet above the end of January elevation. The project ramped outflow down to the 4 kcfs minimum by February 1 to minimize the draft. February inflows averaged 3.2 kcfs, and outflows averaged 4.0 kcfs. The end of February elevation was 2393.85 feet.

The March water supply forecast was issued March 7. It stayed relatively consistent with a value of 6315 kaf. This set the end of month required elevation to 2405.8 feet. The project outflow then remained on minimum of 4 kcfs for the month of March. Inflow for the month averaged 4.2 kcfs. The end of March elevation was 2394.19 feet. The April water supply forecast was issued April 5, and again had a slight drop to a value of 6189 kaf, 105 percent of average, setting the end of month required elevation to 2411.8 feet. Libby Dam outflow then remained at 4 kcfs until April 29 when it was increased to try and maintain the current elevation. April inflows averaged 9.0 kcfs, and outflows averaged 4.2 kcfs. The end of April elevation was 2402.89 feet.

On April 29, the NWD declared that Libby Dam would begin refill on May 1. At that time the inflow was less than the initial variable outflow flood control procedures (VARQ) so outflow was set to generally hold pool. On May 2 the water supply forecast was issued with a value of 6535 kaf, which was 111 percent of average. This rise was caused by the snow water equivalent rising by 10 percent above average in much of the basin for the month of April. The forecast set the May VARQ to 18.0 kcfs, and volume available for the sturgeon pulse to 1140 kaf. On May 6 the discharge was increased to 18.0 kcfs as the inflow was beginning to increase. On May 11 the sturgeon augmentation flow began with Libby Dam releasing full powerhouse capacity, 26.3 kcfs. On May 13, discharge was reduced to 21 kcfs due to the threat of rain below the dam and the resulting threat of exceeding Bonners Ferry flood stage of 1764 feet. Bonners Ferry reached 1763.09 feet on May 14 at 0400, which was its peak for the year of 2013. The Kootenai River below Moyie Gauge peaked at flow of 51.7 kcfs. On the afternoon and evening of May 14, discharge from Libby Dam was increased back to 26.0 kcfs. The first week of full powerhouse for the sturgeon flow ended May 17, when discharge was lowered to 18 kcfs over a day. The second period of full powerhouse for the sturgeon flow began on May 24, with outflow remaining at that level until June 5. The end of May elevation was 2425.00 feet. May inflows averaged 34.3 kcfs, a volume of 2107 kaf. May outflows averaged 20.9 kcfs.

The June water supply forecast was issued on June 4, with a volume of 6464 kaf feet, which was 110 percent of average. On June 5 discharge was decreased from full powerhouse to 22 kcfs. This marked the end of 13 days at full powerhouse for the second peak for the sturgeon flow augmentation. The discharge was further reduced 20 kcfs a day on June 8 and June 9, and 16 kcfs on June 11. This marked the end of the sturgeon flow augmentation operation. The 16 kcfs discharge was held until June 20.

On June 18 a major rainstorm hit the Continental Divide with most of the basin seeing anywhere from 1 to 6 inches of rain and with 10 inches falling near the Continental Divide. As a result, the project saw its largest one day inflow since its completion in 1974 (89.1 kcfs on June 23). To manage the refill, on June 21 the project began to spill 3 kcfs in addition to full powerhouse of 25 kcfs. Pool elevation on that day was 2443.53 feet. On June 27, spill was increased to 5 kcfs for a total project discharge of 30 kcfs. The project ended the month at an elevation of 2455.89 feet. June inflows averaged 44.9 kcfs a volume of 2761 kaf. June outflows averaged 22.7 kcfs.

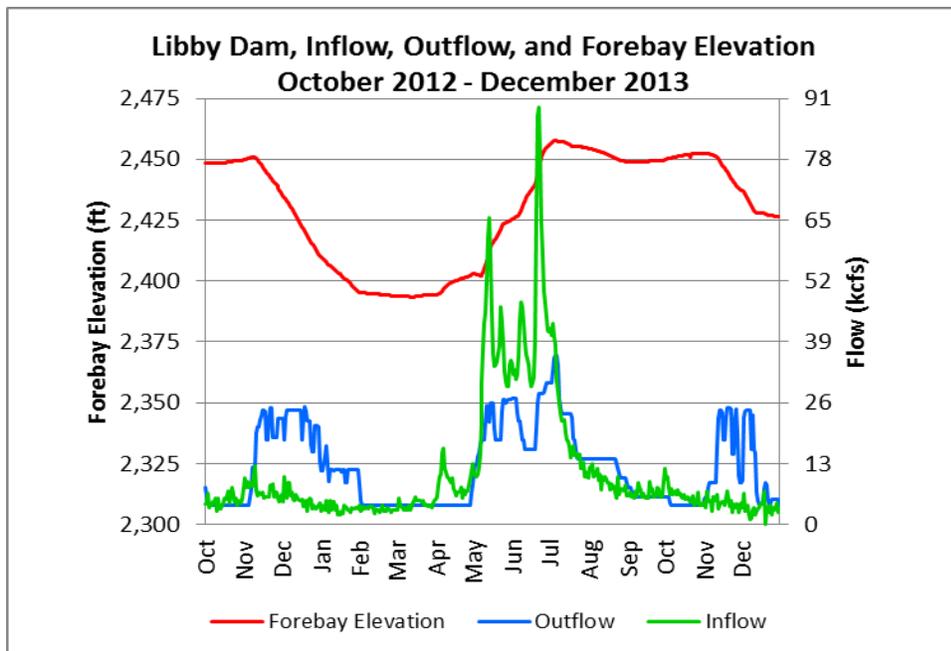


Figure 3. Libby Dam inflow, outflow, and forebay elevation from October 1, 2012 through December 31, 2013.

On July 3, spill was increased again to approximately 11 kcfs, and then increased to 12 kcfs from July 4 to July 6 for total project discharge of 36.0 kcfs. This was done to manage space left in the final upper foot of the pool. Lake Kootenai reached its peak elevation for the year on July 5 at an elevation of 2457.99 feet, 1.01 feet from full pool. By July 10 the project was able to stop spilling. The project discharge remained near full powerhouse capacity until July 18 when it slowly began ramping down, reaching a release of 14 kcfs on July 23. This was held for the rest of July. July inflows averaged 21.1 kcfs. July outflows averaged 22.3 kcfs. The July 31 elevation was 2454.52 feet.

In August the project was operated to remain at 14 kcfs for the month until it neared a pool elevation of 2450 feet. This was done in response to a System Operational Request for the Kootenai Tribe of Idaho to minimize flows in September and October to accommodate habitat restoration work around Bonners Ferry and also meet the 2449 feet FCRPS BiOp target on or before September 30. From August 22 to August 25 discharge was slowly reduced from 14 kcfs to 10 kcfs to slow the draft of the reservoir. The end of August elevation was 2449.07 feet. August inflows averaged 9.0 kcfs while outflows averaged 13 kcfs. The actual April to August volume was 7148 kaf, 121 percent of the average for the 1981-2010 period of record.

Libby Dam reached the required 2449 foot target elevation on September 1. Release was ramped down to 6 kcfs by September 4 and this release was held for the rest of the month. The 6 kcfs discharge is the minimum flow required in September for bull trout pursuant to the 2006 USFWS Biological Opinion regarding the operation of Libby Dam. The projected elevation at the end of September was 2449.75 feet. September inflows averaged 6.9 kcfs and outflows averaged 6.2 kcfs.

From October 3 to 5 Libby Dam's discharge was reduced from 6 kcfs to 4 kcfs. The 4 kcfs discharge was held for the duration of October. October inflow averaged 6.1 kcfs and outflows averaged 4.2 kcfs. To reach its end of December elevation, Libby Dam increased releases to 9 kcfs on November 4 and held that through November 10. Releases were then increased November 11 and 12 to reach full powerhouse of 24.3 kcfs, which was held until November 15. Releases were then dropped to 18 kcfs for the weekend of November 16 and 17, and returned to full powerhouse for the week of November 18-22. Releases were then dropped again to 15 kcfs for the weekend of November 23 and 24. Releases were briefly increased again to full powerhouse for November 25 and 26. Releases were then cut back again for Thanksgiving weekend, ramping down within ramping rates to be at 9 kcfs for November 29-30. The end of November elevation was 2437.38 feet. Inflows for November averaged 4.7 kcfs and outflows averaged 15.8 kcfs.

The Libby Dam water supply forecast for December was issued on December 5, with a volume of 5502 kaf. Under VARQ, this forecast allowed a December draft target elevation of 2426.6 feet, instead of the normal 2411.0 flood risk management elevation, and was the first time since implementation of the December variable draft target that a major shift was called for from elevation 2411.0 feet. To reach the 2426.6 foot elevation, for the first week of the month (December 2 to December 7) discharge was load shaped for full powerhouse of 26.0 kcfs to 21.0 kcfs. Discharge was reduced to 16 kcfs for December 8, but resumed load shaping of full powerhouse of 26.0 kcfs to 21.0 kcfs for December 9. On December 10 through 14 the discharge was dropped to 4.3 kcfs to slowly draft to the required end of month target. Releases were increased again on December 18 to 20 to 8.8 kcfs. By December 22 the release reduced back to one unit with outflow varying from 4.4 to 5.3 kcfs. On December 30, releases were cut to 4.0 kcfs as the end of month required elevation was met. The actual December 31 elevation was 2426.31 feet. December inflows averaged 3.4 kcfs, and outflows averaged 10.7 kcfs.

Grand Coulee Dam

In 2013, Grand Coulee was operated consistent with RPA Action 4 as adjusted in-season to meet real-time considerations such as changing water conditions. The Project supported flows during the juvenile salmonid migration season (e.g., managing reservoir elevations and drafting Banks Lake); and helped support flows for chum salmon. The following paragraphs detail actual operations.

Grand Coulee Dam was operated during November and December 2012 to support chum spawning below Bonneville Dam. Despite efforts to maintain a tailwater elevation of 11.5 feet high local inflows between Grand Coulee Dam and Bonneville Dam forced the chum redd protection tailwater elevation to 13.5 feet for the 2013 season. The high flow conditions made surveying for chum redds a challenge and no redds were actually observed at the 13.5 foot elevation. The 13.5 protection level was set as a protective measure in the event chum had spawned during the high water conditions.

The Northwest River Forecast Center (NWRFC) in Portland, Oregon provided the April-August volume forecast using their daily ensemble streamflow prediction (ESP) forecast procedure. The official forecast for the operating agencies was the forecast issued on the 5th working day of the month.

The water year 2013 started out wet from October through December 2012 then changed to warm and slightly dry starting in January continuing through March. April brought cooler temperatures. The peak runoff occurred in May after some rain on snow events. Flows dipped below average as temperatures rose with the first heat wave in June. July and August were warm and dry with only 25 percent of the average rainfall. The April through August water supply forecast was near average throughout the year, ranging from 105 percent of average in January to 92 percent of average in March. Table 2 shows the water supply forecasts for the The Dalles and Grand Coulee, and the April 30 flood control elevations at Grand Coulee Dam.

Table 2. The Dalles and Grand Coulee Water Supply Forecasts and Grand Coulee April 30 Flood Control Elevations.

	Jan	Feb	Mar	Apr	May	Jun	Jul
The Dalles Apr-Aug forecast (percent of average)	105	94	92	94	94	96	101
Grand Coulee Apr-Sep forecast (percent of average)	99	94	96	99	102	104	108
Grand Coulee Apr 30 flood control elevation (feet)	1235.7	1260.8	1265.1	1258.5	N/A	N/A	N/A

The January forecast was near normal and as a result drafting began in January in anticipation of having to meet an April 10 elevation of 1252.8 feet and an April 30th flood control elevation of 1235.7 feet. Although there was a small decrease in water supply forecast between January and February this decrease caused the April 10 and the April 30th flood control elevations to be over 20 feet higher than they were based on the January forecast. This resulted in a challenge for Grand Coulee operations as operators needed to balance between helping to maintain chum protection levels below Bonneville Dam and supporting flows for spring migrants. Through discussions at TMT, a decision was made to drop chum protection to 11.8 feet starting in late February to save water for spring migrants. The Bonneville tailwater elevation was brought back up to 13.5 feet for one hour per day to re-wet any redds that may have been above 11.8 feet.

Based on the March final forecast and forecasted flood control elevations, the April 10 elevation objective was 1279.9 feet. Grand Coulee passed through elevation 1279.9 feet during the early morning hours of April 10 as the project was drafting towards the April 15 and April 30 flood control targets of 1275.1 feet and 1258.5 feet, respectively. After drafting down to the April 30 flood control elevation of 1258.5 feet, Grand Coulee continued to draft until May 10th with a maximum draft of 1254.4 feet. Refill began soon after with discharges ranging from 150 to 190 kcfs to control the rate of refill. Grand Coulee was operated to refill by mid-July to provide summer flow augmentation. Delay in refill was due to flood control operations. Figure 1 shows inflows, outflows and reservoir operations through the water year.

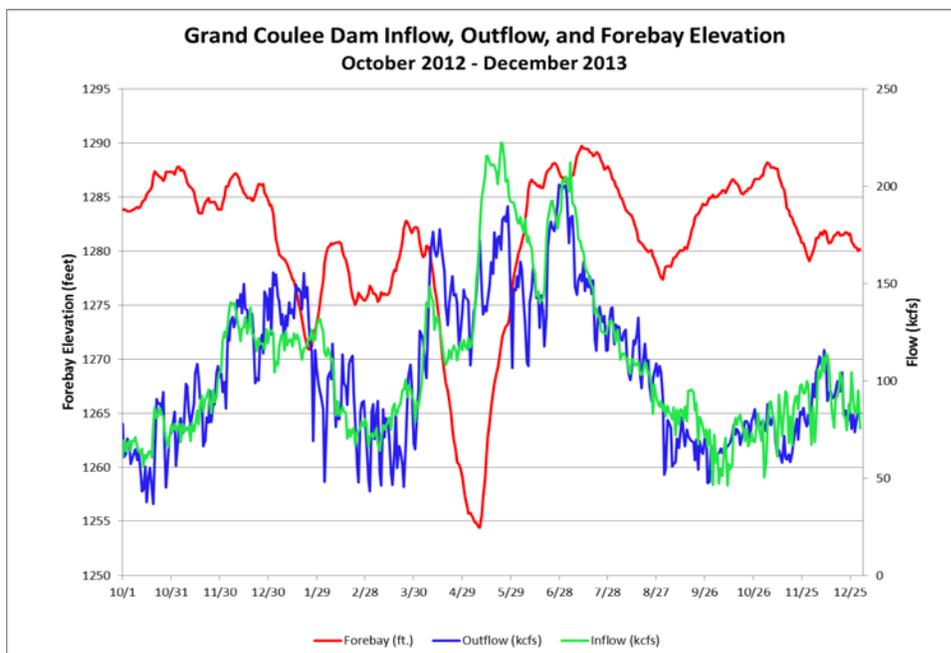


Figure 4. Grand Coulee Dam inflow, outflow, and forebay elevation from October 1, 2012 through December 31, 2013.

Grand Coulee Dam spilled a few days during mid-April, late May, and in late June through early July. For all of these occurrences the spill was over the drum gates so the TDG levels downstream were not increased. During the April and May spill events the TDG levels were less than 110 percent. In late June and early July the downstream TDG levels reached 114 percent below the dam; however, TDG levels flowing into Lake Roosevelt were at 117 percent so spill over the drum gates actually reduced TDG levels slightly.

In order to demonstrate that water was released from Grand Coulee during the spring under the Lake Roosevelt Incremental Storage Release Program, operations staff targeted a refill elevation following a recommendation from the Fish Flow Releases Advisory Group. The refill target elevation was 1289.8 feet which is 0.2 feet below the full pool elevation. Grand Coulee dam was refilled to 1289.8 feet on July 12, 2013 and began the summer draft. The summer draft is set by the RFC's July Final April-August water supply forecast at The Dalles Dam. The July Final April-August water supply forecast at The Dalles was 87.7 maf which set the draft to 1278 feet. The draft was increased an additional 0.3 feet to elevation 1277.7 feet to implement the Lake Roosevelt Incremental Storage Release Program. Grand Coulee Dam was drafted to elevation 1277.4 feet on August 31, 2013.

Banks Lake is required to draft to elevation 1565 feet by August 31 to provide water for summer flow augmentation. Pumping to Banks Lake was reduced and irrigation for the Columbia Basin Project was met by drafting the reservoir 5 feet from full (elevation 1565 feet) by August 31. Banks Lake drafted to elevation 1564.9 feet on August 31, 2013.

Hungry Horse Dam

Hungry Horse Dam was operated through the fall of 2012 and throughout 2013 to maintain the minimum flow requirements in the Flathead River at Columbia Falls and in the South Fork Flathead River below the dam. Minimum flows are for ESA-listed bull trout and were calculated from a sliding scale based on the Hungry Horse Dam inflow volume forecast. The

calculated minimum flows from October 2012 to December 2012 are listed in Table 3. Fall 2012 minimum flows were based on the March 2012 final water supply forecast. Minimum flows for 2013 were based on the water supply forecast for January through March, with the March water supply forecast setting the minimum flows from March to December 2013.

Table 3. Minimum flow requirements from October 2012 to December 2013.

Period	Hungry Horse Minimum Flow (cfs)	Columbia Falls Minimum Flow (cfs)
October-December 2012	900	3,500
January 2013	900	3,500
February 2013	900	3,500
March-December 2013	900	3,500

Hungry Horse Dam operations in 2013 followed VARQ flood control procedures. In January 2013 the water supply forecast for Hungry Horse Dam inflow from May to September was at 116 percent of average and decreased to 103 percent of average by the March forecast. The target April 10 elevation was 3535.9 feet while the actual elevation was 3536.4 feet. The April 30th flood control elevation target was 3532.6 feet; however, Hungry Horse drafted to 3526.6 feet in anticipation of high inflows. The total dissolved gas level of 110 percent was exceeded for 7 days, when water was spilled through the jet flow valves. Spill ranging from 2 to 4 kcfs was released from May 21 through May 27 to control the rate of refill of the reservoir.

As the water supply forecast for 2013 was not in the lowest 20 percentile, draft for flow augmentation was limited to 10 feet. Hungry Horse Dam targeted a September 30, 2013, elevation of 3550.0 feet using steady or slowly declining discharges. Actual operations reached elevation 3550.4 feet on September 30, 2013 and elevation 3550.0 feet on October 5, 2013. Hungry Horse was operated to provide a stable flow during the summer flow augmentation period, with an average flow from August through September 2013 of 2.3 kcfs. Figure 2 shows inflows, outflows and forebay elevations through the water year.

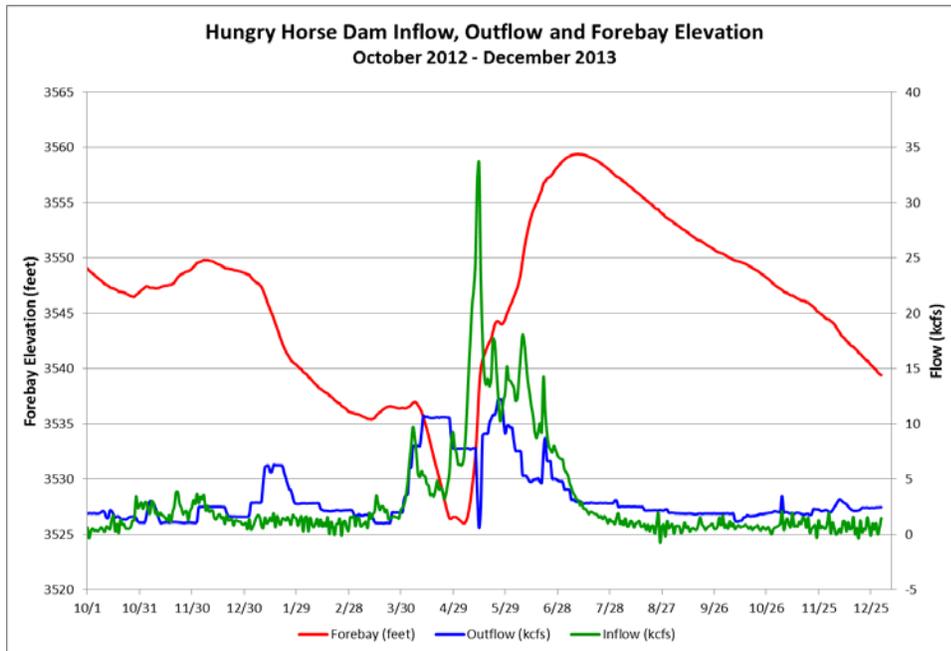


Figure 5. Hungry Horse Dam inflow, outflow, and forebay elevation from October 1, 2012 through December 31, 2013.

Albeni Falls Dam

The project began releasing additional water on September 14, 2012 to draft Lake Pend Oreille from elevation 2062.5 to elevation 2055 feet (all elevations as measured at the Hope gauge). Elevation 2055 feet was established as the winter minimum control elevation target for the winter 2012-2013 operation to support kokanee spawning through interagency discussions and was recommended by TMT pursuant to System Operation Request 2012-USFWS/IDFG -1. On November 6, Lake Pend Oreille was at elevation 2055.49 feet and was within its half-foot operating band for kokanee spawning. The project operated within the half-foot elevation band until Idaho Fish and Game (IDFG) declared the end of kokanee spawning on December 21, 2012.

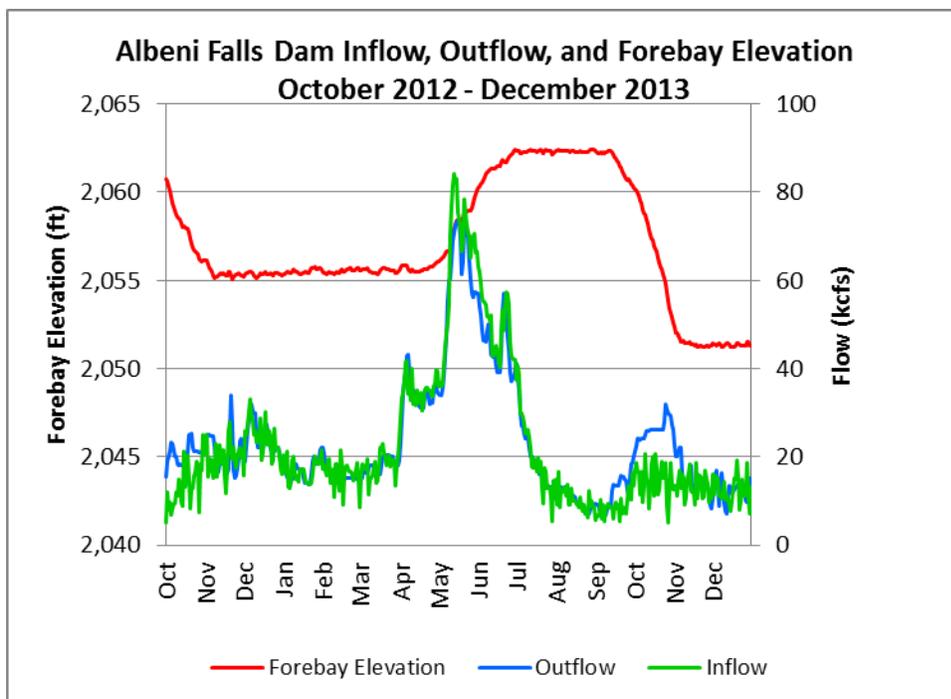


Figure 6. Albeni Falls Dam inflow, outflow, and forebay elevation from October 1, 2012 through December 31, 2013.

Between December 21, 2012 and April 30, 2013, Albeni Falls Dam was operated to maintain Lake Pend Oreille elevation within a 1-foot elevation band (2055 to 2056 feet).

The May 1 water supply forecast for April-July 2013 was 94 percent of average. This forecast led to the start of a slow refill of Lake Pend Oreille on May 1. Due to the high inflows, on May 13 all outflow from the project was transferred to the spillway, and the spillway gates were lifted out of the water and the project went on freeflow. On May 13, the project inflow and outflow was approximately 77 kcf and 64 kcf, respectively. The Hope gauge measured at 2057.20 feet. The project was taken off freeflow a week later, May 20, when project inflow and outflow was approximately 67 kcf and 61 kcf, respectively. The Hope gauge measured 2058.36 feet. The peak inflow for the year was approximately 84 kcf on May 14.

The peak outflow for the year was approximately 73 kcf on May 18. Project outflow averaged 58 kcf in May and 46 kcf in June. The lake reached its normal summer operating range, between 2062.0 feet and 2062.5 feet on June 26. For the remainder of the summer the project operated in the normal summer operating range, with the fall draft beginning on September 16.

In late 2012, IDFG presented information that showed they could not say whether lake levels had benefited kokanee recruitment. As a result, neither USFWS nor IDFG made a System Operation Request for the winter of 2013–14. Since there was no system operational request, the winter minimum control elevation level was set to 2051.0 feet. The target elevation was reached by November 10.

Lake Pend Oreille was operated in a range of 2051.0–2051.5 feet, as measured at the Hope gauge from November 10 through December 27 in order to support kokanee spawning. Kokanee spawning was declared over on December 19. The minimum control elevation for

kokanee spawning and incubation was set at 2051.0 feet for the winter of 2013-14 water year.

RPA Action 5 – Lower Columbia and Snake River Operations

The Action Agencies will operate the FCRPS run-of-river mainstem lower Columbia River and Snake River projects (Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose and Lower Granite projects) to minimize water travel time through the lower Columbia and Snake rivers to aid in juvenile fish passage. These run-of-river operations will be included in the annual WMP (see RPA Action 6).

The 2013 WMP included operations for these run-of-river projects. The projects were operated consistent with the WMP, the 2013 Spring Fish Operations Plan (FOP), and the 2013 Summer FOP which was consistent with the August 2011 Opinion and Order from the U.S. District Court for the District of Oregon (2011 Court Order) to guide spill operations for juvenile fish passage and to also minimize water travel time through the Lower Columbia and Snake rivers to aid in juvenile fish passage and water temperature management. Specific operating rules are used at individual reservoirs to provide salmon flows, protect resident fish, control floods, and operate for navigation and other authorized purposes. These operations are discussed further in the minutes of the TMT “2013 Year End Review Session” (TMT 2013). At Lower Monumental, Ice Harbor, Little Goose, and Lower Granite Projects, the plan was to operate at minimum operating pool (MOP) from April 3 through August 31, 2013. The Corps also continued the variable MOP-plus-2 operation for the Lower Granite pool in 2013 based on System Operational Request 2011-01 from the Columbia River Towboat Association. Variable MOP-plus-2 is to provide safe navigation conditions in the Lower Granite reservoir, which is compromised by sedimentation in the Federal navigation channel. The MOP-plus-2 operation minimizes the duration that Lower Granite Dam must be operated outside of MOP for safe navigation. The storage projects in the Columbia and Snake River systems, which are described under RPA Action 4 above, have limited ability to shape natural runoff. This limited storage capability can be managed to make modest adjustments in river flows for fish but cannot improve a low-water year or store water from an above-average water year for use in future below-average water years. As a result, flow objectives for juvenile fish are goals that cannot be physically achieved under some conditions. The flow objectives were used for pre-season planning and in-season water management to guide decision making. Figures 7, 8, and 9 show the observed outflow at McNary, Lower Granite, and Priest Rapids Dams relative to the flow objectives.

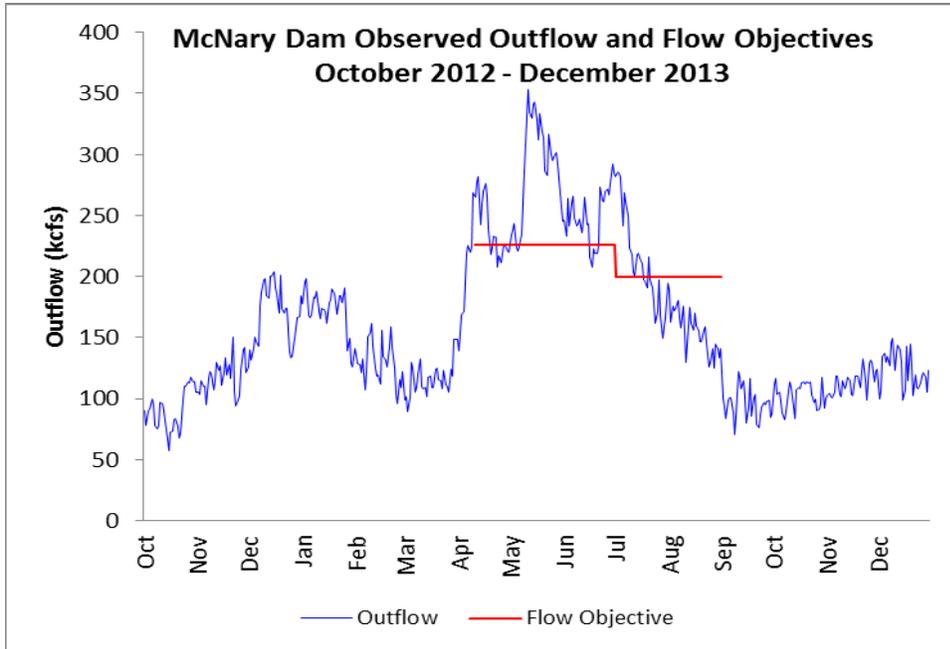


Figure 7. McNary Dam, observed outflow and flow objectives. April 11, 2013 to June 20, 2013 actual mean flow 261.9 kcfs, flow objective 226.0 kcfs. July 01, 2013 to August 31, 2013 actual mean flow 183.9 kcfs, flow objective 200.0 kcfs. The flow objectives are not achievable in all water conditions; rather they are used for pre-season planning and in-season water management to guide decision making.

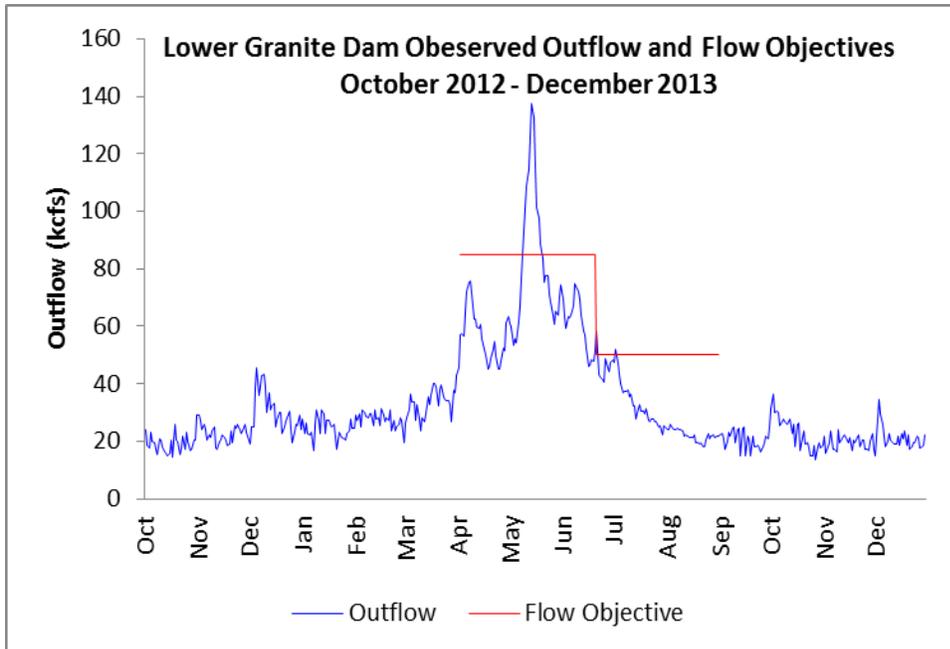


Figure 8. Lower Granite Dam, observed outflow and flow objectives. April 3, 2013 to June 30, 2013 actual mean flow 67.9 kcfs, flow objective 85 kcfs. June 21, 2013 to August 31, 2013 actual mean flow 30.0 kcfs, flow objective 50.0 kcfs. The flow objectives are not achievable in all water conditions; rather, they are used for pre-season planning and in-season water management to guide decision making.

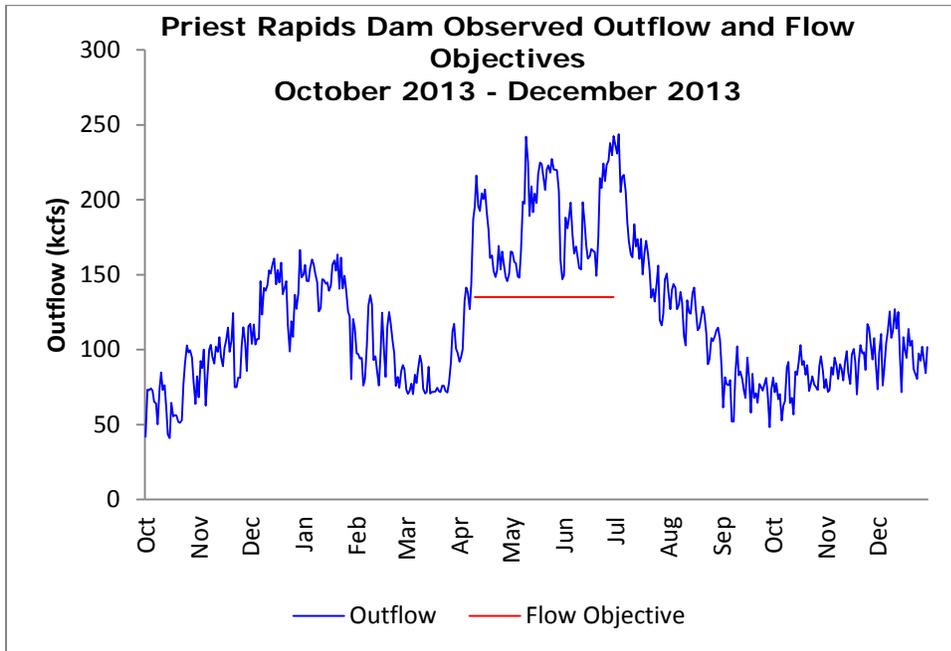


Figure 9. Priest Rapids Dam, observed outflow and flow objectives. April 10, 2013 to June 30, 2013 actual mean flow 187.4 kcfs, flow objective 135.0 kcfs. The flow objectives are not achievable in all water conditions; rather, they are used for pre-season planning and in-season water management to guide decision making.

In 2013, the Columbia River had a slightly below average water year according to NWRFC. The January to July volume as measured at The Dalles Dam (97.7 maf) was 93 percent of normal (104.7 maf for period rankings 1961–2013). The Snake River volume from April to July, as measured at Lower Granite (13.9 maf), was 66 percent of normal (20.9 maf for period rankings 1961–2013).

RPA Action 6 – In Season Water Management

Prioritization of the use of flow augmentation water is done through in-season management by the Regional Forum. Each fall, the Action Agencies will prepare an annual Water Management Plan (WMP) and seasonal updates that describe planned hydrosystem fish operations for the upcoming fall and winter, and for the spring, and summer passage seasons. The annual WMP strives to achieve the best possible mainstem passage conditions, recognizing the priorities established in the FCRPS BA and the need to balance the limited water and storage resources available in the region. Fall/winter and spring/summer updates are prepared as more data is available on the water conditions for that year. A draft update of the WMP will be prepared by October 1 each year, with a final plan completed by January 1. The fall/winter update to the WMP will be drafted by November 1 and finalized by January 1. A draft of the spring/summer update to the WMP will be prepared by March 1 and finalized by May 15.

The annual WMP for the 2013 operating season (October 1, 2012, through September 30, 2013) was developed collaboratively with the region in accordance with the NOAA Fisheries Service 2008 Biological Opinion and NOAA Fisheries 2010 Supplemental Biological Opinion (NOAA Fisheries 2010 Supplemental BiOp). A draft of the WMP for the 2013 operating season was released on October 1, 2012. The final WMP was released on December 31, 2012.

Prior to 2011, the Action Agencies provided a fall/winter and spring/summer update to the WMP. The TMT decided that these bi-annual updates were not providing them updated information frequently enough to assist in informing the decision-making process. In an

effort to increase the frequency of updates to the WMP, the TMT decided to discontinue updating the WMP two times per year and change the updating format to a “seasonal update.” At minimum, the seasonal update would be posted two times per year with a goal of posting at a greater frequency in order to provide the TMT with updated information to assist in the decision-making process. During the 2013 operating season the Action Agencies posted four seasonal updates. Changes to the updating mechanism to the WMP were coordinated with the TMT.

RPA Action 7 – Forecasting and Climate Change/Variability

The Action Agencies will hold annual forecast performance reviews looking at in-place tools for seasonal volume forecasts and to report on the effectiveness of experimental or developing/emerging technologies and procedures. As new procedures and techniques become available and are identified to have significant potential to reduce forecast error and improve the reliability of a forecast, the Action Agencies will discuss the implementation possibilities with regional interests. The purpose is to improve upon achieving upper rule curve elevations by reducing forecasts errors and thereby providing for improved spring flows. The Action Agencies will work collaboratively with other agencies and research institutions to investigate the impacts of possible climate change scenarios to the Pacific Northwest and listed salmon and steelhead. Focus areas will cover (1) modeling the hydrology and operations of the Columbia River system using possible future climate change scenarios, (2) investigating possible adaptation strategies for the system, (3) monitoring the hydrologic system for trends, cycles, and changes, and (4) staying abreast of research and studies that address climate cycles, trends, and modeling.

Columbia River Forecast Group

The Columbia River Forecast Group (CRFG) continues to work collaboratively to assist the Action Agencies in implementing this RPA action. The CRFG annual reports are available at <http://www.salmonrecovery.gov/Hydro/Operations.aspx>.

Because the CRFG has now been in existence since the NOAA Fisheries Service 2008 Biological Opinion, the group used 2013 to review all forecast procedures now used in the basin since its inception. Several forecast techniques and procedures have improved since 2009, while ESPs grew into wider use and acceptance. ESPs can be prepared and issued much more frequently than statistical forecasts. Decision makers have gained considerable advance notice when conditions are changing rapidly in the basin – either wetter or drier. The CRFG is still learning how to use these forecasts, though, since they have their own shortcomings (i.e. under dispersion of potential range of outcomes, longer range/lower skill precipitation forecasts occasionally caused sharp swings in forecasts). In December 2013, the NWRFC switched from using an ESP based on a 3-day Quantity of Precipitation Forecast to one based on a 5-day forecast, which is used for a variety of operations and plan purposes on the Columbia River system, including flood control and storage target set by the Corps Reservoir Control Center. In the past, forecasts for precipitation more than three days in advance were considered to be any more skillful than assuming historical average precipitation. The CRFG recommended this change because their review of recent forecasting information showed precipitation forecasts out to five days in advance are now regularly providing more reliable information for decision makers.

The group found through its year-long forecast evaluations that statistical water supply forecasts remain powerful tools to guide decision-making at headwater projects, especially when statistical variables used in the equations have solid reasoning and meteorological backing. CRFG members applied this guiding principle several times as they adjusted equations this year. For example, BC Hydro and Seattle District, with the approval of the Columbia River Treaty Operating Committee, temporarily adjusted equations for the

Canadian Treaty projects in 2013 when record rainfall in October, 2012, yielded unreasonable early-season volumes. In 2013, the Dworshak forecast, after two years of science and statistical method feedback from CRFG, was adopted for regular use. Finally, initial discussions began on updating and improving the Libby Water Supply forecast equations.

One of the reasons that the forecast equations are being updated is because of changes in available hydro meteorological data. The NRCS solicited feedback from the CRFG and other user groups on possible additions to its snow pillow network as snow courses are reduced or eliminated due to budget pressures and fewer volunteer observers. BPA and BC Hydro began execution of a two-year Memorandum of Agreement to jointly fund the installation of four new snow pillows in the data-sparse Upper Columbia basin, with one new station at Keystone Peak, BC, becoming operational in August, 2013.

In August, the River Management Joint Operating Committee (RMJOC) and its research partners at the University of Washington, Oregon State University and Portland State University presented the RMJOC-II Climate Change Study Project outline and related research. The CRFG will function as the main technical body to review project progress. The project will begin in 2014 and continue through 2017. The overall objective will be to use the latest data from the Global Climate Models, published as part of the Coupled Model Intercomparison Project Phase and generate a new temperature, precipitation and streamflow dataset for use in future planning activities.

Climate Change Studies

In 2013, two Bonneville Power Administration Technology and Innovation Grant research proposals were submitted by Portland State University and the University of Washington. BPA established committees to review and select proposals for funding. Two projects were selected, one with Portland State University and the other with the University of Washington. These research universities will investigate use of multiple hydrologic models and downscaling methods (among other tasks) using the latest International Panel on Climate Change projections (Coupled Model Intercomparison Project Phase 5). Future flows at over 300 locations Columbia River basin-wide will be generated for use in the BPA, Corps, and Reclamation water resource models to evaluate the impact of future climate change on reservoir operations, power, and flooding. Since October 2013, the Action Agencies have been developing daily, unregulated flow at the locations of interest to provide to the researchers for use in their efforts. Future flow simulations will be generated by Portland State University and the University of Washington by late 2015 and early 2016, after which the Action Agencies will begin their analyses.

RPA Action 8 – Operational Emergencies

The Action Agencies will manage interruptions or adjustments in water management actions, which may occur due to unforeseen power system, flood control, navigation, dam safety, or other emergencies. Such emergency actions will be viewed by the Action Agencies as a last resort and will not be used in place of operations outlined in the annual WMP. Emergency operations will be managed in accordance with TMT Emergency Protocols, the Fish Passage Plan (FPP) and other appropriate Action Agencies emergency procedures. The Action Agencies will take all reasonable steps to limit the duration of any emergency impacting fish.

No operational emergencies occurred in 2013.

RPA Action 9 – Fish Emergencies

The Action Agencies will manage operations for fish passage and protection at FCRPS facilities. They may be modified for brief periods of time due to unexpected equipment failures or other conditions. These events can result in short periods when projects are operating outside normal specifications due to unexpected or emergency events. Where there are significant biological effects of more than short duration resulting from emergencies impacting fish, the Action Agencies will develop (in coordination with the in-season management Regional Forum) and implement appropriate adaptive management actions to address the situation. The Action Agencies will take all reasonable steps to limit the duration of any fish emergency.

Between the dates of July 22 through August 10, 2013, the Corps implemented regionally coordinated special operations at Lower Granit Dam to address adult passage delays due to warm incoming river water temperatures at the dam. These operations included intermittent spill levels that were either higher or lower than levels identified in the 2013 FOP. Specifically, on July 29, 2013, from 0000 to 1100 hours and from July 31 at 1100 hours through August 5 at 1700 hours, Unit 1 was operated outside of the 2013 FPP unit operating priority in order to provide attraction flow near the fish ladder, while spilling the remainder of outflow. Based on additional recommendations coordinated with the TMT, from August 5 at 1700 hours through August 10 at 0900 hours, the Corps implemented a modified operation that alternated between a nighttime (1700-0500) operation of Unit 5 at 5 kcfs (minimum amount of generation needed for station service), while spilling up to the TDG cap and a daytime (0500-1700) operation of Unit 1 at 17 kcfs while spilling the remainder of outflow. Operating Unit 5 at 5 kcfs is outside of the 1 percent of peak efficiency range called for in the BiOp and the FOP, and is outside of the unit operating priority specified in the 2013 FPP. In addition, from July 25 on the Corps operated emergency auxiliary water supply pumps to pump cooler water into the ladder. Adult fish passage counts were consistently higher during the special operations than during periods of Unit 2 operation. Throughout the operation, the Corps monitored real-time data and modified the operation as necessary through further coordination with TMT during meetings on July 29, 31, and August 2, 5, 14, and 21. TMT members either supported or did not object to these operations. As discussed in the coverage of RPA Action 28, the Corps is currently designing modifications to the auxiliary ladder pump intakes and discharge routing, for possible construction in 2015.

RPA Action 10 – Describe Actions Taken to Provide 1 maf of Treaty Storage

BPA and the Corps will pursue negotiations with Canada of annual agreements to provide 1 maf of storage in Treaty space by April 15 consistent with:

- 1. Providing the greatest flexibility possible for releasing water to benefit U.S. fisheries May through July.*
- 2. Giving preference to meeting April 10 upper rule curve elevation or achieving refill at Grand Coulee Dam over flow augmentation storage in Canada in lower water supply conditions.*
- 3. Releasing flow augmentation storage to avoid causing damaging flow or excessive TDG in the United States or Canada.*

BPA and the Corps will coordinate with Federal agencies, States and Tribes on Treaty operating plans.

The Columbia River Treaty Operating Committee Agreement on Operation of Treaty Storage for Non-Power Uses for December 1, 2012 through July 31, 2013 (Non-Power Uses Agreement) was executed on December 4, 2012. Under this agreement, one maf of flow augmentation water was stored in Canadian reservoirs in January 2013. All flow

augmentation storage was released by July 31, 2013, under the Non-Power Uses Agreement.

A new Non-Power Uses Agreement for 2014 was executed on November 30, 2013, which provides for one maf of flow augmentation water storage under the same terms as the prior agreement.

BPA and the Corps held meetings with federal agencies, states and tribes in spring 2013 and fall 2013 to discuss the Treaty and non-Treaty storage (NTS) operations and Treaty operating plans.

RPA Action 11 – Non-Treaty Storage

BPA, in concert with BC Hydro, will refill the remaining non-Treaty storage space by June 30, 2011, as required under the 1990 non-Treaty storage agreement. Refill will be accomplished with minimal adverse impact to fisheries operations.

In January 2011, BPA completed the return of NTS called for under the 1990 NTS Agreement (NTSA). Refill was accomplished outside of fish passage season to minimize adverse impact to fisheries.

RPA Action 12 – Non-Treaty Long-Term Agreement

BPA will seek to negotiate a new long-term agreement on use of non-Treaty space in Canada so long as such an agreement provides both power and non-power benefits for BC Hydro, BPA, and Canadian and U.S. interests. As part of these negotiations, BPA will seek opportunities to provide benefits to ESA-listed fish, consistent with the Treaty. If a new long-term, non-Treaty agreement is not in place, or does not address flows for fisheries purposes, BPA will approach BC Hydro about possibly negotiating an annual/seasonal agreement to provide U.S. fisheries benefits, consistent with the Treaty.

BPA entered into a new Columbia River NTSA with BC Hydro on April 10, 2012 (2012 NTSA). The 2012 NTSA allows for coordinated use of non-Treaty storage (NTS) in Canada to shape flows within the year for fisheries benefits, and provides up to an additional half maf of water to benefit fish in the lowest water conditions.

As noted under RPA Action 10, BPA and the Corps held meetings with federal agencies, states and tribes in spring 2013 and fall 2013 to discuss the Treaty and NTS operations and Treaty operating plans.

RPA Action 13 – Non-Treaty Coordination with Federal Agencies, States, and Tribes

Prior to negotiations of new long-term or annual non-Treaty storage agreements, BPA will coordinate with Federal agencies, States, and Tribes to obtain ideas and information on possible points of negotiation, and will report on major developments during negotiations.

As explained in RPA Action 12, BPA entered into the new 2012 NTSA with BC Hydro. The 2012 NTSA allows for coordinated use of NTS in Canada to shape flows within the year for fisheries benefits, and provides up to an additional half maf of water to benefit fish in the lowest water conditions. This action continues to be implemented in 2013.

RPA Action 14 – Dry Water Year Operations

Flow management during dry years is often critical to maintaining and improving habitat conditions for ESA-listed species. A dry water year is defined as the lowest 20th percentile years based on the NWRFC averages for their statistical period of record (currently 1971 to 2000) using the May final water supply forecast for the April to August period as measured at The Dalles. The Action Agencies will complete the following activities to further the continuing efforts to address the dry flow years:

- 1. Within the defined “buckets” of available water (reservoir draft limits identified in RPA Action 4), flexibility will be exercised in a dry water year to distribute available water across the expected migration season to optimize biological benefits and anadromous fish survival. The Action Agencies will coordinate use of this flexibility in the Regional Forum TMT.*
- 2. In dry water years, operating plans developed under the Treaty may result in Treaty reservoirs being operated below their normal refill levels in the late spring and summer, therefore, increasing flows during that period relative to a standard refill operation.*
- 3. Annual agreements between the U.S. and Canadian entities to provide flow augmentation storage in Canada for U.S. fisheries needs will include provisions that allow flexibility for the release of any stored water to provide U.S. fisheries benefits in dry water years, to the extent possible.*
- 4. BPA will explore opportunities in future long-term NTS storage agreements to develop mutually beneficial in-season agreements with BC Hydro to shape water releases using NTS space within the year and between years to improve flows in the lowest 20th percentile water years to the benefit of ESA-listed ESUs, considering their status.*
- 5. Upon issuance of the FCRPS Biological Opinion, the Action Agencies will convene a technical workgroup to scope and initiate investigations of alternative dry water year flow strategies to enhance flows in dry years for the benefit of ESA-listed ESUs.*
- 6. In very dry years, the Action Agencies will maximize transport for Snake River migrants in early spring, and will continue transport through May 31.*

BPA will implement, as appropriate, its Guide to Tools and Principles for a Dry Year Strategy to reduce the effect energy requirements may pose to fish.

The BiOp defines a dry year as a year when the NWRFC May final forecast for April-to-August runoff at The Dalles Dam is below the 20th percentile established in the 1971-2000 period of record, which equates to 72 maf. The 2013 water year was not a dry year, with the May forecast coming in at 82.5 maf or 94 percent of average for the April–August period. The actual runoff volume was 87.1 maf, or almost exactly, 100 percent of average.

The Action Agencies convened a technical workgroup, which scoped and initiated investigations of alternative dry water year flow strategies to enhance flows in dry years for the benefit of ESA listed fish. The group’s analysis contributed to the development of a dry water year’s provision of the 2012 NTSA (see RPA Action 12).

RPA Action 15 – Water Quality Plan for Total Dissolved Gas and Water Temperature in the Mainstem Columbia and Snake Rivers

The Action Agencies will continue to update the Water Quality Plan for Total Dissolved Gas and Water Temperature in the Mainstem Columbia and Snake Rivers (WQP) and implement water quality measures to enhance ESA-listed juvenile and adult fish survival and mainstem spawning and rearing habitat. The WQP is a comprehensive document which contains water quality measures needed to

meet both ESA and Clean Water Act responsibilities. For purposes of this RPA, the WQP will include the following measures to address TDG and water temperature to meet ESA responsibilities:

1. Real-time monitoring and reporting of TDG and temperatures measured at fixed monitoring sites,
2. Continued development of fish passage strategies with less production of TDG, and
3. Update the SYSTDG model to reflect modifications to spillways or spill operations,
4. Continued development and use of SYSTDG model for estimating TDG production to assist in real-time decision making, including improved wind forecasting capabilities as appropriate,
5. Continued development of the CEQUAL-W2 model for estimating river temperatures from Dworshak Dam on the Clearwater and Upper Snake River near the confluence with the Grand Ronde River (USGS Anatone gauge) through the lower Snake River (all four Corps lower Snake River projects) to assist in real-time decision making for Dworshak Dam operations, and
6. Expand water temperature modeling capabilities to include Columbia River from Grand Coulee to Bonneville dams to better assess the effect of operations or flow depletions on summer temperatures, and
7. Investigate alternatives to reduce total mass loading of TDG at Bonneville Dam while maintaining juvenile survival performance, and
8. Continued operation of the Lower Snake River projects at MOP.

Development and calibration of the water quality model for Grand Coulee reservoir has been completed. The model spans the extent of Lake Roosevelt from the international border with Canada down to and including Grand Coulee Dam. The model incorporates the Kettle, Colville, Spokane, and Sanpoil River reaches via U.S. Geological Survey (USGS) gauging stations. The model also uses Reclamation AgriMet weather station data as the forcing variables for meteorological conditions. The model was built using CEQUAL-W2 and is currently calibrated to model Grand Coulee Dam outflow temperatures using recent historical data. Model calibration was limited by the amount of available meteorological data and was only performed for calendar years 2000, 2006, and 2011. The calibration report, authored by Portland State University, is currently in draft format with final reviews in progress.

Work included the development and calibration of a RiverWare model to supplement the CEQUAL-W2 model for Grand Coulee Dam. The RiverWare model contains modeling assumptions and rules that simulate operations at Grand Coulee Dam with regard to powerhouse operations as well as Banks Lake pumping and generation. Given projected inflows and operational assumptions, the RiverWare model is used to route Grand Coulee Dam outflows to the left, right, or third powerhouses, Banks Lake, or spill. RiverWare outputs are used as inputs for CEQUAL-W2 to determine outflow temperatures at each outlet and the weighted average temperature for the total outflow. The RiverWare model was completed and calibrated.

The *2009 Water Quality Plan for Total Dissolved Gas and Water Temperature in the Mainstem Columbia and Snake Rivers* provides the overall framework for addressing water quality measures needed to meet both the ESA and Clean Water Act responsibilities.

In 2013, spill at the projects was managed consistent with the 2009-2013 Total Dissolved Gas Management Plan (BPA et al. 2010). Real-time monitoring was conducted consistent with the 2010-2014 Dissolved Gas Monitoring Plan of Action updated for 2013 (ACOE 2011).

Real-time TDG and temperature values are reported hourly on the water quality pages of the TMT website at http://www.nwd-wc.usace.army.mil/ftppub/water_quality/tdg/.

The Bonneville Dam tailwater fixed monitoring station suffered damage again in 2013 from high runoff flows and the instrumentation conduits were replaced with a more robust design. The System Total Dissolved Gas (SYSTDG) model was used as a real-time decision support tool to manage spill at Lower Columbia and Snake Rivers projects. A statistical evaluation of SYSTDG's performance was conducted to assess how well the model estimated percent TDG. The predictive errors that SYSTDG computed in 2013 compared favorably with the predictive errors from previous years. A summary of the predictive error for each FMS can be found in Appendix G, Tables G1-G8 of the Total Dissolved Gas and Water Temperature Report.

The following improvements were made to the SYSTDG model in 2013:

1. SYSTDG was upgraded to pull data directly from the Corps' CWMS database. This improvement was mostly completed during 2013, but some additional work still remains. It is anticipated that this effort will be completed in 2014.
2. The feature of adding or changing the various spill patterns was added to SYSTDG in 2012 and updated in 2013.
3. The proposed SYSTDG improvements listed in the 2012 statistical analysis (Appendix G) were not incorporated into the model during 2013 due to time and resource constraints.

The CEQUAL-W2 model was used from late June through early September 2013 to support decisions regarding operation of Dworshak Dam for flow augmentation and temperature management on the lower Snake River. The results were presented and discussed routinely with TMT members and Action Agencies to develop best management strategies.

RPA Action 16 – Tributary Projects

The tributary projects that have not yet completed ESA Section 7 consultation are located in the Yakima, Okanogan, and Tualatin river basins. Reclamation will, as appropriate, work with NOAA Fisheries in a timely manner to complete supplemental, project-specific consultations for these tributary projects. These supplemental consultations will address effects on tributary habitat and tributary water quality, as well as direct effects on salmon survival in the tributaries. The supplemental consultations will address effects on mainstem flows only to the extent to which they reveal additional effects on the instream flow regime not considered in the FCRPS and Upper Snake River BA/Comprehensive Analysis.

Reclamation submitted Biological Assessments (BAs) to NOAA Fisheries on the Okanogan, Tualatin, and Yakima projects. Reclamation is currently working with NOAA Fisheries on each of these tributary specific consultations. The current status on each consultation and the predicted future work schedules for these project consultations are provided below.

Okanogan Project Consultation

Reclamation submitted a BA for the future operation and maintenance of the Okanogan Project in 2008. This consultation covers Upper Columbia Steelhead. Since 2009 Reclamation has been collecting data in the Okanogan Basin to determine if the proposed action can be modified to address concerns raised by NOAA Fisheries. Data collection will continue into the 2014 to 2018 period. It is anticipated that Reclamation will reinitiate consultation with NOAA Fisheries in the 2014 through 2015 time period. The objective would be to provide an updated proposed action to NOAA Fisheries at the end of 2015 and to conclude Section 7 consultation with NOAA Fisheries in 2016.

Yakima Project Consultation

Reclamation and the NOAA Fisheries re-initiated consultation at the end of 2012 on mid-Columbia steelhead. Currently, Reclamation, NOAA Fisheries, and the USFWS are revising the 2000 BA, the 2009 BA Supplement, and integrating new information obtained from the Integrated Water Resource Management Planning effort in 2012 into a new BA. Reclamation and NOAA Fisheries will continue to meet on this consultation throughout 2014. For the 2014 through 2018 period, Reclamation and NOAA Fisheries have the objectives of submitting a new BA in 2014 and completing the Section 7 consultation by the end of 2015.

Tualatin Project Consultation

Reclamation submitted a BA to NOAA Fisheries for the future operation and maintenance of the Tualatin Project in 2009 that covers both upper Willamette River steelhead and spring Chinook. In July 2013, NOAA Fisheries issued a draft Biological Opinion on the future operation and maintenance of the Tualatin. Reclamation reviewed and provided comments back to NOAA Fisheries in August 2013. NOAA Fisheries expects that a final Tualatin Project Biological Opinion can be issued to Reclamation by the end of 2014.

RPA Action 17 – Chum Spawning Flows

- 1. Provide adequate conditions for chum spawning in the mainstem Columbia River in the area of the Ives Island complex and/or access to the Hamilton and Hardy Creeks for this spawning population.*
- 2. Provide a tailwater elevation below Bonneville Dam of approximately 11.5 feet beginning the first week of November (or when chum arrive) and ending by December 31, if reservoir elevations and climate forecasts indicate this operation can be maintained through incubation and emergence.*
- 3. Through TMT, if water supply is deemed insufficient to provide adequate mainstem spawning or continuous tributary access, provide, as appropriate, mainstem flow intermittently to allow fish access to tributary spawning sites if adequate spawning habitat is available in the tributaries.*
- 4. Make adjustments to the tailwater elevation through the TMT process consistent with the size of the spawning population and water supply forecasts.*
- 5. After the completion of spawning, use the TMT process to establish the tailwater elevation needed to provide protection for mainstem chum redds through incubation and the end of emergence.*
- 6. If the emergence period extends beyond April 10th and the decision is made to maintain the tailwater, TMT will discuss the impacts of TDG associated with spill for fish in the gravel.*

Bonneville Dam typically starts its spring spill around April 10, but a delay in the start of spill may be needed.

7. *Revisit the chum protection level decision at least monthly through the TMT process to assure it is consistent with the need to provide spring flows for listed Columbia and Snake River stocks.*

2012-13 Operation

All actions below were carried out in coordination with the TMT.

On October 31, 2012, the Action Agencies initiated the chum operation. The Action Agencies issued the following guidance to Bonneville Dam to provide habitat for spawning chum salmon: (1) operate the tailwater between a range of 11.3-11.7 feet, targeting 11.5 feet during the day, and (2) up to 18.5 feet at night.

On November 20, the Action Agencies implemented the following revised chum operation due to increasing inflows: (1) operate the tailwater between a range of 12.2 to 12.8 feet, targeting 12.5 feet, during the day and (2) up to 18.5 feet at night.

On November 27, the Action Agencies implemented the following revised chum operation due to increasing inflows: (1) operate the tailwater between a range of 13.5 to 14.5 feet, targeting 14.0 feet, during the day and (2) up to 18.5 feet at night.

On November 30, the Action Agencies implemented the following revised chum operation due to increasing inflows: (1) operate the tailwater between a range of 13.5 to 15.5 feet, targeting 14.0 feet, and (2) up to 18.5 feet at night.

December 4, the Action Agencies implemented the following revised chum operation with the goal of completing repairs in the spillway while maintaining the chum operation concurrently: (1) maintain the 13.5 feet minimum tailwater during all hours, (2) make best efforts to maintain 13.5 to 15.5 feet tailwater during the day targeting 14.0 feet, (3) if unable to maintain No. 2 then pass up to a maximum of 18.5 feet at night, (4) if unable to maintain No. 3 then pass up to a maximum of 18.5 feet during the day, and (5) if unable to maintain No. 4 then operate to full powerhouse plus operation of the Powerhouse Two Corner Collector.

On December 21, the Action Agencies discontinued the day/night spawning operation and began the 13.5 feet tailwater operation at all hours for chum incubation.

On February 19, 2013, the Action Agencies implemented the following revised chum operation due to a reduction in the water supply forecast: (1) On February 19, the tailwater was reduced to a 13.0 feet minimum, (2) on February 22, the tailwater was reduced to a 12.5 feet minimum, (3) on February 24, the tailwater was reduced to a 12.0 feet minimum, and (4) on February 26, the tailwater was reduced to a 11.8 feet minimum. Additionally, in order to minimize desiccation of chum redds during this tailwater reduction operation the Action Agencies increased the tailwater back up to 13.5 feet for 1 to 2 hours daily.

On April 10 the Action Agencies ended the chum operation because the fish had emerged from the gravel so the operation was no longer needed.

2013-14 Operation

All actions below were carried out in coordination with the TMT.

On November 7, 2013, the Action Agencies initiated the chum operation. The Action Agencies issued the following guidance to Bonneville Dam to provide habitat for spawning chum salmon: (1) Operate the tailwater between a range of 11.3-11.7 feet, targeting 11.5 feet during the day, and (2) up to 18.5 feet at night.

On November 29, the Action Agencies implemented the following revised chum operation due to increasing inflows: (1) Operate the tailwater between a range of 11.6 to 12.0 feet, targeting 11.8 feet, during the day and (2) up to 18.5 feet at night.

On December 5 at 6 a.m. through December 12 at 6 a.m., the Action Agencies implemented the following revised chum operation due to increasing inflows: (1) Operate the tailwater between a range of 12.7 to 13.1 feet, targeting 12.9 feet, during the day and (2) up to 18.5 feet at night.

On December 12 at 7 a.m. the Action Agencies implemented the following revised chum operation due to decreasing inflows: (1) Operate the tailwater between a range of 11.6 to 12.0 feet, targeting 11.8 feet, during the day and (2) up to 18.5 feet at night.

On December 25, the Action Agencies discontinued the day/night spawning operation and began the 11.5 feet tailwater operation on all hours for chum incubation.

On April 2, 2014, the Action Agencies ended the chum operation because the fish had emerged from the gravel so the operation was no longer needed.

Hydropower Strategy 2 (RPA Actions 18–28)

RPA Action 18 – Configuration and Operation Plan (COP) for Bonneville Project

The Corps will consider all relevant biological criteria and prepare, in cooperation with NOAA Fisheries and the co-managing agencies, a Configuration and Operational Plan for the Bonneville Project (2008). As part of the first phase of modifications, the Corps will investigate, and implement the following reasonable and effective measures to reduce passage delay and increase survival of fish passing through the forebay, dam, and tailrace as warranted. Initial modifications will likely include:

Bonneville Powerhouse I

1. *Sluiceway modifications to optimize surface flow outlet to improve fish passage efficiency and reduce forebay delay (2009).*

Powerhouse I sluiceway improvements, which converted the sluiceway to a surface flow outlet, were completed in 2010.

2. *Minimum-gap turbine runner installation to improve survival of fish passing through turbines (2009).*

Installation of the final minimum-gap turbine runners at Powerhouse I was completed in 2010.

Bonneville Powerhouse II

3. *Screened bypass system modification to improve fish guidance efficiency and reduce gatewell residence time (2008).*

Modifications to the juvenile bypass system to improve fish guidance efficiency were completed in 2008. However, after those modifications a fish injury problem was identified. In 2013 the Corps continued an alternatives study to address those increased injury rates. A prototype of the recommended alternative, a gate slot filler, was constructed and tested hydraulically and biologically. Preliminary fish conditions and survival testing using hatchery fish was sufficient to determine that the gate filler prototype did not increase survival sufficiently to continue testing with run-of-river juvenile salmonids (Table 4). Furthermore, hydraulic measurements in the gatewell found through-screen velocities above NOAA Fisheries criteria (Gilbreath et al. 2014). In coordination and agreement with the Fish Facility Design Review Work Group (FFDRWG), on April 11, 2013 the Corps discontinued further evaluation of the gate slot filler prototype. Other alternative improvements are currently being investigated. In 2013, to minimize injury, Powerhouse II turbine units were operated at the lower end of the ± 1 percent peak efficiency range. This operation reduces flow into the gatewells, thereby reducing the injury to fish passing into the juvenile bypass system.

Table 4. Spring Creek National Fish Hatchery subyearling Chinook released into Bonneville Juvenile Bypass System gatewell 14A that were recaptured and confirmed live or dead during the 2013 gatewell improvement prototype test (Gilbreath et al. 2014).

Flow (Percent)	TRDs	Released #	Recaptured #	Recaptured Percent	Mortality of Recaptured #	Mortality of Recaptured Percent	Percent of Release Recaptured Live
Low 1	Out	1148	1099	95.7	16	1.5	94.3
Upper 1	In	1202	855	71.1	135	15.8	59.9
Upper 1	Out	1145	618	54.0	129	20.9	42.7
Collection channel	NA	218	215	98.6	0	0	98.6

4. *Shallow behavioral guidance screen installation to increase Corner Collector efficiency and reduce forebay delay (prototype 2008).*

Testing of a shallow behavioral guidance structure at Powerhouse II was completed in 2010. Due to minimal benefits and high operation and maintenance costs, the structure was removed prior to the 2011 migration season.

Bonneville Dam Spillway

5. *Spillway operation or structure (e.g., spillway deflectors) modification to reduce injury and improve survival of spillway passed fish; and to improve conditions for upstream migrants (2013).*

Hydraulic modeling and fish survival studies were completed and spillway operations that increased survival of juvenile salmonids passing through the spillway were implemented in 2008. A study to identify and evaluate structural fish passage improvements to the spillway was completed in 2009. Further development of structural improvements is on hold pending results of performance

testing.

The COP will be updated periodically and modifications may be made as new biological and engineering information is gathered. The COP and modifications will be coordinated through the Regional Forum. Comments developed by NOAA Fisheries on the draft COPs shall be reconciled by the Corps in writing to NOAA Fisheries' satisfaction before release of the final COP. If Phase I actions fail to meet the intended biological targets, the COP will be updated to identify additional Phase II actions for further implementation.

Performance standard testing was conducted in 2011 for yearling Chinook salmon and juvenile steelhead and in 2012 for subyearling Chinook salmon (Table 5). In 2011, dam passage survival estimates for yearling Chinook were slightly below the 96-percent BiOp performance standard, at 95.6 percent, while juvenile steelhead dam passage survival exceeded the standard at 97.6 percent during the portion of the study period when the target spill level (100 kcfs) was attained (April 30-May 13). The 95 percent confidence intervals of 2011 steelhead survival estimates exceeded the \pm 3% BiOp requirement by \pm 0.5 percent.

Table 5. Dam Passage Survival (with Standard Errors), Passage Times, and Spillway Passage Efficiency for Yearling Chinook Salmon, Juvenile Steelhead, and Subyearling Chinook at Bonneville Dam in 2011 and 2012 (Skalski et al. 2012a, Skalski et al. 2013a). Spill passage efficiency includes spillway and other surface passage route passage.

Species	Dam Passage Survival (Percent with Standard Error)	Forebay/Tailrace Passage Time (Hours)	Spill Passage Efficiency (Percent)
100-kcfs Spill (April 30-May 13, 2011)			
Yearling Chinook	95.7 (0.4)	n/a	n/a
Juvenile Steelhead	97.6 (1.8)	n/a	n/a
181-kcfs Season-wide Spill (April 30-May 31, 2011)			
Yearling Chinook	96.0 (1.8)	0.6/0.4	56.6
Juvenile Steelhead	96.5 (2.1)	0.9/0.4	54.4
149 kcfs Season-wide Spill (June 19 – July 22, 2012)			
Subyearling Chinook	97.4 (0.7)	0.5/0.4	53.2

An additional year of performance standard testing may be required at Bonneville Dam. Pending the results of additional performance standard testing, the Corps will work with NOAA and other regional partners to determine if the juvenile dam passage survival standards have been met or if additional actions and/or operation adjustments may be necessary to meet the performance standards.

RPA Action 19 – Configuration and Operation Plan for The Dalles Project

The Corps will consider all relevant biological criteria and prepare, in cooperation with NOAA Fisheries and the co-managing agencies, a Configuration and Operational Plan for The Dalles Project (2008). As part of the first phase of modifications, the Corps will investigate, and implement the following reasonable and effective measures to reduce passage delay and increase survival of fish passing through the forebay, dam, and tailrace as warranted. Initial modifications will likely include:

1. *Turbine operation optimization to improve overall dam survival (2011).*

A model turbine runner was fabricated in 2009 in preparation for future turbine design work.

A Phase II Turbine Optimization report was completed in 2013. For more details on this report, see RPA 27.

2. *Extended tailrace spill wall to increase direct and indirect survival of spillway passed fish (2010).*

The extended length spillwall was completed in 2010. Additional avian predation deterrent wires were installed over the spillway tailrace in 2011.

The COP will be updated periodically and modifications may be altered as new biological and engineering information is gathered. The COP and modifications will be coordinated through the Regional Forum. Comments developed by NOAA Fisheries on the draft COPs shall be reconciled by the Corps in writing to NOAA Fisheries' satisfaction before release of the final COP. If Phase I actions fail to meet the intended biological targets, Phase II actions, as described in the FCRPS BA – Appendix B.2.1 will be considered for further implementation.

The COP was updated in 2009 and recommended installation of an extended length spillwall as the preferred alternative to improve juvenile fish passage survival. The spillwall construction was completed in 2010 and juvenile fish performance testing conducted in 2010-2012. Current performance testing results are shown in Table 6 below. All juvenile fish survival performance tests have been completed. Dam passage survival standards for all tests were met except for steelhead in 2010 (95.3 percent). Following the 2010 test, avian deterrent wires were installed over the spillway tailrace and the avian predator hazing effort was increased at the project. In 2011, steelhead survival was 99.5 percent. Required precision levels were met for all tests. In addition, all identified survival model assumptions were met in each year (Johnson et al. 2010; Skalski et al. 2011; Skalski et al 2012). Observed SPE values were within or above the range of Accord SPE values for all species tested. Forebay residence times were estimated over a 1 km distance in the performance standard tests, but only over a 100 meter distance in the accord metrics. Therefore a direct comparison of the two values is not a useful way to evaluate whether forebay delay has improved or declined from the estimates included in the accords. In general, overall passage times remain relatively short at The Dalles Dam.

Table 6. Dam Passage Survival (with Standard Errors), Passage Time, and Spill Passage Efficiency for Yearling Chinook, Juvenile Steelhead, and Subyearling Chinook at The Dalles Dam in 2010, 2011, and 2012 (Johnson et al. 2011; Skalski et al. 2012b; Skalski et al. 2013b). Spill Passage Efficiency includes spillway and other surface passage route passage.

Species	Dam Passage Survival (Percent with Standard Errors)	Forebay Passage Time (Hours)	Spill Passage Efficiency (Percent)
The Dalles Dam (2010) – 40 Percent Spill			
Yearling Chinook	96.4 (1.4)	1.28	94.7
Juvenile Steelhead	95.3 (1.4)	1.28	95.4
Subyearling Chinook	94.0 (0.9)	1.20	83.0
The Dalles Dam (2011) – 40 Percent Spill			
Yearling Chinook	96.0 (1.0)	0.97	83.1
Juvenile Steelhead	99.5 (0.8)	0.81	89.2
The Dalles Dam (2012) – 40 Percent Spill			
Subyearling Chinook	94.7 (0.6)	1.08	70.7

RPA Action 20 – Configuration and Operation Plan for John Day Project

The Corps will consider all relevant biological criteria and prepare, in cooperation with NOAA Fisheries and the co-managing agencies, a Configuration and Operational Plan for the John Day Project (2008). As part of the first phase of modifications, the Corps will investigate, and implement the following reasonable and effective measures to reduce passage delay and increase survival of fish passing through the forebay, dam, and tailrace as warranted. Initial modifications will likely include:

1. *Full-flow bypass and PIT Tag detection installation to reduce handling stress of bypassed fish (2007).*

A full-flow PIT detector was installed in the juvenile bypass system in 2007.

2. *Turbine operation optimization to improve overall dam survival (2011).*

Hydraulic and numerical model studies of the turbine environment, laboratory studies on fish, and field studies were conducted to develop and verify a turbine operating point for John Day Dam turbines. However, an evaluation of total mortality, which also incorporates pressure effects on fish, was determined to be infeasible at this time.

A Phase II Turbine Optimization report was completed in 2013. For more details on this report, see RPA 27.

3. *Surface flow outlet(s) construction to increase fish passage efficiency, reduce forebay delay and improve direct and indirect survival (prototype 2008 with final installation by 2013), and improve tailrace egress conditions.*

Spillway weirs were installed in spillbays 18 and 19 in 2010. In 2013, the two prototype spillway weirs and associated handling equipment were modified so they would be suitable for long-term operation and maintenance.

As part of the surface flow outlet system, three tailrace improvements were implemented.

- An extended-length spillway deflector was installed in Bay 20 to improve tailrace egress.
- An expanded avian wire array was installed in 2010. In 2013, the avian wire array was modified to improve reliability and future maintenance.
- New spill patterns were implemented to optimize tailrace egress in conjunction with spillway weir flow.

The COP will be updated periodically and modifications may be altered as new biological and engineering information is gathered. The COP and modifications will be coordinated through the Regional Forum. Comments developed by NOAA Fisheries on the draft COPs shall be reconciled by the Corps in writing to NOAA Fisheries' satisfaction before release of the final COP. If Phase I actions fail to meet the intended biological targets, Phase II actions, as described in the FCRPS BA – Appendix B.2.1, will be considered for further implementation.

The COP was completed in 2007 and recommended installing surface flow outlets and tailrace improvements as Phase I actions. All Phase I configuration modifications have been constructed and tested.

Two years of juvenile survival performance tests have been completed for yearling Chinook and steelhead, and one year has been completed for subyearling Chinook (Table 7). An additional year of performance standard testing for subyearling Chinook at John Day Dam is planned for 2014. Pending the results of additional performance standard testing, the Corps will work with NOAA and other regional partners to determine if the juvenile dam passage survival standards have been met or if additional actions and/or operation adjustments may be necessary to meet the performance standards.

Table 7. Dam Passage Survival (with Standard Errors), Passage Time, and Spill Passage Efficiency for Yearling Chinook Salmon, Juvenile Steelhead, and subyearling Chinook at John Day Dam in 2011 and 2012 (Skalski et al. 2012c; and Skalski et al. 2013c).

Species	Dam Passage Survival (Percent with Standard Error)	Passage Time (Hours) Forebay/Tailrace	Spill Passage Efficiency (Percent)
2011 - 30-Percent Spill			
Yearling Chinook	96.7 (1.0)	2.0/0.6	61.2
Juvenile Steelhead	98.4 (0.9)	4.3/0.6	61.2
2011 - 40-Percent Spill			
Yearling Chinook	97.8 (1.1)	1.5/0.6	66.4
Juvenile Steelhead	99.0 (1.0)	3.2/0.6	65.9
2011 - Seasonwide Spill			
Yearling Chinook	96.8 (0.7)	1.4/0.6	63.7
Juvenile Steelhead	98.7 (0.6)	2.9/0.6	62.9
2012 Seasonwide Spill			
Yearling Chinook	96.7 (0.7)	1.2/0.4	74.6
Juvenile Steelhead	97.4 (0.3)	2.4/0.5	74.5
Subyearling Chinook	94.1 (0.3)	1.0/0.5	69.6

RPA Action 21 – Configuration and Operational Plan for the McNary Project

The Corps will consider all relevant biological criteria and prepare, in cooperation with NOAA Fisheries and the co-managing agencies, a Configuration and Operational Plan for the McNary Project (2009). As part of the first phase of modifications, the Corps will investigate, and implement the following reasonable and effective measures to reduce passage delay and increase survival of fish passing through the forebay, dam, and tailrace as warranted. Initial modifications will likely include:

1. *Turbine operation optimization to improve survival of fish passing through turbines (2013).*

The Phase II Turbine Optimization report was completed in 2013. For more details on this report, see RPA 27.

2. *Improve debris management to reduce injury of bypass and turbine passed fish (2011).*

Screen cleaning data were evaluated in 2009 and 2010, and the frequency of screen cleaning was increased. Beginning in 2010, debris was removed from trashracks a minimum of four times (March, April, May, June) during the passage season. Prior to this, raking occurred initially before watering up the juvenile fish facility in late March and on an as-needed basis after that. The Corps hopes to acquire a boat in 2015 to assist with moving mats of forebay debris over to the spillway for passage.

3. *Relocate juvenile bypass outfall to improve egress, direct, and indirect survival on bypassed fish (2011).*

Juvenile bypass outfall relocation was completed in 2012.

4. *Surface flow outlet installation to increase fish passage efficiency, reduce forebay delay, and improve direct and indirect survival (temporary structure testing in 2007 and 2008 to develop a permanent system).*

Two spillway weirs were installed in 2007, tested in several spillbays, and moved to their expected permanent locations in 2010.

The COP will be updated periodically and modifications may be altered as new biological and engineering information is gathered. The COP and modifications will be coordinated through the Regional Forum. Comments developed by NOAA Fisheries on the draft COPs shall be reconciled by the Corps in writing to NOAA Fisheries' satisfaction before release of the final COP. If Phase I actions fail to meet the intended biological targets, Phase II actions, as described in the FCRPS BA—Appendix B.2.1, will be considered for further implementation.

The Final Draft of the McNary COP was distributed in 2013.

In addition, a study evaluating and comparing fish guidance efficiency with turbine unit head gates in the raised and stored positions was completed in 2013. The study included two operating points and was split between spring and summer migrants. No significant difference in fish guidance efficiency was found between head gate positions or operations for spring or summer migrants and head gates will be lowered to the design storage position in 2014.

One year of performance standard testing was completed for both spring and summer migrants in 2012 at McNary Dam (Table 8). An additional year of performance standard testing is planned for 2014. Pending the results of additional performance standard testing, the Corps will work with NOAA and other regional partners to determine if the juvenile dam passage survival standards have been met or if additional actions and/or operation adjustments may be necessary to meet the performance standards.

Table 8. Dam Passage Survival (with Standard Errors), Passage Time, and Spill Passage Efficiency for Yearling and subyearling Chinook Salmon and Juvenile Steelhead at McNary Dam in 2012 (Skalski et al. 2013d). Target spill was 40 percent spring and 50 percent summer.

Species	Dam Passage Survival (Percent)	Passage Time (Hours) Forebay/Tailrace	Spill Passage Efficiency (Percent)
Yearling Chinook	96.2 (1.4)	1.8/0.4	72.5
Subyearling Chinook	97.5 (1.1)	1.8/0.4	78.3
Juvenile Steelhead	99.1 (1.8)	1.8/0.3	83.2

RPA Action 22 – Configuration and Operation Plan for the Ice Harbor Project

The Corps will consider all relevant biological criteria and prepare, in cooperation with NOAA Fisheries and the co-managing agencies, a Configuration and Operational Plan for the Ice Harbor Project (2008). As part of the first phase of modifications, the Corps will investigate, and implement the following reasonable and effective measures to reduce passage delay and increase survival of fish passing through the forebay, dam, and tailrace as warranted. Initial modifications will likely include:

1. *Guidance screen modification to improve fish guidance efficiency (2010).*

A regional team evaluated the biological effects of possible fish guidance efficiency improvements to the existing standard length traveling screens and concluded that no significant survival benefit would be gained. Therefore, this action was not recommended in the draft COP and has been indefinitely deferred due to a lack of regional support.

2. *Turbine operation optimization to improve survival of turbine passed fish (2011).*

A Phase II Turbine Optimization report was completed in 2013. For more details on this report, see RPA 27.

3. *Spillway chute and/or deflector modification to reduce injury and improve survival of spillway passed fish through the removable spillway weir (2009).*

A construction contract for Spillway chute and deflector modification to reduce injury and improve survival of spillway passed fish through the removable spillway weir was advertised in 2013 to be awarded in 2014.

4. *Turbine unit 2 replacement to improve the survival of fish passing through turbines and reduce oil spill potential (2015).*

Progress continued on the Ice Harbor test turbines to develop a design process and build turbines optimized to improve survival of turbine passed fish. Manufacturing began on the fix blade turbine design, and design continued for an adjustable turbine.

The COP will be updated periodically and modifications may be altered as new biological and engineering information is gathered. The COP and modifications will be coordinated through the Regional Forum. Comments developed by NOAA Fisheries on the draft COPs shall be reconciled by the Corps in writing to NOAA Fisheries' satisfaction before release of the final COP. If Phase I actions fail to meet the intended biological targets, Phase II actions, as described in the FCRPS BA—Appendix B.2.1, will be considered for further implementation.

The Action Agencies believe the current project configuration is ready for full performance standard testing once a single spill operation is identified.

RPA Action 23 – Configuration and Operation Plan for the Lower Monumental Project

The Corps will consider all relevant biological criteria and prepare, in cooperation with NOAA Fisheries and the co-managing agencies, a Configuration and Operational Plan for the Lower Monumental Project (2010). As part of the first phase of modifications, the Corps will investigate, and implement the following reasonable and effective measures to reduce passage delay and increase survival of fish passing through the forebay, dam, and tailrace as warranted. Initial modifications will likely include:

1. *Primary bypass operations with PIT Tag detection installation to reduce handling stress of bypassed fish (2007).*

Installation of PIT Tag detection in the juvenile bypass system was completed in 2007.

2. *Juvenile bypass system outfall relocation to improve egress, direct and indirect survival on bypassed fish (2011).*

Relocation of the juvenile bypass outfall and improvements to the smolt monitoring raceway structures at Lower Monumental Dam were completed in early 2012.

3. *Turbine operation optimization to improve the survival of fish passing through turbines (2013).*

A Phase II Turbine Optimization report was completed in 2013. For more details on this report, see RPA 27.

4. *Removable spillway weir installation to improve fish passage efficiency, reduced forebay delay, and improved direct and indirect survival (2008).*

Spillway weir installation was completed in 2008.

The COP will be updated periodically and modifications may be altered as new biological and engineering information is gathered. The COP and modifications will be coordinated through the Regional Forum. Comments developed by NOAA Fisheries on the draft COPs shall be reconciled by the Corps in writing to NOAA Fisheries' satisfaction before release of the final COP. If Phase I actions fail to meet the intended biological targets, Phase II actions, as described in the FCRPS BA—Appendix B.2.1, will be considered for further implementation.

The final COP report was distributed to the Region in 2013. Performance standard testing at Lower Monumental Dam was conducted in 2012 and 2013 (Table 9). In 2013 the performance study evaluated survival at 17 kcfs spill for subyearling Chinook. Survival estimates for subyearling Chinook salmon met the performance standard requirement of 93 percent survival. Pending the results of additional performance standard testing, the Corps will work with NOAA Fisheries and other regional partners to determine if the juvenile dam passage survival standards have been met or if additional actions and/or operation adjustments may be necessary to meet the performance standards

Table 9. Dam Passage Survival (with Standard Errors), Passage Time, and Spill Passage Efficiency for Yearling Chinook, Juvenile Steelhead, and Subyearling Chinook Salmon at Lower Monumental Dam in 2012 and 2013 (Skalski et al. 2013e, Skalski et al. 2014).

Species	Dam Passage Survival (Percent)	Median Forebay Passage Time (Hours)	Spill Passage Efficiency (Percent)
Lower Monumental 2012			
Yearling Chinook	98.7 (1.8)	2.4	78.9
Steelhead	98.3 (0.4)	2.2	65.9
Subyearling Chinook	97.9 (1.6)	2.6	83.6
Lower Monumental 2013			
Subyearling Chinook	92.97 (1.05)	2.99	89.1

RPA Action 24 – Configuration and Operation Plan for the Little Goose Project

The Corps will consider all relevant biological criteria and prepare, in cooperation with NOAA Fisheries and the co-managing agencies, a Configuration and Operational Plan for the Little Goose Project (2009). As part of the first phase of modifications, the Corps will investigate, and implement the following reasonable and effective measures to reduce passage delay and increase survival of fish passing through the forebay, dam, and tailrace as warranted. Initial modifications will likely include:

1. Turbine operation optimization to improve the survival of fish passing through turbines (2014).

Phase II Turbine Optimization report was completed in 2013. For more details on this report, see RPA 27.

2. Primary bypass operations with PIT Tag detection installation to reduce handling stress of bypassed fish (2008).

Installation of PIT Tag detectors in the Juvenile Bypass System primary bypass pipe was completed in 2010.

3. Primary bypass outfall relocation to improve egress, direct and indirect survival on bypassed fish (2009).

The Juvenile Bypass System primary outfall relocation was completed in 2010.

4. Surface spillway weir and deflector installation to improve fish passage efficiency, reduce forebay delay and improve direct and indirect survival (2009).

Installation of a spillway weir in spillbay 1, along with flow deflectors in spillbays 1 and 8 were completed in 2009.

The COP will be updated periodically and modifications may be altered as new biological and engineering information is gathered. The COP and modifications will be coordinated through the Regional Forum. Comments developed by NOAA Fisheries on the draft COPs shall be reconciled by the Corps in writing to NOAA Fisheries' satisfaction before release of the final COP. If Phase I actions fail to meet the intended biological targets, Phase II actions as described in the FCRPS BA—Appendix B.2.1 will be considered for further implementation.

Performance standard testing Little Goose Dam was conducted in 2012 and 2013. In 2013 the performance study evaluated survival at 30 percent spill for subyearling Chinook. Survival estimates for subyearling Chinook salmon in 2013 were below the performance standard requirement of 93 percent survival (Table 10). The Corps is working with regional partners to determine what actions are necessary to meet the performance standard.

Table 10. Dam Passage Survival (with Standard Errors), Passage Time, and Spill Passage Efficiency for subyearling Chinook Salmon at Little Goose Dam in 2013 (Skalski et al. 2013f, Skalski et al. 2014).

Species	Dam Passage Survival (Percent)	Median Forebay Passage Time (Hours)	Spill Passage Efficiency (Percent)
Little Goose 2012			
Yearling Chinook	98.2 (0.8)	2.58	65.3
Steelhead	99.5 (0.8)	2.67	56.1
Subyearling Chinook	95.1 (1.0)	2.80	72.5

Species	Dam Passage Survival (Percent)	Median Forebay Passage Time (Hours)	Spill Passage Efficiency (Percent)
Little Goose 2013			
Subyearling Chinook	90.76 (1.39)	3.66	76.8

RPA Action 25 – Configuration and Operation Plan for the Lower Granite Project

The Corps will consider all relevant biological criteria and prepare, in cooperation with NOAA Fisheries and the co-managing agencies, a Configuration and Operational Plan for Lower Granite Project (2009). As part of the first phase of modifications, the Corps will investigate, and implement the following reasonable and effective measures to reduce passage delay and increase survival of fish passing through the forebay, dam, and tailrace as warranted. Initial modifications will likely include:

1. *New juvenile fish facility including orifice configuration changes, primary dewatering, holding for transport, and primary bypass to improve direct and indirect survival for all collected fish (2012).*

Design of modifications to the juvenile bypass system continued, including changes to orifices, dewatering, and the primary bypass, including a new outfall. In addition, gatewell egress and injury were assessed for two prototype designs: a broad-crested weir (overflow weir), and an enlarged 14 inch orifice to replace collection channel orifices in Unit 5 (O'Connor et al. 2014).

2. *Turbine operation optimization to improve survival of turbine passed fish (2014).*

A Phase II Turbine Optimization report was completed in 2013. For more details on this report, see RPA 27.

The COP will be updated periodically and modifications may be altered as new biological and engineering information is gathered. The COP and modifications will be coordinated through the Regional Forum. Comments developed by NOAA Fisheries on the draft COPs shall be reconciled by the Corps in writing to NOAA Fisheries' satisfaction before release of the final COP. If Phase I actions fail to meet the intended biological targets, Phase II actions as described in the FCRPS BA—Appendix B.2.1 will be considered for further implementation.

Performance standard testing will be initiated once configuration actions to improve juvenile fish passage survival have been completed.

RPA Action 26 – Chief Joseph Dam Flow Deflectors

The Corps will complete the flow deflector construction at Chief Joseph Dam by 2009.

Construction of flow deflectors on all 19 spillway bays at Chief Joseph Dam was completed in September 2008. This completed the structural component for reduction of TDG downstream of Chief Joseph and Grand Coulee dams. A successful spill test occurred in spring 2009 and no further testing is planned. Chief Joseph Dam was used for system TDG management in 2013.

RPA Action 27 – Turbine Unit Operations

The Action Agencies will operate turbine units to achieve best fish passage survival (currently within 1 percent of best efficiency at mainstem dams on the Lower Columbia and Lower Snake rivers from April

1–October 31 (hard constraint) and from November 1–March 31 (soft constraint) each year. Continue turbine operations evaluations and apply adaptive management to operate units in their optimum configuration for safe fish passage.

In 2013, turbine units on mainstem dams on the Lower Columbia and lower Snake Rivers were operated within 1 percent of best efficiency from April 1 to October 31 (hard constraint) and from November 1 to March 31 (soft constraint).

Passage data collected at Bonneville during 2010-12 performance testing was analyzed in 2013 to examine survival for fish passing turbines operating within the 1 percent peak efficiency range and above the upper limit of the 1 percent operating range. Preliminary findings from this analysis indicate that survival of smolts passing through PH-1 turbines is high (≥ 95 percent) at operating ranges from the low end of 1 percent efficiency to the generator limit, which is above the 1 percent efficiency range. In addition, preliminary findings suggest that there was not a difference in survival for salmonids passing within the 1 percent of peak operating efficiency and salmonids passing at operations above the upper 1 percent operating efficiency (Weiland et al. 2013 AFEP presentation). In addition to analyzing fish survival data, work continued in 2013 to determine the safest operating point for fish passing through existing FCRPS turbines. Physical model studies and numerical model studies were conducted to further this understanding.

The Phase II Turbine Optimization report (ACOE 2013a); referred to as the Biological Index Testing report) was completed by the TSP in 2013. This report considered past turbine modeling and laboratory and field study data collection to provide recommendations for turbine operations that are expected to provide a juvenile fish passage benefit at FCRPS projects. The report may be amended in the future where data gaps exist. Building upon the works of Carlson et al. (2010), the Corps pursued an external tag laboratory and subsequent field study to test a tag for turbine passage that would reduce the potential bias in survival estimates due to the presence of an internal tag for turbine-passed fish. Field testing of the external tag was completed in 2012 (Brown et al. 2013; also see RPA Action 55).

A detailed biological study design for testing of the new Ice Harbor runners was completed in 2013 (Trumbo et al. 2013a). The study design will be used by PNNL in FY14 to develop a multi-year implementation plan for biological testing with preliminary Sensor Fish data being collected in FY14-FY15.

RPA Action 28 – Columbia and Snake River Project Adult Passage Improvements

The Corps will implement the following structural improvements to adult passage at the mainstem Columbia and Snake river projects:

Bonneville Dam

1. *Improve the Bradford Island ladder system to reduce stress and improve reliability of upstream adult passage (2013).*

In 2012, the second phase of a two-phase project was completed to assess the fishway condition and recommend feature repairs/replacement for the Bradford Island fishway. The results of the study will be used by the Corps to establish priorities and budget funds for repairs/replacement.

In addition, the Corps has accomplished the following repairs to the Bradford Island Ladder during 2008-2013:

- repaired A-branch diffusers
- repaired fish valve FV4-3
- refurbished the count station crowder
- repaired a hole in the fish ladder floor at FG3-12
- removed wooden bulkhead in south collection channel

The Dalles Dam

2. *East ladder emergency auxiliary water supply system and/or modifications that return adult salmon and steelhead use of the North ladder to pre-spillwall conditions to improve reliability of upstream adult passage (2013).*

The Corps, in coordination with the Fish Facility Design Review Work Group, identified a preferred alternative for an emergency backup for the east ladder back-up auxiliary water supply in 2012, and developed a design report in 2013.

North Ladder Passage - In 2004, a 150-foot spillway training wall was constructed between spillbays 6 and 7, and a 6-bay spill pattern was implemented to improve juvenile fish survival. Adult passage through the north ladder was notably reduced following the change in spill operation due to the new training wall and spill patterns, particularly during periods of high spill (e.g., >100 kcfs). In 2010, a longer training wall was constructed between spillbays 8 and 9, and an 8-bay spill pattern was implemented. A 2010 radio-telemetry study suggested that adult spring-summer Chinook passage was not delayed as a result of the new tailrace conditions and structure, but the percentage of tagged salmon using the north ladder was lower during higher spill conditions (100-150 kcfs) (Jepson et al. 2011). The percent of fish using the north shore ladder before construction of the spillwall (2000-2003) versus after construction of the extended wall (2010-2012) was assessed as well based on the fish count data. There has been no substantial reduction in north shore ladder use by Chinook and steelhead. Sockeye use of the north shore ladder; however, was substantially lower post-spillwall vs. pre-spillwall. A radio-telemetry study was initiated in 2013 and will continue in 2014 to further assess whether the extended-length spillwall has delayed adult salmon as compared to pre-spillwall conditions. Using results from this study as well as ladder counts, the Corps will work with regional stakeholders to determine whether additional improvements are warranted.

John Day Dam

3. *Adult ladder systems modifications to improve upstream adult passage conditions (2011).*

Structural improvements to the count station and control (exit) section of the North Fish Ladder were completed in spring 2010, and modifications to the lower ladder, entrance, and auxiliary water supply (auxiliary water supply) system were completed in 2013.

Ice Harbor Dam

4. *Repair or replace north shore fishway auxiliary water supply equipment, as needed, so that any two of the three pumps can meet flow criteria.*

Improvements to the Ice Harbor Dam auxiliary water supply were completed in 2009.

Little Goose Dam

5. *Investigate adult passage and determine whether structural, operational, or tailrace modifications can alleviate adult passage delays or blockages during spill operations for optimum juvenile passage (See RM&E Action 54).*

Beginning in 2011 a new spill pattern, with spillbay 8 operating first, was implemented to reduce adult passage delay. This operation was continued in 2013. In addition, an adult passage radio-telemetry study was contracted in 2013 to assess effects of the spill pattern adjustment, with completion of the study expected in 2014.

In 2013 a contract was awarded for construction of a new adjustable spillway weir. The design will allow closure of the weir and provide more flexibility in meeting passage goals for adult and juvenile fish. Installation of the new weir is planned for 2015.

Lower Granite Dam

6. *Investigate and, if necessary, provide additional auxiliary water supply for the new adult trap at lower Granite so that it can operate at full capacity when the forebay is operated at MOP without affecting the fishway auxiliary water supply (2012).*

In 2010 a valve was replaced, allowing the adult trap to receive adequate water supply at MOP. In addition, the modifications to the new juvenile bypass system will route excess water to the auxiliary water supply and the adult trap (2016).

7. *Adult fishway modification to improve upstream adult passage conditions impaired by temperature differentials (the need will be determined by results of further research).*

In 2013, in response to high temperature differentials and resulting passage delays, auxiliary pumps were used to add water to the adult fishway. In addition, spill and turbine operations were varied in an attempt to minimize passage delay (see the discussion under RPA action 9, above). The Corps is currently designing modifications to the auxiliary ladder pump intakes and discharge routing, for possible construction in 2015.

Hydropower Strategy 3 (RPA Actions 29-31)

RPA Action 29 – Spill Operations to Improve Juvenile Passage

The Corps and BPA will provide spill to improve juvenile fish passage while avoiding high TDG supersaturation levels or adult fallback problems. Specific spill levels will be provided for juvenile fish passage at each project, not to exceed established TDG levels (either 110 percent TDG standard, or as modified by State water quality waivers, currently up to 115 percent TDG in the dam forebay and up to 120 percent TDG in the project tailwater, or if spill to these levels would compromise the likelihood of meeting performance standards (see RPA action table, RM&E Strategy 2). The dates and levels for spill may be modified through the implementation planning process and adaptive management decisions. The initial levels and dates for spill operations are identified in Table 2 of the RPA action table. Future Water Management Plans will contain the annual work plans for these operations and spill programs, and will be coordinated through the TMT. The Corps and BPA will continue to evaluate and optimize spill passage survival to meet both the hydrosystem performance standards and the requirements of the Clean Water Act (CWA).

Spill operations were implemented in accordance with the 2013 Fish Operations Plan (FOP) consistent with the 2011 Court Order. The 2013 FOP can be found at http://www.nwd-wc.usace.army.mil/tmt/wqnew/tdg_and_temp/2013/app_e_13.pdf. Implementation of these operations and regional coordination on in-season adjustments are reported on a monthly basis during the migration season and can be found in the 2013 Total Dissolved Gas and Water Temperature Report, Appendix E at http://www.nwd-wc.usace.army.mil/tmt/wqnew/tdg_and_temp/2013/. This report describes the Corps' Columbia River Basin spill and water quality monitoring program for 2013 and covers the Columbia and Snake River dams located in Washington, Idaho and Oregon. The report provides information consistent with the TDG waiver issued by Oregon and the criteria adjustment by Washington, and it also includes the following additional technical information:

- Flow and runoff conditions for the spill season.
- Duration and volume of spill for fish passage versus spill for other reasons for each project.
- Data from the physical and biological monitoring programs, including incidences of gas bubble trauma.
- Progress on implementing measures contained in the Lower Columbia and lower Snake rivers TDG total maximum daily load documents.

Spring Fish Passage Spill Operations

During 2013, spring fish passage spill at the lower Columbia and lower Snake river projects was implemented consistent with the 2013 FOP and the Corps' 2013 Total Dissolved Gas Management Plan (i.e., Appendix 4 of the 2013 Water Management Plan, at http://www.nwd-wc.usace.army.mil/tmt/documents/wmp/2013/Appendices/Appendix_4_120312_1440_Final_Draft.pdf). Spring fish passage spill began April 3, 2013, and continued through June 20 at the lower Snake River projects. In the lower Columbia River, spring fish passage spill began April 10, 2013, and continued through June 19 at McNary Dam, through June 30 at John Day and The Dalles Dams, and through June 15 at Bonneville Dam.

The 2013 FOP called for the following spill operations:

- Lower Granite Dam: 20 kcfs, 24 hours per day.
- Little Goose Dam: 30 percent of total project outflow, 24 hours per day.
- Lower Monumental Dam: To the TDG spill cap, 24 hours per day.
- Ice Harbor Dam: 45 kcfs during the daytime and to the TDG spill cap from April 3 – April 28, then alternating between (a) 30 percent of total project outflow 24 hours per day and (b) 45 kcfs during the day and up to the TDG spill cap at night through June 20.
- McNary Dam: 40 percent of total project outflow.
- John Day Dam: 30 percent of total project outflow from April 10 through April

27,2013; alternating between 30 and 40 percent of total project outflow from April 28 through June 30, 2013.

- The Dalles Dam: 40 percent of total project outflow.
- Bonneville Dam: 100 kcfs, 24 hours per day.

Consistent with the 2010 Supplemental BiOp and the 2011 Court Order, in-season adjustments addressing real-time conditions were implemented in coordination with regional sovereigns.

Summer Fish Passage Spill Operations

During 2013, consistent with the FOP, summer spill began June 21 and continued through August 31 at the lower Snake River projects. Summer spill on the lower Columbia River began June 20 at McNary Dam, July 1 at John Day and The Dalles Dams, and June 16 at Bonneville Dam. Spill continued through August 31.

The 2013 FOP called for the following summer spill operations:

- Lower Granite Dam: 18 kcfs, 24 hours per day
- Little Goose Dam: 30 percent of total project outflow, 24 hours per day
- Lower Monumental Dam: 17 kcfs, 24 hours per day
- Ice Harbor Dam: From June 21 through July 13, spill alternating between (a) 30 percent of the river flow 24 hours per day and (b) 45 kcfs during the day and up to the spill cap at night. From July 13 through August 31, 45 kcfs during the day and up to the TDG spill cap at night.
- McNary Dam: Spill 50 percent of total project outflow
- John Day Dam: Alternating between 30 and 40 percent of total project outflow from July 1 through July 20, and spill to the spill cap up to 30 percent of total project outflow, 24 hours per day from July 20 through August 31.
- The Dalles Dam: 40 percent of total project outflow.
- Bonneville Dam: Spill alternating between (a) 95 kcfs, 24 hours per day and (b) 85 kcfs during the day and 121 kcfs at night from June 16 through July 20. From July 21 through August 31, 2011, 75 kcfs during the day and up to the spill cap at night.

Consistent with the 2010 Supplemental BiOp and the 2011 Court Order, in-season adjustments addressing real-time conditions were implemented in coordination with regional sovereigns.

2013 River Conditions and TDG Monitoring

During the 2013 fish passage spill season, system flows were average due to the average runoff volume. The peak flow occurred on about May 16. For most of spill season, spill

rates followed the FOP requirements with intermittent occurrences of involuntary spill. Daily average total river flows on the lower Columbia River, as measured at Bonneville Dam, from April 1 through August 31, ranged from 120 kcfs to 352 kcfs, averaging 227 kcfs. Total river flows began to recede gradually in early June and continued a steady recession until the end of August when flows fell 120 kcfs. Intermittent involuntary spill occurred 17 days from April 7 to July 3.

On the lower Snake River, as measured at Ice Harbor Dam, daily average total river flow from April 1 through August 31 ranged from 18 kcfs to 136 kcfs, with an average of 51 kcfs. Daily average flow peaked on May 14. Flows began to recede after the May peak with a gradual recession ending the month of August at about 18 kcfs. Daily average flow remained high from May 14 through July 12, resulting in involuntary spill ranging from 30 to 60 kcfs for two months in addition to 27.8 to 66.1 kcfs of fish passage spill. Flows began to recede in late July and continued a steady recession until the end of August, when flows reached 32 kcfs.

Daily average total river flows on the mid-Columbia River, as measured at Chief Joseph Dam from April 1 through August 31, ranged from 86 kcfs to 201 kcfs, averaging 142 kcfs. Flows peaked on June 30 and began to decrease and continued to recede until the end of August when flows dropped to 89 kcfs on August 31. Fish passage spill operations result in supersaturation of TDG in the Columbia and lower Snake rivers at levels above 110 percent, the current State and Federal water quality standards. The States of Washington and Oregon provide limited exceptions to these standards for juvenile fish passage spill. The Corps monitors TDG levels in the river and adjusts spill patterns and spill rates to stay within acceptable levels.

There were a total of 226 instances where TDG exceeded³ State standards as modified by waivers or criteria adjustment. These included 125 instances from voluntary spill and 77 instances from involuntary spill. This information with additional detail is provided in the 2013 Dissolved Gas and Water Temperature Monitoring Report at: http://www.nwd-wc.usace.army.mil/tmt/wqnew/tdg_and_temp/2013/.

Excessive TDG levels can result in gas bubble trauma (GBT). Examination of data obtained from the Fish Passage Center (under "Smolt Data" at www.fpc.org) showed that 13,558 juvenile fish were examined for GBT at Corps dams in 2013. Of the fish examined, 42 were found to have non-severe signs of GBT, and none exhibited severe signs. The symptoms occurred during periods of high river flows.

RPA Action 30 – Juvenile Fish Transportation in the Columbia and Snake Rivers

The Corps and BPA will continue the juvenile fish transportation program toward meeting system survival performance metrics of Snake and Columbia River salmon and steelhead with some adaptive management modifications based on results of RM&E. The Corps and BPA will continue to collect and transport juvenile fish at Lower Granite, Little Goose, Lower Monumental, and McNary dams, although under a modified operation as described in Table 3 and Table 4 of the RPA action table. While the dates mentioned in this section should be considered firm planning dates, if in-season information or results of ongoing RM&E indicates a need for adaptive management (for example, if modifying these dates are likely to increase in-river or system survival and would be likely to provide equivalent or increased SARs of the species transported), the Action Agencies will consider revising the dates and operations through the Regional Forum.

³ The magnitude and duration of exceedences varies.

The 2013 transportation program was conducted in accordance with NOAA Fisheries ESA Permit No. 1237 and the Juvenile Fish Transportation Program criteria in the 2013 Fish Passage Plan. The start dates for transport operations were coordinated with the TMT and were staggered at Snake River operating projects. Collection of juvenile fish for barge transport began April 27, 2013, at Lower Granite Dam, May 2, 2013, at Little Goose Dam, and May 7, 2013, at Lower Monumental Dam. Before transport began, sampling operations were conducted at the Lower Granite, Little Goose, and Lower Monumental facilities in support of research activities, BPA-sponsored smolt monitoring activities, and assessment of bypass system conditions. Smolt Monitoring Program activities occurred daily at Lower Granite Dam throughout the entire season. Transport operations at the Snake River facilities continued through October 1 at Lower Monumental Dam and through October 31 at Little Goose and Lower Granite dams. Since no fish were transported from McNary Dam in 2013, sampled and collected fish at this location were bypassed to the tailrace. Routine fish sampling operations did take place at McNary Dam every other day from April 6, 2013 to September 30, 2013, to support research and BPA-sponsored smolt monitoring activities, as well as to assess bypass system conditions.

Juvenile fish barged during 2013 were released at varying locations below Bonneville Dam as required in the permit. The ending collection date for the barging season in 2013 was August 16 at Little Goose and Lower Granite dams. Because of suspected *Columnaris* sp. infections and increased fish mortality rates, the Lower Monumental facility suspended fish transport operations from August 14 through August 21 and from August 30 through September 4. Fish passing through this facility during these periods were bypassed to the tailrace. Otherwise, Snake River facilities transported juvenile fish by trucks from August 16 through the end of the transport season. Most trucked fish were released into the Bonneville Juvenile Monitoring Facility outfall flume. Some late season fish were trucked and released at Dalton Point below Bonneville Dam to avoid piscivorous birds at the monitoring facility outfall flume. No early season (April) trucking took place in 2013.

Estimates of the number of fish collected, bypassed, and transported as part of the juvenile fish transportation program are based on sampling portions of the fish collected. Sampled numbers were expanded according to the percentage of the time sampled. At Snake River operating projects, the sampled fish were hand-counted and differentiated by species and the presence of adipose fins. A total of 3,894,569 juvenile fish were collected at Lower Granite Dam, with 678,827 of these fish bypassed to the river and 3,211,877 transported. At Little Goose Dam, 2,713,720 juvenile salmon and steelhead were collected in 2013. Of these, 113,320 were bypassed to the river, and 2,598,837 were transported. At Lower Monumental Dam, 1,114,869 juvenile salmon and steelhead were collected in 2013. Of these, 13,893 fish were bypassed, and 1,099,366 were transported. At McNary Dam in 2013, 3,491,995 juvenile salmon and steelhead were collected, 3,490,292 of the fish collected were bypassed to the river, and no juvenile fish were transported.

Table 11. Estimated Proportion of Spring/Summer Chinook and Steelhead Smolts Transported in the Snake River in 2013 (Faulkner et al. 2013).

Species	Percent Transported in 2013
Snake River Spring Chinook—Wild	36
Snake River Spring Chinook—Hatchery	31
Snake River Spring Steelhead—Wild	40
Snake River Spring Steelhead—Hatchery	36

A total of 11,215,153 juvenile salmon and steelhead were collected at all transport program locations in 2013, with 6,910,080 fish transported (62 percent) and 4,296,332 bypassed (38 percent). Of the fish transported, 6,839,678 were transported by barge (99 percent) and 70,402 were trucked (1 percent).

RPA Action 31 – Configuration and Operational Plan Transportation Strategy

The Corps, in coordination with the Regional Forum, will initiate a Configuration Operational Plan in 2009. The plan will be completed in 2010 and will present a strategy for prioritizing and carrying out further transportation actions at each dam. Comments developed by NOAA Fisheries on the draft COPs shall be reconciled by the Corps in writing to NOAA Fisheries' satisfaction before release of the final COP. Construction actions for transportation are primarily in the context of changes to juvenile bypass systems. Changes meant to increase adult salmon returns through the juvenile fish transportation process are being evaluated. Some changes include additional barges, a new juvenile fish facility at Lower Granite Dam and modifications to the juvenile fish facilities at Little Goose, Lower Monumental and McNary dams.

The Transport COP draft was completed in September 2013 and in October was distributed to regional entities for review. The draft contains broad alternatives for transport and focuses on increasing smolt-to-adult return ratios (SARs) for ESA listed Snake River salmonids. Comments were due December 2013 and a final Transport COP is expected in 2014.

Fall Chinook salmon scale pattern analysis – Scales from returning adults in 2007–13 are being collected and analyzed to determine age at ocean entry for different groups of fall Chinook that were PIT tagged as juveniles. This study will provide important information about the unique overwintering strategy of Snake River fall Chinook (SRFC) salmon relative to operational and environmental conditions.

A study to determine seasonal effects of transporting fish from the Snake River to optimize a transportation strategy continued in 2013. The goal of this study is to identify periods and conditions when it is best to transport fish. Biotic and abiotic variables are collected to match weekly SARs of transport and in-river migrant steelhead and yearling Chinook salmon. Results of this study are still being compiled and analyzed. Generally, fish transported later in the season fare better than those transported early, and this study is attempting to identify the conditions that trigger this change in response.

Hydropower Strategy 4 (RPA Action 32)

RPA Action 32 – Fish Passage Plan (FPP)

The Corps will annually prepare a FPP in coordination with NOAA Fisheries and the Regional Forum through the FPOM. The Corps will operate its projects (including juvenile and adult fish passage facilities) year-round in accordance with the criteria in the FPP. Comments developed by NOAA Fisheries on the draft FPP shall be reconciled by the Corps in writing to NOAA Fisheries' satisfaction before release of the final FPP. Key elements of the plan include:

- *Operate according to project-specific criteria and dates to operate and maintain fish facilities, turbine operating priorities, and spill patterns;*
- *Operate according to fish transportation criteria;*
- *Maintain turbine operations within the 1 percent of best efficiency range;*

- *Maintain spillway discharge levels and dates to provide project spill for fish passage;*
- *Implement TDG monitoring plan;*
- *Operate according to protocols for fish trapping and handling;*
- *Take advantage of low river conditions, low reservoir elevations or periods outside the juvenile migration season to accomplish repairs, maintenance, or inspections so there is little or no effect on juvenile fish;*
- *Coordinate routine and non-routine maintenance that affects fish operations or structures to eliminate and/or minimize fish operation impacts;*
- *Schedule routine maintenance during non-fish passage periods;*
- *Conduct non-routine maintenance activities as needed; and*
- *Coordinate criteria changes and emergency operations with FPOM.*

Operations and Maintenance

- *Provide redundancy or contingency plans, developed in coordination with NOAA Fisheries and the Regional Forum, which will assure that key adult fish passage facility equipment operates as necessary to minimize long-term adult passage delays.*
- *Evaluate the condition of items necessary (e.g., spillway hoist systems, cranes, turbine units, auxiliary water supply systems, etc.) to provide safe and effective fish passage and develop a prioritized list of these items that are likely to require maintenance now or within the term of this Opinion.*

The draft 2013 FPP was released in October 2012. The final FPP (ACOE 2013a) was released in March 2013 at: http://www.nwd-wc.usace.army.mil/tmt/documents/fpp/2013/fiinal/FPP13_Final_Revised_20130628.pdf. The FPP was completed in full coordination with the region. Corps fish passage facilities were operated in accordance with criteria in the FPP. Any deviations from the FPP were coordinated with the region and were necessary to protect fish or conduct emergency repairs on vital equipment.

Hydropower Strategy 5 (RPA Action 33)

RPA Action 33 – Snake River Steelhead Kelt Management Plan

The BPA and Corps will prepare a Snake River Kelt Management Plan in coordination with NOAA Fisheries and the Regional Forum. The BPA and Corps will implement the plan to improve the productivity of interior basin B-Run steelhead populations as identified in Sections 8.5. Key considerations in the development and implementation of the plan should include:

- *Measures to increase the in-river survival of migrating kelts,*
- *Potential for the collection and transport (either with or without short-term reconditioning) of kelts to areas below Bonneville Dam,*

- *Potential for long-term reconditioning as a tool to increase the number of viable females on the spawning grounds, and*
- *Research as necessary to accomplish the elements of this plan.*

BPA and the Corps completed the 2013 Kelt Management Plan (KMP) supplement. The goal of kelt management actions is to improve survival and productivity of listed steelhead by allowing kelts to successfully survive and spawn in a subsequent year. The 2013 version of the KMP built upon the framework of previous plans, but also identified future direction through the remainder of the BiOp (2014-2018). The 2013 KMP reviews the goals of the plan and summarizes progress on reconditioning efforts as well as in-river kelt migration studies performed during 2012 and 2013.

In 2013, the reconditioning facility for Snake River B-Run kelts at Dworshak National Fish Hatchery became equipped for full program implementation after completing several years of experimental treatments with short-term and long-term approaches. Sixty-nine reconditioned wild female B-Run kelts were returned to the Snake River from an original group of 110 kelts collected at Lower Granite Dam and 24 kelts retained after air-spawning for hatchery broodstock collection. Collection of good condition kelts at Lower Granite has become more challenging; therefore collection has also been expanded to known B-Run steelhead tributaries (e.g. Fish Creek). Several categories of research were continued 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.

Several research studies were carried out investigating in-river adult out-migration. The Corps completed the second year of its in-river dam route and river reach survival study, using acoustic tags, at three of the lower Snake dams. Survival per kilometer was lowest in dam forebays, and system survival from Lower Granite to below Bonneville Dam was lower in 2013 (34.2 percent) than in 2012 (51.4 percent). Kelts most frequently passed through spillway routes (spillway weirs or traditional spill) during this study. Four of the 324 (1.2 percent) kelts that were tagged with acoustic transmitters in 2012 were detected making upstream migrations in the summer and fall of 2013 (Colotelo et al 2013). The Corps also conducted a direct survival test of hatchery origin steelhead passing through the spillway weir and turbine routes at McNary Dam and commissioned an analysis of PIT data to assess trends in kelt iteroparity rates of winter and summer steelhead from subpopulations throughout the Columbia Basin, hatchery and wild origin spawners, and "A-run and B-run steelhead" originating from the Snake River (Keefer and Caudill 2014).

No transportation of kelts occurred in 2013. 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 and relevant coordinating entities, reserve the option to resume transportation when the number of collected kelts exceeds the capacity of reconditioning programs.

The 2013 reconditioning release represents a substantial 2.3 percent towards meeting the 2018, 6 percent target; this credit, combined with the credit received from winter operations at the Dalles dam, presents 3.2 percent towards meeting the 2018, 6 percent target. As part of further efforts to develop the reconditioning program, BPA continued to fund CRITFC to prepare a master plan for the Snake River kelt reconditioning program. This Snake River kelt master plan will provide a guide to complete the Council's 3-Step process for capital projects and ultimately result in the construction of a kelt reconditioning facility to assist in meeting the BiOp goal of increasing B-Run steelhead productivity by 6 percent.

Habitat Implementation Reports, RPA Actions 34 – 38

Table 12. Habitat Strategy Reporting

RPA Action No.	Action	Annual Progress Report
Habitat Strategy 1		
34	Tributary Habitat Implementation 2007 to 2009 – Progress Toward 2018 Habitat Quality Improvement Targets	Status of project implementation (including project milestones) through December of previous year for all 2007–2009 actions. Report physical metrics for implementation achieved (e.g., miles of access, cfs of streamflow acquired, numbers of screens, miles or acres of habitat protected or enhanced, and miles of complexity enhanced) relative to the project objectives.
35	Tributary Habitat Implementation 2010–18 – Achieving Habitat Quality and Survival Improvement Targets	Status of project implementation (including project milestones) through December of previous year for all actions identified in implementation plans. Report physical metrics for implementation achieved (e.g., miles of access, cfs of streamflow acquired, numbers of screens installed, miles of acres of habitat protected or enhanced, and miles of complexity enhanced by benefited population(s)) relative to the total needed to complete the project and achieve the estimated survival benefits, by project.
Habitat Strategy 2		
36	Estuary Habitat Implementation 2007 to 2009	Status of project implementation (including project milestones) through December of previous year for all 2007–09 actions. Report physical metrics for implementation achieved (e.g., number of acres protected/restored/enhanced; riparian miles protected) relative to the total needed to complete project and achieve the estimated survival benefits.
37	Estuary Habitat Implementation 2010–18 – Achieving Habitat Quality and Survival Improvement Targets	Status of project implementation (including project milestones) through December of previous year for all actions identified in implementation plans. Report physical metrics for implementation achieved (e.g., number of acres protected, restored, enhanced; riparian miles protected) relative to the total needed to complete the project and achieve the estimated survival benefits, by project. By evolutionarily significant unit (ESU), report progress toward ESU/distinct population segment (ESU/DPS)-specific survival benefit. Where ESU/DPS-specific survival benefits are not achieving the progress guidelines above, identify processes or projects in place to ensure achievements by the next comprehensive report.
38	Piling and Piling Dike Removal Program	Status of project implementation (including project milestones) through December of previous year for all actions identified in implementation plans. Report physical metrics for implementation achieved (e.g., number of pilings/pile dikes removed, habitat area restored) by project.

Habitat Strategy 1 (RPA Actions 34 – 35)

RPA Action 34 – Tributary Habitat Implementation 2007 to 2009 – Progress Toward 2018 Habitat Quality Improvement Targets

The Action Agencies will provide funding and technical assistance necessary to implement the specific projects identified for implementation in 2007 to 2009 as part of a tributary habitat program to achieve the population-specific overall habitat quality improvement identified in Table 5 of the RPA action table.

If projects identified for implementation in 2007-2009 prove infeasible, in whole or in part, the Action Agencies will implement comparable replacement projects in 2010-2013 to maintain estimated habitat quality improvements to achieve equivalent survival commitments at the population level, or alternatively at the major population group (MPG) or ESU level. Habitat and population-specific

survival benefits in each implementation plan cycle must also compensate for not meeting estimated benefits in the previous implementation plan cycle. Replacement project selection will follow Action 35 below.

Previous FCRPS Annual Progress Reports (2006, 2007, 2008, and 2009) have reported the progress on RPA 34 actions that were identified in the FCRPS 2007 BA, and also on additional actions and actions implemented in place of those that proved infeasible in whole or in part. These actions implemented from 2007 through 2009 resulted in:

- 119,619 acre-feet of water protected;
- 82 miles of stream habitat treated to enhance complexity;
- 4,130 acres of riparian habitat improved for better function;
- 118 fish screens installed or addressed for fish protection; and
- 696 miles of improved access to fish habitat.

This RPA Action is complete and as envisioned by the RPA, tributary habitat implementation through 2018 is being continued under RPA Action 35.

RPA Action 35 – Tributary Habitat Implementation 2010 – 2018 – Achieving Habitat Quality and Survival Improvement Targets

The Action Agencies will identify additional habitat projects for implementation based on the population specific overall habitat quality improvement still remaining in Table 5 (of the 2008 FCRPS BiOp RPA) below. Projects will identify location, treatment of limiting factor, targeted population or populations, appropriate reporting metrics, and estimated biological benefits based on achieving those metrics. Pertinent new information on climate change and potential effects of that information on limiting factors will be considered.

The technical foundation of the tributary habitat program established under RPA Actions 34 and 35 is a method for estimating (1) the changes in tributary habitat function likely to result from implementation of tributary habitat improvement actions and (2) the corresponding change in fish survival that is likely to occur as the productive capacity of habitat changes.

The approach relies on identifying the factors that limit the productivity of salmon and steelhead tributary habitat; identifying actions that would reduce the magnitude of those limiting factors, thereby improving the quality and function of the habitat; using expert judgment to estimate the change in habitat function as a result of implementing those actions; and then using an empirically based model to estimate the overall change in habitat function and a corresponding change in egg-to smolt survival that would result from that change in habitat function.

The Action Agencies continue to provide funding and technical assistance to improve habitat for more than 80 interior Columbia Basin spring/summer Chinook and summer/winter steelhead populations. For the 56 populations under the FCRPS consultations, actions completed in 2013 have been guided by the 2010-2013 Implementation Plan (2010-2013 IP) (FCRPS 2010) and benefit the 18 priority populations listed in Table 5 of RPA Action 35 and most of the 38 non-priority populations. Physical metrics associated with the actions are reported consistent with the format of RPA Action 35 Table 5 (see Table 13). Cumulative habitat quality and survival estimates for these 56 populations from 2007

through 2011 were reported in the 2013 Comprehensive Evaluation (2013 CE) (BPA et al. 2014a).

RPA Action 35 includes requirements for implementation plans developed based on three-year intervals between 2010 and 2018. The first of these, the 2010-2013 IP (FCRPS 2010a) identified habitat actions for implementation during that three year period. The 2014-2018 IP (BPA et al. 2014a) identified specific habitat actions for a five-year period in response to the 2011 Court Order on the remanded 2010 FCRPS BiOp. As outlined in RPA Action 35, these actions are specific insofar as location, treatment/action type, limiting factor, targeted population or populations, metrics, and estimated biological benefits.

In Section 1 of this APR, Figures 23, 24, 27, 30, and 33 summarize cumulative results from habitat actions completed from 2007 through 2013 that improved water quantity and quality, instream habitat complexity, and riparian condition; restored access, and reduced entrainment at irrigation diversions to benefit salmon and steelhead. Additional information on progress of individual projects and actions is presented in Section 3, Attachment 2, Table 1. This table summarizes metrics at the population level for tributary habitat measures implemented with funding from BPA or with technical assistance from Reclamation in 2013 and summarizes identified limiting factors. The BPA business management system for tracking contracted work and accomplishments (e.g., Pisces and Taurus) are discussed in detail in the 2013 CE and the 2014-2018 IP as well as in the 2014 FCRPS BiOp. Details for BPA projects and actions can be found via the links in Section 3, Attachment 2, Table 1, or via BPA's Report Center Habitat Metrics Report, available at <http://www.cbfish.org/Report.mvc/Index>.

Further details on actions with Reclamation involvement are available in Section 3, Attachment 2, Table 2. In most cases, Reclamation and BPA projects and associated actions are complimentary (both agencies participate in the effort), in which case both BPA and Reclamation project numbers are provided. Reclamation has produced a number of additional reports that document tributary habitat accomplishments. These reports are listed in Section 3, Attachment 3. The reports can be accessed at: <http://www.usbr.gov/pn/fcrps/habitat/projects/index.html>.

Table 13. 2013 Tributary Habitat Completed Metrics (BPA and Reclamation).

ESU/DPS	MPG	Population* 18 Priority Populations in Bold	Water Quantity		Entrain- ment	Passage		Channel Complexity	Water Quality Riparian Protection and Enhancement			
			Acre-feet Protected	CFS protected	# of screens addressed	# of barriers addressed	Stream miles with improved access	Instream miles improved	Stream miles protected	Stream miles improved	Riparian acres protected	Riparian acres improved
Snake River Spring/ Summer-run Chinook Salmon ESU	Dry Clearwater	Lapwai/Big Canyon	0	0	0	1	5.00	0	0.4	20.4	2.0	620.1
		Pottlatch River	0	0	0	0	0	0	0	6.8	0	102.5
		Laywer Creek	0	0	0	0	0	0	0	0	0	0
		Upper South Fork Clearwater	0	0	0	7	10.5	0	0	13.0	0	16.4
	Grande Ronde /Imnaha	Catherine Creek	457.4	2.8	0	3	6.1	0.34	1.52	1.53	24.55	50.9
		Big Sheep Creek	0	0	0	0	0	0	0	0	0	0
		Grande Ronde River upper mainstem	87.6	0.33	0	2	3.0	3.25	1.14	22.85	1.0	180.5
		Imnaha River mainstem	0	0	0	0	0	0	0	0	0	0
		Lostine River	1188.0	15.0	0	2	12.0	0.06	1.28	0	21.0	0
	Lower Snake	Asotin Creek	0	0	0	0	0	1.0	3.04	7.0	35.0	30.0
		Tucannon River	0	0	0	2	1.8	1.60	1.19	1.55	39.9	30.3
	Middle Fork Salmon River	Big Creek	0	0	0	0	0	0	0	0	0	0
		Camas Creek	0	0	0	0	0	0	0	0	0	0
		Marsh Creek	0	0	0	0	0	0	0	0	0	0
		Chamberlain Creek				1	2.5	0	0	0	0	0
	South Fork Salmon River	East Fork South Fork Salmon River	0	0	0	2	0.6	0	0.2	5.0	1.0	0
		Little Salmon River	0	0	0	1	3.0	0	0	0	0	0
		Secesh River	0	0	0	0	0	0	0	0	0	0
		South Fork Salmon River mainstem	0	0	0	0	0	0	0	0	0	0
	Upper Salmon River	East Fork Salmon River	0	0	0	0	0	0	1.3	0.0	5.0	0
		Lemhi River	3281.1	37.81	5	12	25.0	0.66	0.92	0.86	3.55	3.18
		Pahsimeroi River	0	0	1	1	1.2	0	0	0	0	0
		Panther Creek	0	0	0	0	0	0	0.46	0	3.8	0
Salmon River lower mainstem below Redfish Lake		241.2	2.0	0	1	1.0	0	0	0	0	0	
Salmon River upper mainstem above Redfish Lake		893.0	6.0	0	0	0	0	3.34	0.00	18.3	0	
Valley Creek		0	0	0	0	0	0	0	0	0	0	
Yankee Fork		0	0	0	3	1.19	0.69	0	0.34	0	12.25	

			Water Quantity		Entrainment	Passage		Channel Complexity	Water Quality Riparian Protection and Enhancement			
ESU/DPS	MPG	Population* 18 Priority Populations in Bold	Acre-feet Protected	CFS protected	# of screens addressed	# of barriers addressed	Stream miles with improved access	Instream miles improved	Stream miles protected	Stream miles improved	Riparian acres protected	Riparian acres improved
	Wet Clearwater	Lochsa River	0	0	0	1	12.65	0	0	0	0	10.5
		Meadow Creek	0	0	0	1	8.5	0	0	0	0	0
		Lolo Creek	0	0	0	1	15.0	0	0	0.5	0	37.0
Snake River Spring/Summer-run Chinook Salmon ESU			6148	64	6	41	109.03	8	14.8	79.8	155.1	1093.6
Upper Columbia River Spring-run Chinook Salmon ESU	Upper Columbia/East Slope Cascades	Entiat River	180.0	0.99	0	1	0	0.29	0.84	1.37	0	5.6
		Methow River	3088.8	24.0	1	3	1.30	2.41	1.23	1.61	44.70	3.3
		Wenatchee River	7943.5	38.78	1	4	3.65	0.10	0	0.20	0	2.2
Upper Columbia River Spring-run Chinook Salmon ESU			11212.3	63.77	2	8	5	2.80	2.07	3.18	45	11.1
TOTAL Chinook Salmon ESU			17360.60	127.71	8.00	49.00	113.98	10.40	16.86	83.02	199.81	1104.69
Middle Columbia River Steelhead DPS	Cascades Eastern Slope Tributaries	Deschutes River - eastside	1075.4	3.23	0	1	0	0	0.54	43.55	22.7	89.6
		Deschutes River - westside	0.0	0.0	0	0	0	0.1	0.00	1.50	0	0
		Fifteenmile Creek (winter run)	737.3	3.47	0	1	0	0	23.53	0	237.3	0
		Klickitat River	0	0	0	0	0	0	0	4.21	0	72.3
		Rock Creek	0	0	0	0	0	0	0	3	0	8.0
		White Salmon River	0	0	0	0	0	0	0	0	0	0
		Crooked River	12608.0	29.7	1	1	5.31	0	0	0	0	0
	John Day River	John Day River lower mainstem tributaries	0.0	0.0	7	4	14.04	2.50	108.14	37.5	1912.65	40
		John Day River upper mainstem	187.2	1.55	12	4	18.21	0.31	12.14	11	50	154.5
		Middle Fork John Day River	0	0	1	1	8.1	0.25	5.4	25.2	193	289.2
		North Fork John Day River	0	0	1	0	0	2.35	3.3	7.4	104.3	374.35
		South Fork John Day River	0	0	1	0	0	0	5	0	85	0
	Umatilla and Walla Walla River	Touchet River	312.5	9.04	0	1	0.5	0	0	3	60	0
		Umatilla River	516.2	6.28	4	2	20.52	2.54	0	34.3	425	455.82
		Walla Walla River	1128.1	2.77	1	5	34.01	1.5	0	4.7	0	48.4
Willow Creek		0	0	0	0	0	0	0	0	0	0	
Yakima River Group	Naches River	1555.8	7.92	6	1	0.5	0	0	1.1	0	62	
	Satus Creek	0	0	0	0	0	0	0	0	0	20	

			Water Quantity		Entrainment	Passage		Channel Complexity	Water Quality Riparian Protection and Enhancement				
ESU/DPS	MPG	Population* 18 Priority Populations in Bold	Acre-feet Protected	CFS protected	# of screens addressed	# of barriers addressed	Stream miles with improved access	Instream miles improved	Stream miles protected	Stream miles improved	Riparian acres protected	Riparian acres improved	
	Yakima River Group	Toppenish	0	0	1	0	0	0	0	9	0	29.75	
		Yakima River upper mainstem	0	21.39	2	0	0	3	30	6.2	140	65.8	
Middle Columbia River Steelhead DPS			18120.5	85.35	37	21	101.19	13	188.04	191.66	3230.0	1709.7	
Snake River Basin Steelhead DPS	Clearwater River	Clearwater River lower mainstem	0	0	0	1	5	0	0.40	27.21	2.00	722.55	
		Lochsa River	0	0	0	1	12.65	0	0	0	0	10.5	
		Lolo Creek	0	0	0	1	15	0	0	0.5	0	37.0	
		Selway River	0	0	0	1	8.5	0	0	0	0	0	
		South Fork Clearwater River	0	0	0	7	10.5	0	0	13.0	0	16.4	
	Grande Ronde River	Grande Ronde River lower mainstem tributaries	0	0	0	0	0	0	0	0	0	0	0
		Grande Ronde River upper mainstem	545.00	3.13	0	5	9.1	14.18	2.66	28.9	25.55	647.75	
		Joseph Creek	0	0	0	0	0	0	0.00	2.32	0	53.5	
		Wallowa River	1188	15	0	2	12	0.06	1.28	0	21.0	0	
	Imnaha River	Imnaha River	0	0	0	0	0	0	0.00	0	0	0	
	Lower Snake	Asotin Creek	0	0	0	0	0	1.0	4.11	8.05	66.0	96.3	
		Tucannon River	0	0	0	2	1.8	1.6	1.19	1.55	39.9	30.3	
	Salmon River	Big, Camas, and Loon Creek	0	0	0	0	0	0	0.00	0	0	0	0
		East Fork Salmon River	241.2	2	0	0	0	0	1.30	0	5.0	0	
		Chamberlain Creek					1	2.5	0	0.00	0	0	0
		Lemhi River	3281.1	37.81	5	12	24.99	0.66	0.92	0.86	3.55	3.18	
		Middle Fork Salmon River upper mainstem	0	0									
		Little Salmon and Rapid River	0	0	0	1	3	0	0	0	0	0	
		Pahsimeroi River	0	0	1	2	2.2	0	0	0	0	0	
		Panther Creek	0	0	0	0	0	0	0.46	0	3.8	0	
Salmon River upper mainstem		893	6	0	3	1.19	0.69	3.34	0.34	18.3	12.25		
Secesh River		0	0	0	0	0	0	0	0	0	0		
South Fork Salmon River	0	0	0	2	0.6	0	0.2	5.0	1	0			
Snake River Basin Steelhead DPS			6148	64	6	41	109.03	18	15.86	87.73	186.11	1629.73	

		Water Quantity		Entrainment	Passage		Channel Complexity	Water Quality Riparian Protection and Enhancement				
ESU/DPS	MPG	Population* 18 Priority Populations in Bold	Acre-feet Protected	CFS protected	# of screens addressed	# of barriers addressed	Stream miles with improved access	Instream miles improved	Stream miles protected	Stream miles improved	Riparian acres protected	Riparian acres improved
Upper Columbia River Steelhead DPS	Upper Columbia / East Slope Cascades	Entiat River	180	0.99	0	1	0	0.29	0.84	1.37	0	5.6
		Methow River	3088.8	24.0	1	3	1.3	2.41	1.23	1.61	44.7	3.3
		Okanogan River	1948.6	33.31	20	1	0	1.3	0.4	5	7.52	67.3
		Wenatchee River	15766.5	73.78	1	4	3.65	0.1	0	0.2	0	2.2
		Crab Creek	0	0	0	0	0	0	0	0	0	116.9
Upper Columbia River Steelhead DPS			20983.90	132.08	22.00	9.00	4.95	4.10	2.47	8.18	52.22	195.3
TOTAL Steelhead DPS			51153.00	281.37	65.00	71.00	215.17	34.84	206.37	287.57	3468.28	3534.76

- a. *During 2010 to 2018, the Action Agencies will provide funding and/or technical assistance to implement specific habitat projects to achieve the specified habitat quality improvements listed in Table 5. Habitat quality improvements associated with projects will be estimated in advance of project selection by expert panels. The Action Agencies will convene expert panels to estimate changes in habitat limiting factors from the implementation of Action Agency habitat actions.*

The Action Agencies provided funding and/or technical assistance to implement specific habitat actions listed in Appendix A of the 2010–2013 IP. The IP included the expert panel estimates for changes in limiting factors projected to result from implementing these habitat actions. Progress on actions implemented in 2013 resulted in:

- 45,253 acre-feet of water protected;
- 35 miles of stream habitat treated to enhance complexity;
- 3,535 acres of riparian habitat improved for better function;
- 65 fish screens installed or addressed for fish protection; and
- 215 miles of improved access to fish habitat.

Detailed 2013 habitat metrics by population that contribute to these metrics are presented in Section 3 of this report.

- 1) *The Action Agencies shall convene an expert panel to evaluate the percent change in overall habitat quality at the population scale from projects implemented previously (if quantitative objectives not met) and projects proposed for the implementation until the next check-in.*

The Action Agencies have continuously improved the expert panel process since they initially convened expert panel workshops in 2007. This has included incorporating new information on habitat condition and fish habitat relationships, helping panels to better evaluate and estimate benefits from habitat actions. The most recent panel workshops were convened in 2012. The outputs of the 2012 workshops informed the Action Agencies 2013 CE and 2014-2018 IP as well as the 2014 FCRPS BiOp. The 2014 FCRPS BiOp incorporated several recommendations for process improvements to the expert panel workshops. In late 2013 and early 2014, the Action Agencies with NOAA Fisheries initiated a series of discussions for improving the expert panel process. The discussion of refinements is in process and is intended to inform refinements to the expert panel process in 2016.

- 2) *The Action Agencies will continue to maintain a data management system for storing the material compiled, reviewed, and finalized by the expert panels. The expert panel will use methods consistent with the NWF v NOAA Fisheries E Remand Collaboration Habitat Workgroup process.*

The expert panels will continue to follow the Remand Collaboration Habitat Workgroup process⁴ to finalize changes in habitat limiting factors associated with

⁴ *A method developed and updated by the Remand Collaboration Habitat Workgroup in which the group identifies site-specific limiting habitat factors, estimates the current status of limiting factors, evaluates actions to address the limiting factors, estimates the potential status of the limiting factors, and calculates the percent change in habitat quality attributable to the project. See also <http://www.usbr.gov/pn/fcrps/habitat/panels/reference/1B-CA-AppC.pdf>.*

the completed planned, replacement, and additional 2013–2018 habitat actions and to estimate changes in limiting factors from planned and supplemental actions at the 2016 expert panel workshops. In addition, the expert panels will incorporate best available science and will document how that material was used to guide deliberations, as was recommended in the 2014 FCRPS BiOp.

- 3) *Project proposals will clearly describe the completed project in terms of quantitative habitat metrics which can be used to quantitatively evaluate progress and completion of individual projects.*

Quantitative habitat metrics for habitat improvement actions completed in 2013 are presented in Section 3, Attachment 2, Table 1 of this report.

- 4) *The Action Agencies will use the expert panels to provide input on changes in habitat quality and function as a result of limiting factor improvements from project actions for the priority population areas and this information will be used to assess improvements to salmonid survival.*

At the 2012 workshops, expert panels estimated changes in limiting factor habitat functions that resulted from habitat improvement actions completed from 2009 to 2011 (2013 CE). Habitat Quality Improvement (HQI) estimates from the expert panels were then compiled and calculated by the Action Agencies for the “Look Back” (2009 to 2011) and the “Look Forward” (2012 to 2018). Based on these estimates, the Action Agencies identified 49 of 56 populations “on track” to meet the 2018 HQIs and 7 of 56 populations requiring additional effort to meet the 2018 HQIs. In 2013 supplemental actions were included in the 2014-2018 IP. These supplemental actions will be evaluated during the 2016 expert panel workshops. The action agencies completed a preliminary evaluation of the supplemental actions as part of the 2013 CE. In all but one case the supplemental actions were determined sufficient to achieve HQI performance standards.

- 5) *If actions from the previous cycle prove infeasible, in whole or in part, the Action Agencies will ensure implementation of comparable replacement projects in the next implementation plan cycle to maintain estimated habitat quality improvements at the population level and achieve equivalent survival benefits. If infeasible at the population level, then alternatively replacement projects will be found to provide benefits at the MPG or ESU/DPS level. Selection of replacement projects to ensure comparable survival benefits will be made based on input from expert panels, regional recovery planning groups, the Northwest Power and Conservation Council, and NOAA Fisheries.*

The Action Agencies will continue to fund and provide technical assistance for, and implement habitat actions identified in the 2010-2013 and 2014-2018 IPs. Actions determined to be infeasible, in whole or in part, will be replaced with comparable actions that will be documented in the next implementation plan. Local watershed groups, which generate proposals for the expert panel process, typically maintain lists of actions that can replace actions determined to be infeasible.

- 6) *The Action Agencies will continue to work cooperatively with the Council to identify priorities and obtain ISRP review of projects proposed for BPA funding.*

The Action Agencies continue to cooperate with the Northwest Power and Conservation Council (NPCC) to identify program priorities and obtain Independent Scientific Review Panel (ISRP) review of projects as appropriate. In 2012 and 2013, actions proposed by project sponsors through the BPA’s Fish and

Wildlife Program were included in the NPCC's 2013 geographic categorical review. Project sponsors were directed to identify the BiOp relevance of proposed actions in their proposals. The Action Agencies included the limiting factor pie charts⁵ in the template for the geographic categorical review to encourage proposals for habitat actions that would result in the greatest benefits to fish populations. Through these efforts the Action Agencies establish greater consistency between BiOp implementation and the BPA's Fish and Wildlife Program implementation.

- 7) *RM&E will inform the relationship between actions, habitat quality and salmon productivity for use in a model developed through the FCRPS RM&E Strategy 3, Action 57 and new scientific information will be applied to estimate benefits for future implementation.*

The Action Agencies have entered into the fourth year of monitoring under the Columbia Habitat Monitoring Program (CHaMP) project. CHaMP and the Integrated Status and Effectiveness Monitoring Program (ISEMP) will deliver data on habitat status and trends and fish presence and abundance that can be correlated to estimate fish-habitat status and trends. These data will inform the Action Agencies and others in the region about habitat status and trends and about relationships between habitat and fish population productivity. These data will inform the Action Agencies and others in the region about habitat status and trends and about relationships between habitat and fish population productivity. The data will also be used in development of life cycle models, which the Action Agencies continue to fund, consistent with the 2010 Supplemental BiOp⁶. The Action Agencies will also continue to fund the Intensively Monitored Watersheds (IMWs) that are providing data on habitat attributes relative to various treatment types.

An example of how CHaMP and ISEMP results, and results from IMWs explain the benefits of tributary habitat improvements is presented below (C. Beasley, Pers. Comm. June 2014).

"After reconnecting Little Springs Creek in fall 2011 juvenile Chinook salmon and steelhead; likely seeking refuge in the cooler spring water available in Little Springs Creek, moved into the creek. Juvenile Chinook salmon that used Little Springs Creek in 2012 survived to emigrate from the Lemhi River at a rate of 29 percent, slightly lower than the population in the Lemhi River. In 2013, after a habitat restoration action was completed in Little Springs Creek, 80 percent of the juveniles that reared in Little Springs Creek survived to emigrate from the Lemhi River. This difference in survival is striking, considering that overall survival for juvenile Chinook salmon was lower in 2013 than in 2012. Similarly, the

⁵ The AAs have developed "Pie Maps" that illustrate numerical limiting factor data. The whole pie illustrates a number of limiting factors. Pie size is relative to the importance of a particular limiting factor relative to other factors. The AAs prepared limiting factor pie maps for expert panel use in evaluating planned and completed habitat improvement actions. <http://www.usbr.gov/pn/fcrps/habitat/panels/piemaps/index.html>

⁶ CHaMP and ISEMP are pursuing three approaches to establish relationship between habitat and fish status and trends. The Net Rate of Energy Intake (NREI) is a bioenergetics based approach that looks at food availability and flow. A 2-dimensional flow model that uses CHaMP DEMs will be used to estimate the number of juveniles of X species a stream reach can accommodate. A second approach relies on Habitat Suitability Index (HSI) models that relate habitat attributes to species-specific habitat requirements. Fish and habitat relationships are based on values from the literature. A third approach will rely on Boosted Regression Trees (BRT) to correlate observed habitat characteristics and empirical measures of fish density to predict fish densities or biomass based on habitat attributes. All of these approaches are in development.

abundance of juvenile Chinook salmon increased five-fold from 2012 to 2013, despite the fact that the abundance of juvenile Chinook salmon in the Lemhi River was 62 percent lower in 2013 than in 2012. The

abundance of juvenile O. mykiss followed a similar pattern, increasing from 436 juveniles in 2012 to 1,297 in 2013.

These results underscore the importance of IMWs as an evaluation tool. Changes in the abundance of juvenile Chinook salmon and O. mykiss in Little Springs Creek are compelling. Given the intensity of monitoring in the Lemhi River, we can state that changes in juvenile abundance in Little Springs Creek are not only statistically significant, they are in the opposite direction of the larger population. In other words, the increase in abundance in Little Springs Creek is not the result of a random change in spatial distribution or an increase in the number of juvenile Chinook salmon or O. mykiss. Because we can estimate survival for the population at large, we know with certainty that the habitat restoration actions in Little Springs Creek resulted in a dramatic increase in juvenile survival."

Results like these, together with data derived through Action Effectiveness Monitoring (AEM) will inform the relationship between actions, habitat quality, and salmon productivity. Expert panel determinations of limiting factor weights and function, and of change in limiting factor function as a result of implementing habitat improvement actions, will continue to be based on expert opinion. Increasingly, panel deliberations will be informed by data and results of research. As more data becomes available in formats that can be used by the expert panels, the Action Agencies will make these products available to the panels.

- 8) *If new scientific or other information (except incomplete implementation or project modifications) suggests that habitat quality improvement estimates for projects from the previous cycle were significantly in error, the Action Agencies will examine the information and review the project or projects in question and their estimated benefits. This review will occur as part of the 2009 Annual Report and the Comprehensive RPA Evaluations in 2013 and 2016 and will be performed in conjunction with NOAA Fisheries. In the event such review finds that habitat quality improvement benefits were significantly overstated, the Action Agencies will implement replacement projects (selected as per Action 35 above) to provide benefits sufficient to achieve the habitat quality improvement and population-or MPG-specific survival benefit estimated for the original project or projects.*

New scientific or other information has not suggested that previous habitat quality improvement estimates are significantly in error. New information on the habitat quality improvement estimates for actions from 2010 to 2012 and beyond 2013, will be examined as part of the 2016 expert panel workshops and reported in the 2016 CE. Noteworthy in this proceeding will be the expert panel review of the supplemental actions that the Action Agencies incorporated into the 2014-2018 IP. The need to identify supplemental actions for these populations necessitated Action Agency assessment of benefits. The Action Agency approach is documented in the 2013 CE and the 2014-2018 IP. Supplemental actions have not yet been reviewed by expert panels. The Action Agencies identified the supplemental actions after the 2012 expert panel workshops, because their analysis of the expert panel results (based on the HCW CHWG method) indicated that additional HQI was needed to meet Table 5 HQI performance standards for seven populations. The Action Agencies did a preliminary assessment of the benefits of the supplemental actions, using an approach documented in the 2013 CE Appendix B "Supplemental Action Benefit Estimate Methodology" and applied in the 2014-2018 IP. When the expert panels meet in 2016, they will review the

supplemental actions and, as necessary, revise any metric benefits.

- b. *During 2010-2018, for non-bolded populations in Table 5, the Action Agencies may provide funding and/or technical assistance for replacement projects should they become necessary for the Action Agencies to achieve equivalent MPG or ESU survival benefits.*

In 2013, the Action Agencies provided funding and technical assistance for actions that improve habitat for non-bolded populations in RPA Action 35, Table 5. The actions are part of a larger effort to address limiting factors in other watersheds to benefit listed species. See Appendix D, 2014-2018 IP.

Habitat Strategy 2 (RPA Actions 36 – 38)

RPA Action 36 – Estuary Habitat Implementation 2007 to 2009

The Action Agencies will provide funding to implement specific actions identified for implementation in 2007–2009 as part of a 10-year estuary habitat program to achieve the estimated ESU survival benefits of 9.0 percent and 6.0 percent for ocean type and stream-type ESUs, respectively. Projects in an early state of development such that quantitative physical metrics have not been related to estimated survival benefits will be selected per Action 37. If projects identified for implementation in 2007–2009 prove infeasible, in whole or in part, the Action Agencies will implement comparable replacement projects in 2010–2013 to provide equivalent habitat benefits needed to achieve equivalent survival benefits.

Actions for this RPA Action are found in the 2009 FCRPS Annual Report (FCRPS 2010b). Some projects scheduled for completion in 2007–2009 were carried forward to the 2010–2013 period and the associated benefits are included in the estimates for the 2010–2013 implementation cycle.

During the 2007–2009 implementation period some projects proved infeasible in whole or in part. The Action Agencies implemented additional projects in 2010–2013 to provide survival benefits equivalent to those of the projects that proved infeasible. This RPA Action is complete and as envisioned by the RPA, estuary habitat implementation through 2018 is being continued under RPA Action 37.

RPA Action 37 – Estuary Habitat Implementation 2010 – 2018 – Achieving Habitat Quality and Survival Improvement Targets

The Action Agencies will provide funding to implement additional specific projects as needed to achieve the total estuary survival benefits identified in the FCRPS BA. Projects will identify location, treatment of limiting factor, targeted ESU/DPS or ESUs/DPSs, appropriate reporting metrics, and estimated biological benefits based on the achieving of those metrics. Pertinent new information on climate change and potential effects of that information on limiting factors will be considered.

In 2013 the Action Agencies provided funding for implementation of projects progressing toward achieving the total FCRPS BiOp estuary survival benefits called for by 2018. Most projects implemented in the estuary are selected on an annual basis. Out year planning and scheduling was also conducted.

The Action Agencies use the Expert Regional Technical Group (ERTG) to evaluate the biological benefits of estuary habitat projects. This review combines available scientific data and expert opinion to estimate the benefits to all up river ESA listed ESU/DPSs including interior population of listed juvenile salmonids. This review evaluates habitat quality and quantity, access (includes fish entering the site and food exported from the site), and the

likelihood that the project will function as designed. The ERTG incorporates new information into their process as it becomes available. In 2013, the Corps and Pacific Northwest National Laboratory (PNNL) completed An Evidence-Based Evaluation of the Cumulative Effects of Tidal Freshwater and Estuarine Ecosystem Restoration on Endangered Juvenile Salmon in the Columbia River (Diefenderfer et al. 2013). This multi-year study provides the best evidence to date of the cumulative benefits provided by estuary habitat restoration. The paper, documenting the results of the study was provided to the ERTG to inform their review of future projects.

In 2013, the Action Agencies completed on-the-ground habitat actions for eight projects in the estuary and continued planning and development of additional projects for future implementation (See Section 3, Attachment 4 for status of projects). These projects yielded 3.89 Ocean Survival Benefit Units (SBUs) and 1.35 Stream SBUs by restoring 1,467 acres throughout the Columbia River estuary. All of the habitat projects below have been reviewed by the ERTG:

The Action Agencies continue to use the Columbia Estuary Ecosystem Restoration Plan (CEERP) to guide their estuary restoration efforts. The purpose of CEERP is to establish the strategic, adaptively managed scientific basis for the ecosystem restoration and associated RME that the Action Agencies are funding in the Lower Columbia River estuary (LCRE). In 2013, the CEERP documents were updated to include any new lessons and associated adaptive management.

As part of the CEERP process, the Action Agencies have developed an out year prioritization process that evaluates cost, SBUs and implementation likelihood of all potential estuary actions. This process was described in detail in the 2013 Comprehensive Evaluation. In 2013, the Action Agencies met monthly with project sponsors to refresh the cost, SBU, and implementation likelihood data of current and future actions. All changes to estuary action data are catalogued in cbfish.org at <http://www.cbfish.org/EstuaryAction.mvc/Index>. If these changes resulted in an action no longer being feasible, the Action Agencies identified other actions with greater or equal SBU values. See Section 3, Attachment 4 for more details.

In 2013, the Action Agencies funded, and with their partners, completed the following actions (partnering organization shown in parentheses):

Dibblee Point Restoration: Improved hydrologic connectivity to 13 acres of backwater habitat by replacing an undersized culvert under a gravel access road. Adjacent wetlands were excavated to elevations supportive of intertidal marsh and frequently inundated floodplain habitats. Riparian forest was restored around the perimeter of the site through native plantings. (Columbia River Estuary Study Taskforce)

Honeyman Creek Restoration: Restored a portion of the Scappoose Bay Bottomlands adjacent to Honeyman Creek by increasing hydrologic connectivity between the Lower Columbia River and the Malarkey Ranch. Multiple undersized culverts were replaced with bridges and riparian planting occurred along channel edges. The project improved water quality, restored tidal hydrology, and increased connectivity between the mainstem and 58 acres of floodplain wetland. (Estuary Partnership and Scappoose Bay Watershed Council)

Horsetail Creek Restoration: Improved connectivity to 110 acres of floodplain wetland by replacing a culvert under I-84. Additional actions included berm removal and increased instream habitat complexity. An artificial pond was enhanced to allow for cooler conditions, reducing habitat suitability for invasive warm water predators. (Estuary Partnership)

LA (Louisiana) Swamp Restoration: Restored 32 acres of floodplain wetland by breaching a levee along Westport Slough, the adjacent blind slough to the west of the site, and along Tandy Slough in several strategic locations. The existing drainage network behind the levee was enhanced and expanded to emulate complex, sinuous channels. Exotic vegetation was also removed across the entire property with native riparian vegetation planted along Tandy Creek, Westport Slough and on created contours of elevation within the site. (Estuary Partnership)

Sandy River Dam Removal: The Corps removed a 1930's era diversion dam across the main channel of the Sandy River near the confluence with the Little Sandy River, reconnecting approximately 190 acres of historical channel with the estuary. Implementation of the project restored flows to the east channel improving rearing habitat for interior Columbia Basin ESUs. Riparian areas were re-vegetated in disturbed areas and invasive plants were treated along the historical river bank.

Sauvie Island, North Unit (Ruby Lake) Restoration - Phase 1: Initiated Phase I of a multiphase project designed to improve hydrology and connectivity to approximately 600 acres of the northern tip of the Sauvie Island Wildlife Area. Phase I removed a water control structure in Ruby Slough, restoring hydrologic connectivity between the mainstem and Ruby Lake's seasonal wetlands. In addition, marsh plain surfaces were excavated to lower elevations, allowing a larger portion of the wetlands to be inundated, benefiting native plant species. Removal of the water control structure re-established connectivity to over 123 acres of historical habitat. A potential fish stranding risk was minimized and food web connectivity was enhanced. Phase 1 is the first part of a three phase effort to restore habitat function and natural hydrology on the North Unit. (Columbia River Estuary Study Taskforce)

Skamokawa Creek - Dead Slough Restoration: Re-established four miles of meandering channel and tidal-fluvial hydrology to the historical Skamokawa Creek channel. Actions in this phase included a major tidegate retrofit at the lowest reach of the historical channel, interior culvert retrofits, and channel enhancements. This project complements an upstream inlet structure that created a connection to the historical channel (constructed in 2008). Together, the two projects allow juvenile fish ingress/egress in the channel under most hydrologic conditions. (Estuary Partnership and Cowlitz-Wahkiakum Conservation District)

Grays Bay Kandoll Farm Restoration - Phase 2: Built upon previous Kandoll Farm restoration efforts to increase hydrology and juvenile salmonid ingress/egress to the 163 acre site. Habitat structure and function were improved by expanding hydrologic connectivity between the floodplain and the Grays River, increasing floodplain complexity by promoting sinuous channel development, and increasing habitat capacity by adding large wood. Restoration of natural processes at the site will improve sediment dynamics and increase organic material exchange between the site and the Columbia River. (Columbia Land Trust)

Chinook River Washington Department of Fish and Wildlife (WDFW) – Phase 1: Acquired 2 parcels, totaling 202 acres of land, adjacent to the Chinook River at its confluence with Baker Bay and three miles from the Columbia River mainstem. The larger Chinook site (~900 acres) is primarily owned by WDFW; however, there are also private inholdings which constrain operations of a large tidegate located at the confluence with Baker Bay. Acquisition of these two parcels will allow WDFW to actively manage the tidegate (to clarify, the tidegates will primarily remain open) in order to benefit juvenile salmonid ingress/egress. A future phase of the project may involve replacing the tidegates with a bridge or large culvert. The parcels are located just inside and northeast of the

tidegates where the river passes under SR-101 and will significantly improve opportunity to increase tidal prism through tidegate management. Future restoration actions at the site include managing tidegates to maximize fish passage, tidal flux and increased salinity intrusion; removing blockages and restoring historical channels; and planting riparian areas and controlling exotic plants. (WDFW)

Kerry Island - Phase 1: Acquired this 110 acre property on Westport Slough, two miles from the Columbia River near Puget Island and the town of Westport, Oregon. As a result of the human development, there is no fish access to the isolated freshwater scrub-shrub, forested wetlands and historical sloughs that remain throughout the interior of the property. Columbia Land Trust will jump-start passive habitat-forming processes through invasive plant management and native plantings. Future active restoration actions include levee removal and channel enhancements to restore tidal function to the island. (Columbia Land Trust)

Wallooskee Youngs – Phase 1: Acquired this 193 acre (163 of which are lowland) site located in Youngs Bay at the confluence with the Wallooskee River, five miles from the mainstem Columbia River. The site is currently drained pasture land behind an extensive levee that surrounds the perimeter. Active restoration of the site will include breaching the levee in multiple locations to restore tidal and riverine hydrology, excavating new channel signatures, and actively removing/managing invasive vegetation. Passive restoration includes transitioning from pasture land to ecologically beneficial uses, allowing natural plant communities to re-establish. (Cowlitz Tribe)

Grays River Confluence – Phase 1: Acquired this 123 acre site located in Grays Bay at the mouth of the Grays River, about a half-mile from the Columbia River mainstem. This acquisition, along with future adjacent land acquisitions, will allow CLT to restore natural hydrology, turning this currently diked pasture land into an ecologically valuable site that will benefit listed salmonids as well as local wildlife. Restoration actions include breaching the levee in multiple locations, filling ditches, and removing internal barriers. Passive restoration will occur as CLT transitions the land use from pasture to natural wetlands and initiates perpetual stewardship activities. (Columbia Land Trust)

In 2013 the Action Agencies also took the following actions to implement the steps called for in RPA Action 37 above:

1. *Action Agencies will actively engage the LCREP Science workgroup to identify project benefits in coordination with other regional experts, using recovery planning products and the modified LCREP project selection criteria (FCRPS BA Attachment B.2.2-3) to identify projects that will benefit salmon considered in this RPA.*

In 2013, the Action Agencies continued to use the ecosystem criteria developed by the Lower Columbia Estuary Program's (LCEP's) Science Workgroup to help select restoration and protection projects in the Lower Columbia River and estuary. Additionally, the LCEP was instrumental in coordinating and hosting the 2014–2018 out-year restoration project development process undertaken with all regional partners by the Action Agencies.

2. *To support project selection the Action Agencies will convene an expert regional technical group. This group will use the habitat metrics to determine the estimated change in survival which would result from full implementation.*

The ERTG was established in 2009 and began evaluating Federal projects for their survival benefit potential. The ERTG has five members, representing: the Oregon Department of Fish and Wildlife (ODFW); WDFW; NOAA Fisheries, NWFSC; the

Department of Energy's Pacific Northwest National Laboratory; and the Skagit River System Cooperative. In 2013, the ERTG completed the following:

- Reviewed and scored 21 estuary actions; and
 - Produced an approach to calculating SBUs for floodplain lake reconnection projects (ERTG 2013).
3. *Project proposals will clearly describe the completed project in terms of quantitative habitat metrics which can be used to quantitatively evaluate progress and completion of individual projects.*

The ERTG template continues to be refined to ensure that the ERTG has the best available information on proposed projects. In 2013 the template was updated to include a requirement for a landscape level map in addition to the site specific map.

4. *The expert regional technical group will use the approach originally applied in the FCRPS BA (Attachment B.2.2) (Estimated Benefits of Federal Agency Habitat Projects in the Lower Columbia River Estuary) and all subsequent information on the relationship between actions, habitat and salmon productivity models developed through the FCRPS RM&E to estimate the change in overall estuary habitat and resultant change in population survival.*

The ERTG previously reviewed and improved the approach for determining SBU values applied in the FCRPS BA. The improved version was used to estimate changes in estuary habitat and population survival during 2013. In 2013, the ERTG provided additional guidance on floodplain lake reconnection projects (ERTG 2013).

5. *If actions from the previous cycle prove infeasible, in whole or in part, the Action Agencies will ensure implementation of comparable replacement estuary projects in the next implementation plan cycle to maintain estimated habitat quality improvements at the ESU/DPS level and achieve equivalent survival benefits. Selection of replacement projects, to ensure comparable survival benefits, will be made based on input from expert panels, regional recovery planning groups, the Northwest Power and Conservation Council, and NOAA Fisheries.*

Some projects scheduled for completion in 2013 were delayed or proved infeasible. The delayed projects will be constructed by the end of the BiOp period. In 2013, the Action Agencies and project partners started an out-year planning and prioritization initiative to identify future project opportunities some of which may be used as replacement projects. This initiative prioritized project opportunities based on cost, biological benefit (survival benefit units), and implementation likelihood.

Replacement project selection was guided by input from expert panels, regional recovery planning groups, the NPCC, and NOAA Fisheries.

6. *FCRPS RM&E results will actively inform the relationship between actions, estuary habitat change and salmon productivity and new scientific information will be applied to estimate benefits for future implementation.*

As information from FCRPS estuary research and restoration project effectiveness monitoring becomes available, it is applied to the process of estimating benefits for projects implemented between 2010 and 2018. This process is outlined in the CEERP documents.

7. *If new scientific or other information (except incomplete implementation of project modification) suggests that habitat quality improvement estimates for projects from the*

previous cycle were significantly in error, the Action Agencies will examine the information and review the project or projects in question and their estimated benefits. This review will occur as part of the 2009 Annual Report and the Comprehensive RPA Evaluations in 2013 and 2016 and will be performed in conjunction with NOAA Fisheries. In the event such review finds that habitat based survival improvement were significantly overstated, the Action Agencies will implement replacement projects (selected as per new projects above) to provide benefits sufficient to achieve the ESU/DPS-specific survival benefit estimated for each affected project.

In 2013, the Action Agencies engaged research agencies, consultants, LCEP’s Science Workgroup, the Corps’ Anadromous Fish Evaluation Program (AFEP), the ERTG, and other sources regarding new scientific information. The Action Agencies have examined that information, and have found no indication that any habitat quality improvement estimates for projects completed in the 2010 implementation cycle were “significantly overstated.” The Action Agencies will continue to coordinate with LCEP’s Science Workgroup and the ERTG regarding new scientific information. When available, new scientific information resulting from FCRPS RME will be applied to estimate benefits for projects implemented between 2010 and 2018.

RPA Action 38 – Piling and Piling Dike Removal Program

To increase access to productive habitat and to reduce avian predation, the Action Agencies will develop and implement a piling and pile dike removal program.

1. In 2008, the Action Agencies will work with [the] Lower Columbia River Estuary Program to develop a plan for strategic removal of structures that have lower value to navigation channel maintenance, present low-risk to adjacent land use, support increased ecosystem function, and are cost-effective.
2. Beginning in 2008 and 2009, the Action Agencies will begin implementation. Implementation will continue through 2018.

Efforts to implement this RPA Action were discontinued based on updated scientific information. The 2014 Supplemental Biological Opinion stated it is not possible to determine whether the removal of pile structures would actually provide survival benefits to juvenile salmon and steelhead. As a result, the BiOp did not call for further implementation of RPA Action 38. All survival benefit units attributed to RPA Action 38 in the Action Agencies’ 2007 Biological Assessment are now being acquired by implementing additional projects under RPA Action 37.

Hatchery Implementation Reports, RPA Actions 39 – 42

Table 14. Hatchery Strategy Reporting.

RPA Action No.	Action	Annual Progress Report
Habitat Strategy 1		
39	FCRPS Funding of Mitigation Hatcheries – Programmatic	Status of submittal/approval of Hatchery and Genetic Management Plans (HGMPs), including site-specific application of Best Management Practices.
40	Reform FCRPS Hatchery Operations to Reduce Genetic and Ecological Effects on ESA-Listed Salmon and Steelhead	Status of implementation through December of the previous year for all reforms identified in the BiOp RPA table, action 40, Table 6. Status of implementation of future reforms identified by the Action Agencies following the Hatchery Scientific Review Group process.

Hatchery Strategy 2		
41	Implement Safety Net Programs to Preserve Genetic Resources and Reduce Short-term Extinction Risk	Status of implementation through December of the previous year for all safety net programs identified in the BiOp RPA table, action 41, Table 7.
42	Implement Conservation Programs to Build Genetic Resources and Assist in Promoting Recovery	Status of implementation through December of the previous year for all conservation programs identified in the BiOp RPA table, action 42, Table 8.

RPA Action 39 – FCRPS Funding of Mitigation Hatcheries – Programmatic

The FCRPS Action Agencies will continue funding hatcheries in accordance with existing programs, and will adopt programmatic criteria for funding decisions on mitigation programs for the FCRPS that incorporate BMPs. The Hatchery Effects Report, the August 2006 NOAA Fisheries paper to the PWG and the NOAA Fisheries 2007 Guidance Paper should be considered in developing these criteria in addition to the BMPs in the Action Agencies' BA. Site specific application of BMPs will be defined in ESA Section 7, Section 10, or Section 4(d) consultations with NOAA Fisheries to be initiated and conducted by hatchery operators with the Action Agencies as cooperating agencies.

In 2008 and 2009, NOAA Fisheries asked the Action Agency-funded hatchery operators to update the hatchery and genetic management plans for their respective hatchery programs. The Action Agencies have since worked collaboratively with hatchery program operators on the development and submittal of hatchery and genetic management plans for consultation. Information from the reports of the USFWS Hatchery Review Team process, the Columbia Basin Hatchery Scientific Review Group process, and regionally reviewed best management practices has guided and informed the development of program-specific hatchery and genetic management plans.

In 2013, the Action Agencies continued to fund mitigation hatcheries in accordance with existing programs and used the programmatic funding criteria developed in 2008 to complete checklists for FCRPS mitigation program funding decisions. The hatchery programs funded by the Action Agencies are described briefly in Tables 15 through 17.

Table 15. FCRPS –Funded Hatchery Programs in the Upper Columbia Region.

Program	Basin	Operator	Lead Action Agency	Status of Consultation Process, December 2013
Leavenworth National Fish Hatchery (NFH) Spring Chinook	Wenatchee	USFWS	Reclamation	Draft BiOp versions reviewed by Reclamation and USFWS, then revised by NOAA Fisheries. New information resulted in changes to Draft BiOp and additional review cycles.
Entiat NFH Summer Chinook Program	Entiat	USFWS	Reclamation	NOAA Fisheries issued BiOp and permits April 18, 2013.
Winthrop NFH Methow Composite Spring Chinook	Methow	USFWS	Reclamation	NOAA Fisheries issued a letter of sufficiency on March 2013 and began drafting BiOp.
Winthrop NFH Steelhead	Methow	USFWS	Reclamation	NOAA Fisheries issued a letter of sufficiency on March 2013 and began drafting BiOp.
Methow Coho	Methow	Yakama Nation (YN)	BPA	NOAA Fisheries issued a letter of sufficiency in December 2010. BiOp has been drafted.
Wenatchee Coho	Wenatchee	YN	BPA	NOAA Fisheries issued a letter of sufficiency in December 2010. BiOp has been drafted.

Table 16. FCRPS-Funded Hatchery Programs in the Mid-Columbia Region.

Program	Basin	Operator	Lead Action Agency	Status of Consultation Process, December 2013
Yakima Spring Chinook	Yakima	YN	BPA	NOAA Fisheries issued BiOp and permits November 2013.
Yakima Summer-Fall Chinook 1	Yakima	YN	BPA	NOAA Fisheries issued BiOp and permits November 2013.
Yakima Coho	Yakima	YN	BPA	NOAA Fisheries issued BiOp and permits November 2013.
Touchet Endemic Steelhead	Walla Walla	WDFW	BPA, Lower Snake River Compensation Plan (Lower Snake River Compensation Plan)	NOAA Fisheries issued a letter of sufficiency in March 2011. Status in 2013 is consultation "to be scheduled".
Umatilla Spring Chinook	Umatilla	Oregon Department of Fish and Wildlife (ODFW) & Confederated Tribes of the Umatilla Indian Reservation (CTUIR)	BPA	NOAA Fisheries issued BiOp and permits April 2011.
Umatilla Fall Chinook 2	Umatilla	ODFW & CTUIR	BPA and Corps	NOAA Fisheries issued BiOp and permits April 2011.
Umatilla Coho 3	Umatilla	ODFW & CTUIR	BPA	NOAA Fisheries issued BiOp and permits April 2011.
Umatilla Summer Steelhead	Umatilla	ODFW & CTUIR	BPA	NOAA Fisheries issued a letter of sufficiency in March 2011. Status in 2013 is consultation "to be scheduled".

Table 17. FCRPS-Funded Hatchery Programs in the Snake River Region.

Program	Basin	Operator	Lead Action Agency	Status of Consultation Process, December 2013
Lyons Ferry Summer Steelhead	Lower Snake	WDFW	BPA (Lower Snake River Compensation Plan)	NOAA Fisheries issued a letter of sufficiency in May 2011. Status in 2013 is consultation in process, expected summer 2014.
Snake River Stock Fall Chinook (Lyons Ferry Hatchery) 1	Lower Snake	WDFW	BPA (Lower Snake River Compensation Plan)	NOAA Fisheries issued BiOp and permits in 2012.
Tucannon Summer Steelhead Endemic	Tucannon	WDFW	BPA (Lower Snake River Compensation Plan)	NOAA Fisheries issued a letter of sufficiency in May 2011. Status in 2013 is consultation in process, expected summer 2014.
Tucannon Spring Chinook	Tucannon	WDFW	BPA (Lower Snake River Compensation Plan)	NOAA Fisheries issued a letter of sufficiency in August 2011. Status in 2013 is consultation in process, expected summer 2014.
NF Clearwater River Summer Steelhead (B-	Clearwater	IDFG	BPA (Lower Snake River	NOAA Fisheries issued a letter of sufficiency in August 2011.

Program	Basin	Operator	Lead Action Agency	Status of Consultation Process, December 2013
Run-Clearwater River Hatchery)			Compensation Plan)	There may be a need to update the HGMP to reflect current program.
Clearwater River Basin Spring/Summer Chinook (Clearwater Hatchery)	Clearwater	IDFG	BPA (Lower Snake River Compensation Plan)	NOAA Fisheries issued a letter of sufficiency in August 2011. There may be a need to update the HGMP to reflect current program
Clearwater River Basin Spring/Summer Chinook (Kooskia Hatchery)	Clearwater	NPT	BPA (Lower Snake River Compensation Plan)	NOAA Fisheries issued a letter of sufficiency in August 2011. There may be a need to update the HGMP to reflect current program.
NF Clearwater Summer Steelhead (B-Run-Dworshak NFH)	Clearwater	USFWS	Corps	Applicant updating the HGMP to reflect changes to the program that have occurred since the original HGMP submittal.
NF Clearwater Spring Chinook (Dworshak NFH)	Clearwater	USFWS	BPA (Lower Snake River Compensation Plan)	HGMP submitted in 2011. Formal review and comments from NOAA Fisheries pending. There may be a need to update the HGMP to reflect current program.
Clearwater Spring Chinook (NPTH-Hatchery)	Clearwater	Nez Perce Tribe (NPT)	BPA	HGMP submitted in 2011. Formal review and comments from NOAA Fisheries pending. There may be a need to update the HGMP to reflect current program.
Clearwater Fall Chinook (NPTH-Hatchery)	Clearwater	NPT	BPA	NOAA Fisheries issued BiOp and permits in 2012.
Grande Ronde Summer Steelhead-Wallowa Stock (Cottonwood Creek/Lyons Ferry Hatchery)	Grande Ronde	WDFW	BPA (Lower Snake River Compensation Plan)	NOAA Fisheries issued a letter of sufficiency in May 2011. Status in 2013 is consultation in process.
Grande Ronde Summer Steelhead (Wallowa Stock)	Grande Ronde	ODFW	BPA (Lower Snake River Compensation Plan)	NOAA Fisheries issued a letter of sufficiency in May 2011. Status in 2013 is consultation in process.
Upper Grande Ronde River Spring/Summer Chinook Salmon Stock	Grande Ronde	ODFW & CTUIR	BPA (Lower Snake River Compensation Plan)	NOAA Fisheries issued a letter of sufficiency in August 2011. Status in 2013 is consultation in process.
Catherine Creek Spring/Summer Chinook	Grande Ronde	ODFW & CTUIR	BPA (Lower Snake River Compensation Plan)	NOAA Fisheries issued a letter of sufficiency in May 2011. Status in 2013 is consultation in process.
Wallowa/Lostine Spring Chinook	Grande Ronde	ODFW, NPT & CTUIR	BPA (Lower Snake River Compensation Plan)	NOAA Fisheries issued a letter of sufficiency in August 2011. Status in 2013 is consultation in process.
Lookingglass Creek Spring/Summer Chinook	Grande Ronde	ODFW	BPA (Lower Snake River Compensation Plan)	NOAA Fisheries issued a letter of sufficiency in March 2012. Status in 2013 is consultation in process.
Little Sheep Creek Summer Steelhead	Imnaha	ODFW	BPA (Lower Snake River	NOAA Fisheries issued a letter of sufficiency in August 2011.

Program	Basin	Operator	Lead Action Agency	Status of Consultation Process, December 2013
			Compensation Plan)	Status in 2013 is consultation in process.
Imnaha Spring/Summer Chinook	Imnaha	ODFW	BPA (Lower Snake River Compensation Plan)	NOAA Fisheries issued a letter of sufficiency in August 2011. Status in 2013 is consultation in process, though applicant is reconsidering adult management strategies; BiOp expected 2014.
Upper Salmon River B-Run Steelhead	Salmon	IDFG	BPA (Lower Snake River Compensation Plan)	NOAA Fisheries issued a letter of sufficiency in August 2011. There may be a need to update the HGMP to reflect current program.
Upper Salmon Spring Chinook (Sawtooth Hatchery)	Salmon	IDFG	BPA (Lower Snake River Compensation Plan)	NOAA Fisheries issued a letter of sufficiency in August 2011. There may be a need to update the HGMP to reflect current program.
South Fork Salmon Summer Chinook (McCall Fish Hatchery)	Salmon	IDFG	BPA (Lower Snake River Compensation Plan)	NOAA Fisheries issued a letter of sufficiency in August 2011. There may be a need to update the HGMP to reflect current program.
Johnson Creek Summer Chinook (South Fork Salmon)	Salmon	IDFG & NPT	BPA (Lower Snake River Compensation Plan)	Applicant submitted HGMP in 2011. Formal review and comments from NOAA Fisheries pending.
Yankee Fork Summer Steelhead Streamside Incubation Supplementation	Salmon	IDFG & Shoshone-Bannock Tribes	BPA	NOAA Fisheries issued a letter of sufficiency in August 2011. There may be a need to update the HGMP to reflect current program.
Yankee Fork Summer Steelhead Supplementation	Salmon	IDFG & Shoshone-Bannock Tribes	BPA	NOAA Fisheries issued a letter of sufficiency in August 2011. There may be a need to update the HGMP to reflect current program.
Yankee Fork Chinook Supplementation	Salmon	IDFG & Shoshone-Bannock Tribes	BPA	Operator updating the HGMP to reflect current program.
Panther Creek Chinook Supplementation	Salmon	IDFG & Shoshone-Bannock Tribes	BPA	Operator developing an HGMP to be submitted in 2014.
SF Salmon-Dollar Creek Summer Chinook (McCall FH-Egg Box)	Salmon	IDFG & Shoshone-Bannock Tribes	BPA	HGMP submitted in 2011. Formal review and comments from NOAA Fisheries pending. There may be a need to update the HGMP to reflect current program.
E. Fork Salmon River Natural integrated Steelhead (Sawtooth)	Salmon	IDFG	BPA (Lower Snake River Compensation Plan)	HGMP submitted in 2011. Formal review and comments from NOAA Fisheries pending. There may be a need to update the HGMP to reflect current program.
Little Salmon River A&B Run Steelhead	Salmon	IDFG	BPA (Lower Snake River	HGMP submitted in 2011. Formal review and comments

Program	Basin	Operator	Lead Action Agency	Status of Consultation Process, December 2013
(Niagara/Magic Valley)			Compensation Plan)	from NOAA Fisheries pending. There may be a need to update the HGMP to reflect current program.
Upper Salmon River A-Run Steelhead (Sawtooth/ Magic Valley/Hagerman National)	Salmon	IDFG	BPA (Lower Snake River Compensation Plan)	HGMP submitted in 2011. Formal review and comments from NOAA Fisheries pending. There may be a need to update the HGMP to reflect current program.
Snake River Sockeye	Salmon	IDFG	BPA (Lower Snake River Compensation Plan)	NOAA Fisheries issued BiOp and permits in 2013.

RPA Action 40 – Reform FCRPS Hatchery Operations to Reduce Genetic and Ecological Effects on ESA Listed Salmon and Steelhead

The Action Agencies will undertake/fund reforms to ensure that hatchery programs funded by the Action Agencies as mitigation for the FCRPS are not impeding recovery. The Action Agencies will work with FCRPS mitigation hatchery operators to cost effectively address needed reforms of current hatchery programs while continuing to meet mitigation responsibilities. Specific reforms to be implemented under this action (following any necessary regulatory approval) are listed in Table 6 of the RPA action table. Other reforms will be identified and implemented following the conclusion of the Columbia River Hatchery Scientific Review Group process.

1. *For Lower Columbia Chinook: The COE will review the John Day Hatchery Mitigation Program.*

The Corps continued an engineering study in 2013, with a final report due in 2014. The report will recommend specific improvements to the current John Day Mitigation production program.

2. *For Snake River Steelhead: Fund the Tucannon River steelhead supplementation program to transition to local broodstock using BMPs.*

This action will be funded by BPA and implemented by the Lower Snake River Compensation Plan program office, WDFW, and the Lower Snake River Compensation Plan hatchery program operator for the Tucannon River steelhead supplementation program. For Tucannon steelhead, WDFW developed a revised HGMP (released September 22, 2011) to eliminate releases of Lyons Ferry Hatchery steelhead in the Tucannon River and to increase production of the endemic Tucannon River summer steelhead program. A summary of the proposed changes was submitted to the U.S. v Oregon Production Advisory Committee for review and approved by the U.S. v Oregon Parties in 2011. The current Tucannon River endemic stock summer steelhead smolt production was increased from 50,000 to 75,000 fish annually (beginning with BY2010 production for release in 2011). Releases in 2013 (BY12) were limited to 58,000 due to broodstock limitations. It is expected that releases in 2014 (of BY13 fish) will reach closer to 100,000 fish. Program expansion to 150,000 annual smolt releases has been tentatively agreed to by co-managers and will be implemented following co-manager and NOAA Fisheries agreement on adult management when adults return, and modification and agreement of HGMP changes.

Expansion of the program above 75,000 smolts long-term will require modification of Lyons Ferry or Tucannon Hatchery and will require release of an ad-clipped component to meet Lower Snake River Compensation Plan harvest mitigation

responsibility. Co-managers are discussion options for hatchery modification.

3. *For Middle Columbia Steelhead: Fund the Touchet River steelhead supplementation program to transition to local broodstock using BMPs.*

This action will be funded and implemented by the Lower Snake River Compensation Plan program office and WDFW. For Touchet steelhead, WDFW submitted a HGMP to NOAA Fisheries in November 2010 to align with NOAA Fisheries' request to consult on mid-Columbia River stocks. The new HGMP is consistent with the current management plan and the U.S. v Oregon agreement. At this time, the program remains the same (50,000 smolts annually) and continues to be evaluated.

Twelve years of RME data has indicated that the current supplementation program may not be supporting the native Touchet River population as intended. As part of the Annual Operations Plan process in 2013, hatchery co-managers and technical representatives have agreed to move forward with engaging in regional discussions for a potential change in the endemic program.

4. *For Upper Columbia Steelhead: For the Winthrop NFH steelhead program, implement measures to transition to local broodstock and to manage the number of Winthrop NFH-produced steelhead on the spawning grounds. Such broodstock and adult escapement reform measures, including capital construction, would be identified through development of an updated HGMP and ESA consultation. Implementation of reform measures is contingent on a finding, in consultation with NOAA Fisheries, that the measures are biologically and economically feasible and effective. Implementation of reforms will be prioritized and sequenced.*

The Winthrop NFH is in the process of transitioning to local broodstock by collecting more brood from the Winthrop Basin via hatchery volunteers, and angling. The program began in 2008 with 25,000 juvenile steelhead from local broodstock, and has transitioned over time to 40,000 in 2009, 50,000 in 2010, 60,000 in 2011, and 100,000 in 2012. In 2013, enough local broodstock were collected to produce 81,000 smolts.

The USFWS continued with increasing efforts to manage returning Winthrop NFH-produced steelhead on the spawning grounds in 2013. All NFH-produced steelhead collected through hatchery volunteers or angling was removed, and Action Agencies increased efforts to remove more hatchery returns. These efforts were previously defined through a Value Planning process with Methow River Basin stakeholders to discuss local broodstock collection and possible hatchery reforms to more effectively manage returning adults. In 2013, per the recommendation from the team, Reclamation funded a scope of work within the funding agreement with USFWS to enable implementation of proposals to increase local broodstock collection, enhance returning hatchery fish management, and monitor these efforts.

Hatchery Strategy 2 (RPA Actions 41 – 42)

RPA Action 41 – Implement Safety Net Programs to Preserve Genetic Resources and Reduce Short-term Extinction Risk

The Action Agencies will continue to fund the operation of on-going "safety net" programs that are providing benefits to ESA-listed stocks at high risk of extinction by increasing genetic resources and will identify and plan for additional safety-net programs, as needed.

1. *For Snake River sockeye: Continue to fund the safety net program to achieve the interim goal of annual releases of 150,000 smolts while also continuing to implement other release strategies in nursery lakes such as fry and parr releases, eyed-egg incubation boxes, and adult releases for volitional spawning (see Action 42 for expansion of the program for building genetic resources and assisting in promoting recovery).*

BPA continued to fund BPA Project 2007-402-00 (Snake River Sockeye Salmon Captive Broodstock) to preserve this species. The program has produced hundreds of thousands of progeny from remnants of the wild stock. Since 1999, 4,826 adults from the program have returned to Redfish Lake in Idaho.

2. *For Snake River Spring/Summer Chinook: For the Tucannon River spring/summer Chinook safety-net supplementation program fund capital construction, operation and monitoring and evaluation costs to implement a program that builds genetic diversity using local broodstock and a sliding scale for managing the composition of natural spawners comprised of hatchery-origin fish.*

BPA Project 2000-019-00 (Tucannon River Spring Chinook Captive Brood), a one-generation safety-net program, was completed as planned in 2010. BPA, through the Lower Snake River Compensation Plan Direct Funding Agreement, continues to fund an integrated conservation hatchery program for Tucannon River spring/summer Chinook salmon with an annual production goal of 225,000 yearling smolts.

3. *For Snake River Spring/Summer Chinook: For the Upper Grande Ronde and Catherine Creek safety net supplementation programs fund capital construction, operation and monitoring and evaluation costs to implement a program that builds genetic diversity using local broodstock, and a sliding scale for managing the composition of natural spawners comprised of hatchery origin fish.*

BPA continued to fund this safety-net program through BPA Project 2007-404-00 (Spring Chinook Captive Propagation—Oregon). The Catherine Creek and Lostine River have met adult return goals of 150 spawning adults in nature, therefore these two safety-net programs have now been phased out. Adult return goals have not been met for the upper Grande Ronde stock; this safety-net work continues to be funded under this project.

4. *For Snake River Spring/Summer Chinook: Fund the Johnson Creek/South Fork Salmon River safety net supplementation program, as described in the existing Section 10 permit.*

BPA continued to fund implementation of this RPA action through BPA Project 1996-043-00 Johnson Creek Artificial Propagation Enhancement Project. This project releases up to 110,000 spring/summer Chinook salmon smolts annually in Johnson Creek, Idaho, as a safety net program. Only natural origin Johnson Creek fish are used for broodstock. Egg incubation and rearing occur at McCall Fish Hatchery.

5. *For Snake River Spring/Summer Chinook: Fund the experimental captive rearing program for East Fork and West Fork Yankee Fork Salmon River (until phased out by IDFG).*

All captive rearing in this experimental program has ended and the last remaining brood year (BY05) was released as mature adults to their natal waters in 2010. During 2013, the project continued to monitor the reproductive performance of captive-reared Chinook salmon released to spawn in natal streams through BPA Project No. 2007-403-00 Idaho Snake River Spring Chinook Captive Propagation.

6. *For Snake River Steelhead, as a project to benefit primarily B-Run steelhead, the Action*

Agencies will work with NOAA Fisheries to develop a trigger for future artificial propagation safety-net planning or to identify populations for immediate safety-net planning.

The Action Agencies continued to fund collection of B-Run steelhead population viability data in order to inform development of a trigger (see also RPA Subaction 50.5). The 2014 NOAA Fisheries Supplemental BiOp stated that calculation of average A- and B-run populations is no longer valid and that initial monitoring results indicated that some populations assumed to be either A-run or B-run may instead support a mixture of the two run times. Ongoing RME efforts and studies using adult PIT Tag detections should allow for more improved population specific assessments in NOAA Fisheries' next 5-year status review. At that time, NOAA Fisheries and the Action Agencies will review the development of a trigger, as described above.

RPA Action 42 – Implement Conservation Programs to Build Genetic Resources and Assist in Promoting Recovery

The Action Agencies will implement conservation programs for ESA-listed stocks where the programs assist in recovery.

1. *For Upper Columbia Spring Chinook: Fund reintroduction of spring Chinook salmon into the Okanogan Basin consistent with the Upper Columbia Salmon Recovery Plan including capital construction, operation and monitoring and evaluation costs to implement a transition to local broodstock and a sliding scale for managing the composition of natural spawners composed of hatchery origin fish. Re-introduction will be coordinated with the restoration and improvement of spring Chinook habitat in the Okanogan Basin and will be contingent on the availability of within ESU broodstock from the Methow Basin.*

Activities in 2013 for this RPA action included planning, writing an HGMP, coordination with NOAA Fisheries, and partner/public outreach. NOAA Fisheries continued to work on development of the NEPA and ESA processes associated with the HGMP which will result in their issuance of a Section 10(a)(1)(A) permit. The Section 10 permits will authorize the transfer of 200,000 Methow Composite spring Chinook juveniles/gametes from Winthrop

NFH to the Chief Joseph Hatchery Program at the Tonasket acclimation pond on the Okanogan River. The project sponsors anticipate getting the Permit by mid-September 2014.

2. *For Upper Columbia Steelhead: Fund a program to recondition natural origin kelts for the Entiat, Methow and Okanogan basin, including capital construction, operation and monitoring and evaluation costs.*

In 2013, 6 natural origin females were obtained from live spawning at Winthrop NFH, and another 1 natural origin female was collected from Little Bridge Creek/Twisp, one of the 3 temporary weirs operated for this purpose. Three of those survived to be released in the fall, and all 3 were re-maturing.

3. *For Upper Columbia Steelhead: Fund a program that builds genetic diversity using local broodstock and accelerates steelhead recovery in the Okanogan Basin as steelhead habitat is restored and improved, including capital construction, operation, and monitoring and evaluation costs.*

This action is being implemented by the Confederated Tribes of the Colville Reservation (CTCR) through BPA Project 2007-212-00 (Locally Adapted Okanogan Steelhead Broodstock). A contract to complete the Master Plan (Step 1 of the

NPCC's Three-Step Process) is in place through September 2014. A draft Master Plan has been presented by a consultant for CTCR review, but the plan will not move forward in

the three-step process until sufficient capital funds for operation and maintenance, and monitoring and evaluation can be confirmed.

4. *For Middle Columbia Steelhead: Fund a program to recondition natural origin kelts in the Yakima River basin including capital construction, implementation and monitoring and evaluation costs.*

BPA continued to fund this action through BPA Project 2007-401-00 (Kelt Reconditioning/Reproductive Success). The project collects steelhead kelts from Mid-Columbia DPS populations (e.g., Satus Creek, Toppenish Creek, and Naches River) at Prosser Dam on the Yakima River for reconditioning. In 2013, 224 long-term reconditioned steelhead kelts were released to the Yakima River for potential repeat spawning.

5. *For Snake River Steelhead: For the East Fork Salmon River, fund a small-scale program (no more than 50,000 smolts) including trapping locally returning steelhead in the East Fork Salmon River for broodstock, and follow BMPs for rearing, release, and adult management strategies. Fund capital construction, operation, and monitoring and evaluation costs to implement a program that builds genetic diversity using local broodstock and a sliding scale for managing the composition of natural spawners comprised of hatchery origin fish.*

In 2013, BPA continued to fund operation and maintenance for this action through the Lower Snake River Compensation Plan Direct Funding Agreement. An HGMP for this program was submitted to NOAA Fisheries in 2011. Site-specific application of BMPs will be defined during the ESA consultation, which is expected to be completed in 2014.

6. *For Snake River Spring/Summer Chinook Salmon: For the Lostine and Imnaha rivers, contingent on a NOAA Fisheries approved HGMP, fund these hatchery programs including capital construction, operation and monitoring and evaluation costs to implement supplementation programs using local broodstock and following a sliding scale for managing the composition of natural spawners composed of hatchery origin fish.*

HGMPs for the Lostine and Imnaha rivers supplementation programs were submitted to NOAA Fisheries for ESA consultation by the NPT and ODFW in May 2011. After review and discussions with NOAA Fisheries, and NOAA Fisheries sent "sufficiency" letters to NPT and ODFW stating the documents were sufficient to begin the consultation process. BPA must await NOAA Fisheries and FWS decisions with regard to ESA consultation, as well as other regulatory and compliance processes and potential updates to design and budget before making a financial commitment for construction of Northeast Oregon Hatchery Lostine and Imnaha spring/summer Chinook propagation facilities.

7. *For Snake River Sockeye: Fund further expansion of the sockeye program to increase total smolt releases to between 500,000 and 1 million fish.*

Construction of the Springfield Sockeye Hatchery was completed in 2013 and this new facility, combined with existing facilities, will enable the Snake River sockeye captive propagation program to achieve release goals consistent with this RPA Subaction. The construction and the operation and maintenance of the new hatchery is funded under BPA Project 2007-402-00 (Snake River Sockeye Captive Broodstock).

8. *For Snake River Sockeye: The Action Agencies will work with appropriate parties to investigate feasibility and potentially develop a plan for ground transport of adult sockeye from LGR Dam to Sawtooth Valley lakes or artificial propagation facilities.*

The Action Agencies, together with state and federal fishery agencies, implemented a pilot project in 2010 to evaluate feasibility of ground transport from the Lower Granite (LGR) Dam adult trap to IDFG’s Eagle Hatchery. Ground transport would be a feasible option if future river conditions and low return numbers warrant its use, and if NOAA Fisheries and the fishery co-managers, in coordination with the Action Agencies, decide to implement this option.

9. *For Columbia River Chum: Fund a hatchery program to re-introduce chum salmon in Duncan Creek including capital construction, implementation and monitoring and evaluation costs as long as NOAA Fisheries considers it beneficial to recovery and necessary to reduce extinction risk of the target population.*

This RPA Subaction has been incorporated into the RPA Subaction 42.10 below.

10. *For Columbia River Chum: Fund assessment of habitat potential, development of reintroduction strategies, and implementation of pilot supplementation projects in selected Lower Columbia River tributaries below Bonneville Dam.*

BPA continued to fund BPA Project 2008-710-00 which addresses chum reintroduction and habitat assessment actions associated with RPA Subactions 42.9 and 42.10 (BPA Project 2001-053-00, Reintroduction of Chum Salmon into Duncan Creek associated with RPA Subaction 42.9, was merged into BPA Project No. 2008-710-00 (Development of an Integrated Strategy for Chum Salmon Restoration in the Tributaries below Bonneville Dam). In 2013, this project continued to plan construction of spawning channels at Elochoman River and Skamokawa Creek, continued to collect chum salmon broodstock to be used for supplementing Duncan Creek and in artificial production programs, and continued monitoring and evaluation activities throughout the project area.

Predation Management Implementation Reports, RPA Actions 43 – 49

Table 18. Predation Management Strategy Reporting.

RPA Action No.	Action	Annual Progress Report
Predation Management Strategy 1		
43	Northern Pikeminnow Management Program (NPMP)	Annual progress reports will describe actions taken, including: Number of pikeminnow removals, Estimated reduction of juvenile salmon consumed, Average exploitation rate, and Results of periodic program evaluations (including updates on age restructuring and compensatory responses).

RPA Action No.	Action	Annual Progress Report
Predation Management Strategy 1		
44	Develop strategies to reduce non-indigenous fish	Beginning in 2010, annual progress reports will describe actions taken as a result of the workshop.
Predation Management Strategy 2		
45	Caspian Tern	Annual progress reports will describe actions taken toward the implementation of the Caspian Tern Management Plan.
46	Double-Crested Cormorant	Progress will be documented in the Action Agencies' annual implementation reports.
47	Inland Avian Predation	Annual progress reports will describe actions taken if warranted.
48	Other Avian Deterrent Actions	Annual deterrent actions will not be reported.
Predation Management Strategy 3		
49	Marine Mammal Control Measures	Not applicable.

Predation Management Strategy 1 (RPA Actions 43 – 44)

RPA Action 43 – Northern Pikeminnow Management Program

Action Agencies will continue to annually implement the base program and continue the general increase in the reward structure in the northern pikeminnow sport-reward fishery consistent with the increase starting in 2004. To better evaluate the effects of the NPMP, BPA will increase the number of tagged fish. The Action Agencies will evaluate the effectiveness of focused removals of pikeminnow at The Dalles and John Day dams and implement as warranted. Additional scoping of other mainstem dams will be based upon evaluations and adaptive management principles with input from NOAA Fisheries, and other regional fisheries managers.

The 2010 NOAA Fisheries Supplemental BiOp calls for BPA to increase tagging efforts to boost the number of tagged northern pikeminnow to better inform and increase the statistical significance of the biological evaluation of pikeminnow removals. The evaluation component of the NPMP uses tag recoveries in sponsored fisheries to quantitatively measure the benefit of removals within the year and cumulatively. Evaluation indicates that, as a result of the program, pikeminnow predation on juvenile salmon has declined 40 percent, saving 3 to 5 million juvenile salmon annually that would otherwise have been eaten by this predator. In 2013, researchers continued to maintain higher tagging effort. The general increase in tagging and resultant improvement in estimation is consistent with the 2008 BiOp and with recommendations of the Independent Scientific Advisory Board (ISAB) (Hankin and Richards 2000).

In 2013, the exploitation rate on northern pikeminnow was 10.8 percent, within the program objective based on the hypothesis that a 10 to 20 percent exploitation rate (on northern pikeminnow 9 inches or longer) could achieve up to a 50 percent reduction in predation mortality (Rieman and Beamesderfer 1990). The exploitation rate was based on a numerical catch of 164,196 from the sport reward and dam angling fisheries. As part of the ongoing annual evaluation of the NPMP, managers determined that continued implementation of the dam angling program component is warranted based on the 2013 catch of 4,039 from the forebays and tailraces of The Dalles and John Day Dams. This represents a 1.8-percent increase in catch from 2011.

RPA Action 44 – Develop Strategies to reduce non-indigenous Fish

The Action Agencies will work with NOAA Fisheries, states and tribes to coordinate to review, evaluate, and develop strategies to reduce non-indigenous piscivorous predation. The formation of a workshop will be an initial step in the process.

In 2013, the Action Agencies funded the last year of a study to address the prioritized non-native fish predation issues resulting from a series of workshops in 2009. The study objectives were to evaluate the physiological condition of smallmouth bass, walleye and channel catfish as they head into the over-wintering time-period, and to determine whether American shad, as a prey item, may be contributing to an enhanced physiological condition of non-native predators. Generally, the study concluded that predators that ate mostly fish were in better condition than those that ate mostly crustaceans or other items, and the notion that consumption of American shad may be significantly enhancing the condition of nonnative predators, and perhaps improving their overwinter survival and making them more effective predators on juvenile salmonids, was inconclusive.

Predation Management Strategy 2 (RPA Actions 45 – 48)

RPA Action 45 – Reduce Caspian Terns on East Sand Island in the Columbia River Estuary

The FCRPS Action Agencies will implement the Caspian Tern Management Plan. East Sand Island tern habitat will be reduced from 6.5 to 1.5 to 2 acres. It is predicted that the target acreage on East Sand Island will be achieved in approximately 2010.

In November 2006, the USFWS and Corps signed separate records of decision adopting the Caspian Tern Management Plan. NOAA Fisheries completed the BiOp for the proposed action on February 16, 2006. In 2008, the Corps began the implementation of the Caspian Tern Management Plan with the construction of a one-acre island in Fern Ridge Reservoir. Since then, the Corps has constructed a total of nine sites, but one site (Dutchy Island) was later removed. In 2013, a total of 7.8 acres was available to terns nesting in southern Oregon and northern California. These sites are listed in Table 18, below. Of these, all, except for Orem's Unit provided functional nesting habitat in 2013. Due to the number of alternative nest sites made available in interior Oregon and northern California, the area made available for tern nesting at East Sand Island was limited to 1.58 acres, the same as in 2012. Additional, alternative tern nesting habitat is being pursued in San Francisco Bay, California to allow a further reduction in the amount of nesting habitat made available on East Sand Island.

The Caspian tern colony on East Sand Island in the Columbia River estuary, the largest of its kind in the world, consisted of about 7,400 breeding pairs in 2013. This is an increase from the estimate of 6,400 pairs in 2012, and the first increase since the initiation of habitat reduction on East Sand Island in 2008, when the colony numbered about 10,000 breeding pairs. In 2013, the tern colony area was maintained at 1.58 acres; the same as 2012. This acreage is about 32 percent of the colony area made available in 2001-2007. This restriction resulted in an average nesting density of 1.17 nests/m², an increase from 1.06 nests/m² in 2012, and is the highest tern nesting density so far observed in the Columbia River estuary.

The average proportion of juvenile salmonids in the diet of Caspian terns during the 2013 nesting season was 32 percent, similar to 2009-2012. The estimated total smolt consumption by Caspian terns nesting at East Sand Island in 2013 was 4.6 million (95% c.i.

= 3.9 - 5.3 million), similar to 2012 and 2011. Tern predation rates were significantly higher on steelhead populations (8.6 – 12.5 percent, depending on the population) compared with other juvenile salmonid populations (0.6 – 1.4 percent, depending on the population).

Table 19. Status of Caspian Tern Nesting Islands for the 2013 Breeding Season (Roby et al. 2014).

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

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

RPA Action 46 – Double-Crested Cormorants

The FCRPS Action Agencies will develop a cormorant management plan encompassing additional research, development of a conceptual management plan, and implementation of warranted actions in the estuary.

East Sand Island is home to the largest double-crested cormorant colony in western North America and is the largest known breeding colony of the species world-wide. In 2013, the Action Agencies continued to evaluate potential management techniques to reduce losses of juvenile salmonids due to double-crested cormorant predation in the Columbia River estuary. Available nesting habitat was reduced to 4.5 acres using privacy fencing to isolate the nesting colony area. Human hazing was used to evaluate the efficacy of diverting the double-crested cormorants into the nesting colony. Both methods were successful at crowding double-crested cormorants into one contiguous colony area.

In 2013, the colony consisted of about 14,916 breeding pairs, the largest double-crested cormorant colony recorded on East Sand Island, and about 15 percent larger than was recorded in 2011-2012. Double-crested cormorants nesting at this colony consumed approximately 16.3 million juvenile salmonids (95 percent c.i. = 11.4 – 21.1 million), not significantly different from the number of smolts consumed by cormorants in 2012. The majority of their diet was comprised of sub-yearling Chinook salmon (about 11.4 million or 70 percent). Springs migrants (coho, yearling Chinook, sockeye salmon and steelhead) comprised about 4.8 million smolts (95 percent c.i. = 3.8 – 5.8 million) (Roby et al. 2014). For the past five years at East Sand Island, smolt consumption by double-crested cormorants has been significantly greater than that by Caspian terns. Adult and juvenile double-crested cormorants were banded with a field readable leg-band, and eighty-three adults were tagged with a satellite transmitter for the purpose of evaluating dispersal

patterns and potentially identifying alternative, preferred nest sites. Of those that dispersed, most remained in the Columbia River estuary, returning to East Sand Island; some were re-sighted or detected the Salish Sea/Puget Sound region, western British Columbia; outer Washington coast; interior Washington, Oregon coast; Willamette Valley; California coast; and interior California. Although there were no banded cormorants re-sighted in the Columbia Plateau region during 2013, one cormorant banded at the East Sand Island colony was re-sighted near Richland, Washington during the post-breeding season 2012.

In 2012, the USACE initiated development of a Draft Environmental Impact Statement (DEIS) for Double-Crested Cormorant Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary. Development of that DEIS continued through 2013. Various management actions being evaluated include (1) Non-Lethal: hazing and habitat modification; and (2) Lethal: take of eggs and/or adults. The DEIS is in-preparation, and a signed Record of Decision is anticipated by December 2014. Implementation of management actions is scheduled to begin in spring 2015.

RPA Action 47 – Inland Avian Predation

The FCRPS Action Agencies will develop an avian management plan (for Double-Crested Cormorants, Caspian Terns, and other avian species as determined by RM&E) for Corps-owned lands and associated shallow water habitat.

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

As a note, while early drafts of the IAPMP had originally included “dam-component” actions, regional discussions concluded that improvements to the Corps’ avian deterrent program will continue to be addressed through the Fish Passage Operations and Maintenance (FPOM) group, that they will be included in the Fish Passage Plan (FPP) per RPA Action 48, and that they will not be included within this habitat-based management plan developed for RPA Action 47.

RPA Action 48 – Other Avian Deterrent Actions

The Corps will continue to implement and improve avian deterrent programs at all lower Snake and Columbia River dams. This program will be coordinated through the Fish Passage Operations and Maintenance Team and included in the FPP.

Avian deterrent actions, such as long-term hazing and wire arrays, were implemented in consultation with FPOM and in accordance with the FPP (ACOE 2013b), as called for in RPA Action 48.

As in 2012, the Corps continued to coordinate with FPOM to standardize methods of counting and reporting the abundance and location of avian predators.

Predation Management Strategy 3 (RPA Action 49)

RPA Action 49 – Marine Mammal Control Measures

The Corps will install and improve, as needed, sea lion excluder gates at all main adult fish ladder entrances at Bonneville Dam annually. In addition, the Corps will continue to support land and water based harassment efforts by Oregon Department of Fish and Wildlife (ODFW), Washington Department of Fish and Wildlife (WDFW), and Columbia River Inter-Tribal Fish Commission (CRITFC) to keep sea lions away from the area immediately downstream of Bonneville Dam.

In 2013, the Corps implemented and evaluated a variety of sea lion deterrents, from physical barriers to non-lethal harassment (Stansell et al. 2013). Sea lion exclusion devices (SLEDs) were installed at Powerhouse 1 on January 31, at Cascades Island on February 4, at Powerhouse 2 south entrances on February 26, at Powerhouse 2 north entrances on March 13, and at the B-branch fishway on March 18. These dates were later than normal due to construction activities, which affected crane and staff availability. All SLEDs were removed on June 13. The SLEDs feature 15.38-inch (39.05-centimeter) gaps that are designed to allow fish passage. Floating orifice gates were also equipped with SLED-like barriers. Acoustic deterrent devices, which were used from 2006 through 2010, proved to be ineffective and are no longer deployed.

Since 2006, the Corps has contracted with the U.S. Department of Agriculture (USDA) Wildlife Services to harass sea lions away from fishways and other dam structures. Dam-based harassment by USDA agents began the first week in March and continued seven days per week through the end of May. Dam-based harassment involved a combination of acoustic, visual, and tactile non-lethal deterrents, including above-water pyrotechnics (cracker shells), and rubber buckshot from shotguns.

In part supported by BPA, CRITFC conducted boat-based harassment from the first week in March 2013 through mid-May. The Corps granted boats 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 second powerhouse (PH2) corner collector and smolt monitoring facility. Boat crews ceased use of seal bombs after adult salmonid passage exceeded 1,000 fish per day. Corps biologists coordinated with USDA agents and boat-based crew from CRITFC on all sea lion harassment activities at Bonneville Dam to ensure safety and increase the effectiveness of harassment efforts.

Physical barriers continued to be effective at keeping sea lions out of the fishways. Non-lethal hazing with pyrotechnics from both the dam face and by boat continued to have short-term impacts at driving or keeping some sea lions away from the fishways. However, some individual sea lions were not chased away at all and continued to hunt near the dam.

RME Implementation Reports, RPA Actions 50 – 73

The 2014 NOAA Fisheries Supplemental BiOp includes a large, comprehensive research and monitoring program covering status monitoring, action effectiveness research, and critical uncertainties research in the areas of fish population status, hydro, tributary habitat, estuary/ocean, harvest, hatchery, and predation. This program includes numerous individual projects, many of which have been collecting needed data for multiple years. The following sections list the individual projects that support each RME RPA subaction and

include computer links to find detailed, information through access to the Project technical and annual reports. These reports are the products of the contracted agency and/or tribal staff and do not necessarily represent the scientific or policy interpretation of any entity including the Action Agencies or NOAA Fisheries.

Summaries of the results of these research and monitoring efforts can be found in Section 1 of the APR under RME.

For all RPA RME actions in RPA Actions 50-73, individual BPA project information can be found at: <http://www.cbfish.org/BiologicalOpinionAction.mvc/Index/2013/BiOpRpaStatus>

A 2013 compilation of annual reports for these projects can be found at http://www.cbfish.org/Content/2013_Sponsors_RPA_Annual_Reports_Final.pdf

Table 20. RME Strategy Reporting.

RPA Action No.	Action	Annual Progress Report
RME Strategy 1		
50	Fish Population Status Monitoring	Status of project implementation (including project milestones) through December of the previous year for all actions identified in Attachment B.2.6-1 or subsequent implementation plans.
51	Collaboration Regarding Fish Population Status Monitoring	Status of project implementation (including project milestones) through December of the previous year for all actions identified in implementation plans.
RME Strategy 2		
52	Monitor and Evaluate Fish Performance within the FCRPS	Status of project implementation (including project milestones) through December of the previous year for all actions identified in implementation plans.
53	Monitor and Evaluate Migration Characteristics and River Condition	Status of project implementation (including project milestones) through December of the previous year for all actions identified in implementation plans.
54	Monitor and Evaluate Effects of Configuration and Operation Actions	Status of project implementation (including project milestones) through December of the previous year for all actions identified in implementation plans.
55	Investigate Hydro Critical Uncertainties and Investigate New Technologies	Status of project implementation (including project milestones) through December of the previous year for all actions identified in implementation plans.
RME Strategy 3		
56	Monitor and Evaluate Tributary Habitat Conditions and Limiting Factors	Status of project implementation (including project milestones) through December of the previous year for all actions identified in implementation plans.
57	Evaluate the Effectiveness of Tributary Habitat Actions	Status of project implementation (including project milestones) through December of the previous year for all actions identified in implementation plans.
RME Strategy 4		
58	Monitor and Evaluate Fish Performance in the Estuary and Plume	Status of project implementation (including project milestones) through December of the previous year for all actions identified in implementation plans.
59	Monitor and Evaluate Migration Characteristics and Estuary/Ocean Conditions	Status of project implementation (including project milestones) through December of the previous year for all actions identified in implementation plans. Tabulate the amount of absolute acreage by habitat type that is restored or protected every year. (Initiate in FY 2007–09 projects.) Report annually on indices of productivity for the estuary and ocean (i.e., Pacific Decadal Oscillation, primary productivity indices).

RPA Action No.	Action	Annual Progress Report
60	Monitor and Evaluate Habitat Actions in the Estuary	Status of project implementation (including project milestones) through December of the previous year for all actions identified in implementation plans.
61	Investigate Estuary/Ocean Critical Uncertainties	Status of project implementation (including project milestones) through December of the previous year for all actions identified in implementation plans.
RME Strategy 5		
62	Fund Selected Harvest Investigations	Status of project implementation (including project milestones) through December of the previous year for all actions identified in implementation plans.
RME Strategy 6		
63	Monitor Hatchery Effectiveness	Status of project implementation (including project milestones) through December of the previous year for all actions identified in implementation plans.
64	Investigate Hatchery Critical Uncertainties	Status of project implementation (including project milestones) through December of previous year for all actions identified in implementation plans.
65	Investigate Hatchery Critical Uncertainties	Status of project implementation (including project milestones) and analysis of new information through December of the previous year.
RME Strategy 7		
66	Monitor and Evaluate the Caspian Tern Population in the Columbia River Estuary	Status of project implementation (including project milestones) through December of the previous year for all actions (habitat actions are population response) identified in implementation plans.
67	Monitor and Evaluate the Double-Crested Cormorant Population in the Columbia River Estuary	Status of project implementation (including project milestones) through December of the previous year for all actions (habitat actions are population response) identified in implementation plans.
68	Monitor and Evaluate Inland Avian Predators	Status of project implementation (including project milestones) through December of the previous year for all actions (habitat actions are population response) identified in implementation plans.
69	Monitoring Related to Marine Mammal Predation	Status of project implementation (including project milestones) through December of the previous year for all actions (habitat actions are population response) identified in implementation plans.
70	Monitoring Related to Piscivorous (Fish) Predation	Status of project implementation (including project milestones) through December of the previous year for all actions identified in implementation plans.
RME Strategy 8		
71	Coordination	Status of coordination of RME projects through December of the previous year will be provided.
72	Data Management	Status of data management projects through December of the previous year will be provided.
RME Strategy 9		
73	Implementation and Compliance Monitoring	The Action Agencies will use the project-level detail contained in the Action Agencies' BA databases to track results and assess our progress in meeting programmatic-level performance targets. This performance tracking will be reported through annual progress reports and the 2013 and 2016 comprehensive reports.

RME Strategy 1 (RPA Actions 50–51)

RPA Action 50 – Fish Population Status Monitoring

The Action Agencies will enhance existing fish population status monitoring performed by fish

management agencies through the specific actions listed below. In addition, ancillary population status and trend information is being obtained through several ongoing habitat and hatchery improvement projects.

1. *Implement and maintain the Columbia River Basin passive integrated transponder (PIT)-Tag Information System (annually).*

BPA Project 1990-080-00 (Columbia Basin PIT Tag Information) covered the PTAGIS which is operated and maintained at <http://www.ptagis.org/ptagis>. PIT Tags are primarily used for hydro system and tributary survival assessments, as well as tributary assessments of population adult return abundance and diversity to help assess viable salmon population attributes of spawner abundance, adult productivity, spatial distribution, and diversity.

BPA Project 2003-017-00 (ISEMP) is a collaborative effort between the ISEMP project and Columbia River Basin PIT Tag Information project supported rapid reduction of PIT Tag data to support assessment of adult returns.

2. *Monitor adult returns at mainstem hydroelectric dams using both visual counts and the PIT Tag detection system (annually). (See Hydrosystem section).*

BPA Project 1987-127-00 (Smolt Monitoring Program) is a long-term effort involving multiple agencies to gather data on abundance, passage timing, system travel time and survival, and physical condition of smolts moving out of tributaries and past Snake and Columbia River hydro projects.

BPA Project 1989-107-00 (Statistical Support for Salmon) conducted additional tagging of hatchery populations to improve the resolution of watershed estimates of juvenile hydrosystem survival. The project has provided guidance and technical assistance in mark-recapture study design and data analysis to multiple tribal, state, and federal agencies.

BPA Project 1990-055-00 (Idaho Steelhead Monitoring and Evaluation Studies-ISMES)) conducted additional tagging of hatchery populations to improve the resolution of watershed estimates of juvenile hydrosystem survival and wild steelhead populations in the Clearwater River and upper reaches of the Snake River.

BPA Project 1991-029-00 (RME of emerging issues and measures to recover the Snake River fall Chinook salmon ESU) conducted wild and hatchery origin fall Chinook tagging with a special focus on investigating passage timing of the 'reservoir-type' yearling life history type and the 'ocean-type' subyearling migrants observed among fall Chinook above Lower Granite Dam.

BPA Project 1994-033-00 (Fish Passage Center) provided technical analysis, data summaries, graphic representations for the state, federal and tribal fishery managers' use in developing their recommendations for fish passage management to the federal operators and regulators and the National Marine Fisheries Service. The Fish Passage Center (FPC) designs and oversees the implementation and conducts the analysis of the

Smolt Monitoring Program (SMP), including the dissolved gas trauma monitoring, and distributes the data daily to public and private entities in the region.

BPA Project 1996-020-00 (Comparative Survival Study (CSS)) built a long-term database monitoring smolt-to-adult return rates and passage characteristics of

specific wild and hatchery groups of spring/summer Chinook and steelhead throughout the Columbia River Basin. Marked fish utilized in the CSS may be from groups PIT Tagged specifically for this program or may be from marked groups planned for other research studies.

BPA Project 2007-083-00 (Grande Ronde Supplementation Monitoring and Evaluation on Catherine Creek/upper Grande Ronde River) conducted additional tagging of hatchery populations to improve the resolution of watershed estimates of juvenile hydrosystem survival. The Umatilla Tribe provided additional spring Chinook tag groups in the upper Grande Ronde River and Catherine Creek.

BPA Project 2008-311-00 (Natural Production Management and Monitoring) conducted additional tagging of hatchery populations to improve the resolution of watershed estimates of juvenile hydrosystem survival and in Idaho tagged additional steelhead and spring Chinook in the Warm Springs River and Shitike Creek.

3. *Monitor juvenile fish migrations at mainstem hydroelectric dams using smolt monitoring and the PIT Tag detection system (annually). (See Hydrosystem section)*

This RPA calls for the continued acquisition of adult return information at key dams in the FCRPS. Visual counts occur at all sites. PIT Tagged fish need only be interrogated and logged at strategic dams in the FCRPS - currently Bonneville, McNary and Lower Granite dams.

BPA Project 2005-002-00 (Lower Granite Dam Adult Trap Operations) utilized an adult trap at Lower Granite Dam for broodstock collection, sampling, genetic stock identification (GSI), and PIT Tag status monitoring of wild adult steelhead and wild adult Chinook. The Corps selected the Dalles Dam for installation of an adult PIT Tag detection system to further monitoring.

In 2013, the Corps implemented its adult fish count program as described in the Fish Passage Plan (ACOE 2013). Results are available in the 2013 Annual Fish Passage Report: Columbia and Snake Rivers (ACOE 2014).

4. *Fund status and trend monitoring as a component of the pilot studies in the Wenatchee, Methow, and Entiat river basins in the Upper Columbia River, the Lemhi and South Fork Salmon river basins, and the John Day River Basin to further advance the methods and information needed for assessing the status of fish populations. (Initiate in FY 2007-2009 Project Funding, review and modify annually to ensure that these projects continue to provide a means of evaluating the effectiveness of tributary mitigation actions).*

BPA Project 1987-127-00 (Smolt Monitoring by Non-Federal Entities) implemented tagging of fish which are used and assessed primarily in the ISEMP project. The SMP provides data on movement of salmonid smolts out of major drainages and past the series of dams on the Snake and Columbia rivers. Indices of migration strength and migration timing are provided for the run-at-large at key monitoring sites. In addition, marked smolts from hatcheries, traps, and dams provide measures of smolt speed and in-river survival through key reaches.

BPA Project 1991-073-00 (Idaho Natural Production Monitoring and Evaluation) monitored and evaluated the status of wild Snake River spring-summer Chinook salmon and summer steelhead populations in the Salmon and Clearwater river subbasins, including the Lemhi and South Fork Salmon rivers. The Idaho Natural Production Monitoring and Evaluation Project study is to determine effectiveness of habitat mitigation for steelhead and spring/summer Chinook in Idaho. This project

assesses population characteristics, survival, and productivity.

BPA Project 1998-016-00 (Escapement and Productivity of Spring Chinook and Steelhead) provided basin-wide status and trend data for anadromous salmonids in the John Day River Basin. To accomplish this, researchers estimate out-migrant abundance of summer steelhead, physical characteristics of outmigrant salmonids, SARs for summer steelhead, summer steelhead life-history patterns, and productivity of summer steelhead populations.

BPA Project 2002-060-00 (Nez Perce Harvest Monitoring on Snake and Clearwater Rivers) provided ancillary information, specifically Adult Harvest information, which is used in adult run reconstruction to support Adult-to-Adult productivity. The primary objective of the Nez Perce Harvest Monitoring Project is to develop and implement a biologically sound anadromous fish harvest monitoring program through a step-wise harvest planning and implementation approach to specific fisheries.

BPA Project 2003-017-00 (ISEMP) implemented both status and trend monitoring (fish and habitat) and watershed-level action effectiveness monitoring in five IMWs throughout the Columbia River Basin. The IMWs continued in the Entiat River, Bridge Creek, and Lemhi River watersheds, while status and trend monitoring is implemented in the Wenatchee, John Day, and Lemhi river watersheds.

BPA Project 2010-034-00 (Upper Columbia Spring Chinook and Steelhead Juvenile and Adult Abundance, Productivity and Spatial Structure Monitoring) evaluated precision and accuracy of the smolt monitoring methodology for both steelhead and spring Chinook; estimated the proportion of hatchery steelhead in each primary population; estimated the precision of redd counts for both steelhead and spring Chinook; and evaluated the accuracy of the steelhead spawning ground survey design.

BPA Project 2010-036-00 (Lower Columbia Coded Wire Tag (CWT) Recovery Project) provided ancillary information, specifically adult harvest information, which is used in adult run reconstruction to support Adult-to-Adult productivity which may be to support Pilot studies in the upper Columbia and Salmon MPGs. Washington's current tag recovery program in the lower Columbia River is centered on the recovery of CWTs from fisheries and escapement sampling, and development of escapement estimates primarily for Chinook salmon.

5. *Provide additional status monitoring to ensure a majority of Snake River B-Run steelhead populations are being monitored for population productivity and abundance. (Initiate by FY 2009, then annually.)*

BPA implemented 13 projects to support this RPA. In addition NOAA Fisheries supported the Potlatch River as an IMW with fish-in fish-out intensive monitoring efforts.

BPA Project 1983-350-03 (Nez Perce Tribal Hatchery Monitoring and Evaluation) monitored and evaluated hatchery and natural fish through PIT Tagging, weir

operation and/or spawning ground surveys, screw trapping, habitat surveys, genetic analysis, and harvest monitoring.

BPA Project 1989-098-00 (The Salmon Studies in Idaho Rivers- IDFG) supported smolt trap infrastructure used to monitor B-Run Steelhead in coordination with the

ISEMP project.

BPA Project 1990-055-00 (ISMES) continued to operate temporary weirs to estimate escapement in Fish Creek (Lochsa River), Rapid River (Little Salmon River), and Big Creek (lower Middle Fork Salmon River). Wild fish were sampled further; scales were collected, and a small portion of the anal fin was removed for a genetics tissue sample.

BPA Project 1991-073-00 (Idaho Natural Production Monitoring and Evaluation Project) is a long-term monitoring and research project to determine the effectiveness of habitat mitigation for Idaho steelhead and spring/summer Chinook through assessments of population characteristics, survival, and productivity.

BPA Project 2003-017-00 (ISEMP) implemented both status and trend monitoring (fish and habitat) and watershed-level action effectiveness monitoring in five IMWs throughout the Columbia River Basin. The IMWs continued in the Entiat River, Bridge Creek, and Lemhi River watersheds, while status and trend monitoring is implemented in the Wenatchee, John Day, and Lemhi river watersheds.

BPA Project 2005-002-00 (Lower Granite Dam Adult Trap Operations) supported PIT Tagging of adult steelhead returns for adult escapement assessments and parental-based tagging for GSI. Ongoing discussions with NOAA Fisheries, the Action Agencies and the sponsors are underway to ensure increased trapping does not increase ESA take and that the study design for representational marking is not compromised.

BPA Project 2009-005-00 (Influence of Environment and Landscape on Salmonid Genetics) supported single nucleotide polymorphism genetic analysis of steelhead samples from other projects. The project focuses on evaluation of thermal adaptation, smoltification, and summaries for ongoing and future work on several traits of interest including disease resistance, run timing, heritability of age-at-maturity, and ongoing work for thermal adaptation. The most applicable component of the study for B-Run steelhead is genetic associations to run timing and heritability of age-at-maturity.

BPA Project 2010-026-00 (Chinook and Steelhead Genotyping for GSI at Lower Granite Dam) conducted the evaluation and maintenance of single nucleotide polymorphism panels for GSI in the Snake River Basin. Summarized efforts to update and maintain genetic baselines for both steelhead and Chinook salmon in the basin to monitor genetic diversity and for use as a reference for GSI. In addition, the project addresses the use of GSI to estimate proportions, abundance, and biological parameters for wild stocks (both juveniles and adults) at Lower Granite Dam.

BPA Project 2010-031-00 (Snake River Chinook and Steelhead Parental Based Tagging) continued development and evaluation of a new genetic technology called Parentage Based Tagging (PBT). PBT can serve as a versatile tool for the genetic tagging steelhead and Chinook salmon in the Snake River Basin. To support this RPA, Objective 2, creation of genetic parental databases, serves as a major component of the RPA strategy.

BPA Project 2010-038-00 (Lolo Creek Permanent Weir Construction) continued the design phase and underwent National Environmental Policy Act (NEPA) review prior to weir installation in 2013. This weir is needed to support high precision monitoring

requirements for Lolo Creek fish-in and fish-out assessments under RPA Subaction 50.6 and the Adaptive Management Implementation Plan (AMIP), but will also support improved monitoring of B-Run Steelhead under project 1983-350-03.

BPA Project 2010-057-00 (B-Run steelhead supplementation effectiveness research) supported additional marking and tagging of fish and supported infrastructure used to monitor B-Run Steelhead.

6. *Review and modify existing Action Agencies' fish population status monitoring projects to improve their compliance with regional standards and protocols, and ensure they are prioritized and effectively focused on critical performance measures and populations.*

BPA Project 1983-350-03 (Nez Perce Tribal Hatchery Monitoring and Evaluation) monitored and evaluated hatchery and natural fish through PIT Tagging, weir operation and/or spawning ground surveys, screw trapping, habitat surveys, genetic analysis, and harvest monitoring.

BPA Project 1987-127-00 (Smolt Monitoring by Non-Federal Entities) implemented tagging of fish which are used and assessed primarily in the ISEMP project. The SMP provides data on movement of salmonid smolts out of major drainages and past the series of dams on the Snake and Columbia rivers. Indices of migration strength and migration timing are provided for the run-at-large at key monitoring sites. In addition, marked smolts from hatcheries, traps, and dams provide measures of smolt speed and in-river survival through key reaches.

BPA Project 1988-022-00 (Umatilla Fish Passage Operations) addressed inadequate flow and migration conditions by constructing fish passage facilities, initiating a trap and haul program, and implementing the Umatilla Basin Project flow enhancement effort. The Fish Passage Operations Project objective is to increase adult and juvenile migrant survival in the Umatilla Basin.

BPA Project 1988-053-03 (Hood River Production Monitoring and Evaluation-ODFW) implemented, monitored, and evaluated actions in the Hood River Master Plans for consistency with Hood River Production Plan (HRPP) goals.

BPA Project 1988-053-04 (Hood River Production Monitoring and Evaluation-ODFW) monitored and evaluated actions taken to re-establish spring Chinook salmon, and improve wild production of summer and winter steelhead in the Hood River subbasin. Data will be used to develop, and refine, management objectives for the HRPP.

BPA Project 1988-053-08 (Hood River Production Operation and Maintenance and Powerdale) funded for the operation and maintenance of the Powerdale Dam Fish Trap, rearing of Hood River origin steelhead at Oak Springs Hatchery, and rearing of spring Chinook at Pelton Ladder associated with the HRPP.

BPA Project 1989-024-01 (Evaluate Umatilla Juvenile Salmon and Steelhead Outmigration) was requested by the Oregon Department of Fish and Wildlife (ODFW) and the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) based on both a local and regional high priority need for information on life history characteristics, survival, and success of hatchery- and naturally-reared salmon and steelhead in the Umatilla River and provides estimates of smolt abundance, migration timing and survival, life history characteristics and productivity status and trends for all anadromous salmonid species in the Umatilla River basin.

BPA Project 1989-098-00 (Salmon Studies in Idaho Rivers-IDFG) helped determine the utility of supplementation as a potential recovery tool for imperiled stocks of spring and summer Chinook salmon in Idaho. The goals are to assess the use of hatchery Chinook salmon to restore or augment natural populations, and to evaluate the effects of supplementation on the survival and fitness of existing natural populations.

BPA Project 1990-005-00 (Umatilla Hatchery Monitoring and Evaluation) funds the Umatilla Fish Hatchery which was constructed to reintroduce spring and fall Chinook salmon and supplement summer steelhead in the Umatilla River. The Umatilla Hatchery

Monitoring and Evaluation project began in 1991 to evaluate hatchery rearing techniques and juvenile and adult production goals.

BPA Project 1990-005-01 (Umatilla Basin natural Production Monitoring and Evaluation) the Umatilla Basin Natural Production Monitoring and Evaluation Project provided information to tribal, state and federal fisheries managers by monitoring the status and trends in the abundance, distribution, movement and survival of summer steelhead and spring Chinook salmon during adult migration, spawning, rearing and juvenile migration in the Umatilla River Drainage. BPA evaluated these trends in relation to environmental, ecological, and anthropogenic factors.

BPA Project 1990-055-00 (Idaho Steelhead Monitoring and Evaluation Studies) continued to operate temporary weirs to estimate escapement in Fish Creek (Lochsa River), Rapid River (Little Salmon River), and Big Creek (lower Middle Fork Salmon River). Wild fish were sampled further; scales were collected, and a small portion of the anal fin was removed for a genetics tissue sample.

BPA Project 1991-028-00 (PIT Tagging Wild Chinook) assessed the migrational characteristics and estimate parr-to-smolt survival for Snake River wild spring/summer Chinook salmon smolts at Lower Granite Dam. Characterize parr and smolt survival and movement out of natal rearing areas of selected streams and examine the relationships between fish movement, environmental conditions within the streams, and weather and climate data.

BPA Project 1991-073-00 (Idaho Natural Production Monitoring and Evaluation) is a long-term research project that originated in the 1980s to determine effectiveness of habitat mitigation for steelhead and spring/summer Chinook in Idaho. This project assessed population characteristics, survival, and productivity in 2013.

BPA Project 1992-026-04 (Grand Ronde Early Life History of Spring Chinook and Steelhead) investigated the critical habitat, abundance, migration patterns, survival, and alternate life history strategies exhibited by spring Chinook salmon and summer steelhead juveniles from distinct populations in the Grande Ronde River and Imnaha River subbasins. This project provides information on abundance of spring Chinook salmon and steelhead parr and estimated for egg-to-parr and parr-to-smolt survival for spring Chinook salmon and parr-to-smolt survival for steelhead, and assessed stream health in selected study streams.

BPA Project 1995-063-25 (Yakima River Monitoring and Evaluation-Yakima/Klickitat Fisheries Project) monitored and evaluated activities for the Yakima River Subbasin assigned to the Yakama Nation Fisheries staff. This monitoring and evaluation project continued efforts to gather baseline information on habitat quantity and

quality, and demographics, life history and abundance of Klickitat spring Chinook, steelhead, and other species of interest. Methods of detecting indices of increasing natural production for these stocks were developed, as well as methods of detecting a realized increase in natural production.

BPA Project 1995-063-35 (Klickitat River Monitoring and Evaluation-Yakima/Klickitat Fisheries Project) continues efforts to gather baseline information on habitat quantity and quality, and demographics, life history and abundance of Klickitat spring Chinook, steelhead, and other species of interest. Methods of detecting indices of increasing natural production for these stocks were developed, as well as methods of detecting a realized increase in natural production.

BPA Project 1996-019-00 (Data Access in Real Time) supported multiple populations of this RPA through compilation of data. They also create ad host software to analyze PIT Tag Data systems. Without this customized software, sponsors would have a difficult time synthesizing PIT Tag data for adult escapement.

BPA Project 1996-035-01 (Yakama Reservation Watershed Project) conducted comprehensive watershed restoration activities including headwater wetland rehabilitation; adult and juvenile fish passage restoration; stream channel and riparian area restoration; minimum instream flow implementation and modification of irrigation water sources and uses; physical monitoring that includes precipitation, groundwater, discharge from streams, canals and drains, temperature, water quality, fish habitat structure and quality according to accepted protocols; and biological monitoring including spawning ground surveys, snorkel surveys and smolt trapping.

BPA Project 1996-043-00 (Johnson Creek Artificial Propagation Enhancement) continued the small-scale supplementation initiative integrated with a monitoring and evaluation program that was designed to increase survival of a weak but recoverable spawning aggregate of summer Chinook salmon.

BPA Project 1997-015-01 (Imnaha River Smolt Monitoring) provided the FPC's SMP with tributary specific emigration data from the Imnaha River. It continues to collect a time series of Chinook salmon and steelhead data.

BPA Project 1998-007-02 (Grand Ronde Supplementation Operation and Maintenance, and Monitoring and Evaluation on Lostine River) utilizes supplementation with conventional and captive brood production to prevent extirpation and begin rebuilding of ESA listed spring Chinook.

BPA Project 1998-007-03 (Grand Ronde Supplementation Operation and Maintenance on Catherine Creek/Upper Grande Ronde River) preserves the genetic variability and enhance the population size of the depressed spring Chinook salmon populations in Catherine Creek and the Upper Grande Ronde River using a hatchery program based on the indigenous stock.

BPA Project 1998-016-00 (Escapement and Productivity of Spring Chinook and Steelhead) provided basin-wide status and trend data for anadromous salmonids in the John Day River Basin. To accomplish this, researchers estimated out-migrant abundance of summer steelhead, physical characteristics of outmigrant salmonids, SARs for summer steelhead, summer steelhead life-history patterns, and productivity of summer steelhead populations.

BPA Project 1998-019-00 (Wind River Watershed) is a collaborative effort to restore

wild steelhead in the Wind River. The four agencies forming the nucleus of this partnership include the USFS, WDFW, USGS Biological Research Division, and Underwood Conservation District. This partnership, with support from BPA, continues to conduct important habitat, research, monitoring and coordination activities across the subbasin working at multiple levels to identify and characterize key limiting habitat factors in the Wind River, to restore degraded habitats and watershed processes, to measure, track and document fish populations, life histories, and interactions, and to share information across agency and non-agency boundaries.

BPA Project 1999-020-00 (Analyze persistence and Dynamics in Chinook Redds) addressed at least three critical needs identified in Regional Program documents: (1) the need for long-term information to assess trends in wild Chinook salmon populations; (2) the need for evaluation of broad scale population sampling and inventory methods; and (3) the need for analysis of the spatial structure of wild Chinook salmon populations.

BPA Project 2002-032-00 (Snake River Fall Chinook Salmon Life History Investigations) objectives are: increase the understanding of how reservoir water temperature, reservoir water velocity, and migration timing affect juvenile fall Chinook salmon behavior, survival, and life history; to increase the understanding of when to spill water and transport fish in the Snake River to increase juvenile fall Chinook salmon survival; and decrease the uncertainty in how the reservoir life history affects estimates of smolt-to-adult return rates of Snake River fall Chinook salmon.

BPA Project 2002-053-00 (Asotin Creek salmon Population Assessment) assessed the status of anadromous salmonid populations in the Asotin Creek watershed above George Creek. It is also estimated the abundance, productivity, survival rates, and temporal and spatial distribution of steelhead/rainbow trout (*Oncorhynchus mykiss*) and Chinook salmon (*O. tshawytscha*).

BPA Project 2002-060-00 (Nez Perce Harvest Monitoring on Snake and Clearwater Rivers) provided ancillary information, specifically Adult Harvest information, which is used in adult run reconstruction to support Adult-to-Adult productivity. The primary objective of the Nez Perce Harvest Monitoring Project is to develop and implement a biologically sound anadromous fish harvest monitoring program through a step-wise harvest planning and implementation approach to specific fisheries.

BPA Project 2003-017-00 (ISEMP) implemented both status and trend monitoring (fish and habitat) and watershed-level action effectiveness monitoring in five IMWs throughout the Columbia River Basin. The IMWs continued in the Entiat River, Bridge Creek, and Lemhi River watersheds.

BPA Project 2003-022-00 (Okanogan Basin Monitoring and Evaluation Program) developed in consultation with Canadian officials, various federal, state and tribal monitoring programs and experts at the local level, supported decision-making and provided the necessary implementation and resource management infrastructure for the Upper Columbia, the Colville Tribes, the public, and our resource management partners.

BPA Project 2007-083-00 (Grand Ronde Supplementation Monitoring and Evaluation on Catherine Creek/Upper Grande Ronde River) monitored and evaluated the effectiveness of supplementation in recovering spring Chinook salmon populations in

the upper Grande Ronde River and Catherine Creek.

BPA Project 2007-402-00 (Snake River Sockeye Captive Propagation) recovery efforts are collaborative in nature and directly involve the Idaho Department of Fish and Game (IDFG), the National Marine Fisheries Service (NOAA Fisheries), the Shoshone-Bannock Tribes, the Oregon Department of Fish and Wildlife (ODFW), and the University of Idaho. Efforts in 2013 included: fish culture, genetic support, maintenance of captive broodstocks, broodstock rearing and research, habitat limnological research and monitoring and evaluation.

BPA Project 2009-004-00 (Monitoring Recovery Trends in Key Spring Chinook Habitat Variable and Validation of Population Viability Indicators) focused on monitoring recovery trend through identifying areas that have depressed populations creating a baseline and future modeling.

BPA Project 2010-028-00 (Estimate Adult Steelhead Abundance in Small Streams Associated with Tucannon & Asotin Populations) continued to assess adult abundance associated with Tucannon and Asotin steelhead populations.

BPA Project 2010-030-00 (Viable Salmonid Population Estimates for Yakima Steelhead MPG) improved tracking of the Upper Yakima and Naches population distributions is the primary focus of this objective.

BPA Project 2010-032-00 (Imnaha River Steelhead Status Monitoring) quantified adult steelhead escapement into the Imnaha River Subbasin and described the population's spatial distribution within the subbasin. A properly monitored Imnaha steelhead population will contribute towards understanding the status and viability of the entire Snake River ESU and informed management decisions.

BPA Project 2010-034-00 (Upper Columbia Spring Chinook and Steelhead Juvenile and Adult Abundance, Productivity and Spatial Structure Monitoring) objectives are: (1) evaluate precision and accuracy of the smolt monitoring methodology for both steelhead and spring Chinook; (2) estimate the proportion of hatchery steelhead in each primary population; (3) estimate the precision of redd counts for both steelhead and spring Chinook; (4) and evaluate the accuracy of the steelhead spawning ground survey design.

BPA Project 2010-035-00 (Abundance, Productivity and Life History of Fifteen Mile Creek Winter Steelhead) funded ODFW to establish a comprehensive monitoring and evaluation program for abundance, productivity, and life history of steelhead in the Fifteen Mile Creek population, which is ESA listed as a component of the Mid-C steelhead DPS.

BPA Project 2010-038-00 (Lolo Creek Permanent Weir Construction) continued the design phase and underwent National Environmental Policy Act (NEPA) review prior to weir installation in 2013. This weir is needed to support high precision monitoring requirements for Lolo Creek fish-in and fish-out assessments under RPA Subaction 50.6 and the Adaptive Management Implementation Plan (AMIP), but will also support improved monitoring of B-Run Steelhead under BPA Project 1983-350-03.

BPA Project 2010-042-00 (Tucannon Expanded PIT Tagging) increased the detection of PIT Tagged steelhead (Snake River steelhead DPS) and spring Chinook salmon (Snake River spring/summer Chinook ESU) that enter the river upon return as adults.

7. *Fund marking of hatchery releases from Action Agencies funded facilities to enable monitoring of hatchery-origin fish in natural spawning areas and the assessment of status of wild populations (annually).*

In 2013, BPA continued to support and fund a policy of 100 percent mark of all hatchery fish to meet viable salmonid population, hatchery, and habitat action effectiveness evaluation needs identified under several RPAs and regional recovery plans. However, while mark rates achieve this goal for the majority of hatcheries, there are some programs that still do not mark 100 percent of their fish releases.

BPA continued to work with regional agencies on the importance of high, known mark rates, and to require better reporting of hatchery fish mark rates to better assess where there may be deficiencies or issues that need to be addressed.

8. *Report available information on population viability metrics in annual and comprehensive evaluation reports. (Initiate in FY 2008).*

The Action Agencies continued to support the reporting of available population viability metrics through StreamNet project data collection and transfer to the NOAA Fisheries Salmon Population Summary (SPS) database to facilitate population viability assessments

(<http://q.streamnet.org/Request.cfm?cmd=BuildPicklist&NewQuery=BuildCriteria&PicklistItem=DataCategory>). In addition to the StreamNet project and the multiple monitoring projects listed above under the RPA 50 subactions that support population viability assessments, BPA participated and supported the Coordinated Assessments (CA) Project. The CA project is a collaborative effort working with fishery management co-managers and NOAA Fisheries to develop data exchange templates to facilitate assessments for viable salmonid population indicators such as adult spawner abundance, spawner to adult ratios, and recruit per spawner relationships for ESA listed populations. BPA also developed guidelines and templates for RME reporting to facilitate more consistent and timely reporting of monitoring results and actively supported the development and required use of a monitoring protocol documentation tool and other coordination tools under the Pacific Northwest Aquatic Monitoring Partnership to help further advance coordination, data sharing, evaluation, and reporting of population viability metrics.

RPA Action 51 – Collaboration Regarding Fish Population Status Monitoring

The Action Agencies will enhance existing fish populations status monitoring performed by fish management agencies through the following collaboration commitments:

1. *Support the coordination, data management, and annual synthesis of fish population metrics through Regional Data Repositories and reports (Annually).*

BPA Project 1988-108-04 (StreamNet – Coordinated Information System/Northwest Environmental Database [NED] managed by PNAMP staff at the USGS continued to support the implementation of the Coordinated Assessments Projects through PNAMP, CBFWA, and StreamNet to develop standard data exchange templates across the Northwest for the indicators of adult spawner abundance and juvenile salmonid out-migrant production.

BPA Project 1989-098-00 (Salmon Studies in Idaho Rivers-IDFG) helped determine the utility of supplementation as a potential recovery tool for imperiled stocks of spring and summer Chinook salmon in Idaho. Our goals are to assess the use of

hatchery Chinook salmon to restore or augment natural populations, and to evaluate the effects of supplementation on the survival and fitness of existing natural populations.

BPA Project 1994-033-00 (Fish Passage Center) provided technical analysis, data summaries, graphic representations for the state, federal and tribal fishery managers' use in developing their recommendations for fish passage management to the federal operators and regulators and NOAA Fisheries. The FPC designs and oversees the implementation and conducts the analysis of the SMP, including the dissolved gas trauma monitoring, and distributes the data daily to public and private entities in the region.

BPA Project 1996-019-00 (Data Access in Real Time (DART)) supported ISEMP and PTAGIS in development of software to rapidly assess PIT Tag array detections for population adult escapement which could be supported across the basin.

BPA Project 1996-043-00 (Johnson Creek Artificial Propagation Enhancement) has been on-going since 1996. The project evaluated the life cycle of natural- and hatchery-origin supplementation spring/summer Chinook salmon from Johnson Creek (part of the Snake River spring/summer Chinook ESU). Key performance measures associated with abundance, survival-productivity, distribution, genetics, life history, habitat, and in-hatchery metrics were quantified.

BPA Project 1997-030-00 (Chinook Salmon Adult Abundance Monitoring) monitored escapement of natural-origin spring/summer Chinook salmon (Snake River spring/summer Chinook ESU) escapement was estimated using dual frequency identification sonar (DIDSON) technology. Validation monitoring of DIDSON target counts with underwater optical cameras occurred for the purpose of species identification.

BPA Project 1999-020-00 (Analyze persistence and Dynamics in Chinook Redds) research addressed at least three critical needs identified in Regional Program documents: (1) the need for long-term information to assess trends in wild Chinook salmon populations; (2) the need for evaluation of broad scale population sampling and inventory methods; and (3) the need for analysis of the spatial structure of wild Chinook salmon populations.

BPA Project 2003-017-00 (ISEMP) implemented both status and trend monitoring (fish and habitat) and watershed-level action effectiveness monitoring in five IMWs throughout the Columbia River Basin. The IMWs continued in the Entiat River, Bridge Creek, and Lemhi River watersheds, while status and trend monitoring is implemented in the Wenatchee, John Day, and Lemhi river watersheds.

BPA Project 2004-002-00 (Pacific Northwest Aquatic Monitoring Program Coordination) charged the Pacific Northwest Aquatic Monitoring Program with providing a forum for coordination of aquatic monitoring efforts in the region to promote consistency in monitoring approaches and protocols; follow a scientific foundation; support monitoring policy and management objectives; and collect and present information in a manner that can be shared.

BPA Project 2007-407-00 (Upper Snake River Tribe Coordination) funded the Upper Snake River Tribe to pursue, promote and initiate efforts to restore the Upper Snake River Basin, its affected tributaries, and lands to a natural condition.

BPA Project 2008-507-00 (CRITFC's Tribal Data Network Accord Project) demonstrated implementation of coordination and standardization tools through evaluation and application of handheld technologies for data capture (e.g., the Digital Pen).

BPA Project 2010-036-00 (Lower Columbia Coded Wire Tag (CWT) Recovery Project) provided ancillary information, specifically adult harvest information, which was used in adult run reconstruction to support Adult-to-Adult productivity which supported Pilot studies in the upper Columbia and Salmon MPGs. Washington's tag recovery program in the lower Columbia River centered on the recovery of CWTs from fisheries and escapement sampling, and development of escapement estimates primarily for Chinook salmon.

2. *Facilitate and participate in an ongoing collaboration process to develop a regional strategy for status and trend monitoring for key ESA fish populations. (Initiate in FY 2008).*

BPA Project 1989-107-00 (Statistical Support for Salmon) funded Columbia Basin Research to support the Survival Under Proportional Hazards program, which estimated survival using release-recapture data as a function of environmental and experimental effects. Columbia Basin Research also studied the relationship of climate and snowpack to stream temperatures in a series of Columbia region tributaries (<http://www.cbr.washington.edu/data/Streams/data.html>).

BPA Project 2004-002-00 (Pacific Northwest Aquatic Monitoring Program Coordination) funded the Pacific Northwest Aquatic Monitoring Program to provide a forum for coordination of aquatic monitoring efforts in the region to promote consistency in monitoring approaches and protocols; follow a scientific foundation; support monitoring policy and management objectives; and collect and present information in a manner that can be shared.

BPA Project 2010-026-00 (Chinook and Steelhead Genotyping for GSI at Lower Granite Dam) conducted the evaluation and maintenance of single nucleotide polymorphism panels for GSI in the Snake River Basin. Summarized efforts to update and maintain genetic baselines for both steelhead and Chinook salmon in the basin to monitor genetic diversity and for use as a reference for GSI. In addition, the project addresses the use of GSI to estimate proportions, abundance, and biological parameters for wild stocks (both juveniles and adults) at Lower Granite Dam.

3. *Provide cost-shared funding support and staff participation in regional coordination forums such as the Pacific Northwest Aquatic Monitoring Partnership fish population monitoring workgroup and the Northwest Environmental Data Network to advance regional standards and coordination for more efficient and robust monitoring and information management (annually).*

BPA Project 1989-107-00 (Statistical Support for Salmon) Columbia Basin Research continued to support the Statistical Support for Salmon program, which estimated survival using release-recapture data as a function of environmental and experimental effects.

BPA Project 1994-033-00 (Fish Passage Center) provided technical analysis, data summaries, graphic representations for the state, federal and tribal fishery managers' use in developing their recommendations for fish passage management to the federal operators and regulators and NOAA Fisheries. The FPC designs and oversees the implementation and conducts the analysis of the SMP, including the

dissolved gas trauma monitoring, and distributes the data daily to public and private entities in the region.

BPA Project 1996-043-00 (Johnson Creek Artificial Propagation Enhancement) continued the small-scale supplementation initiative integrated with a monitoring and evaluation program in 2013 that was designed to increase survival of a weak but recoverable spawning aggregate of summer Chinook salmon.

BPA Project 2004-002-00 (Pacific Northwest Aquatic Monitoring Program Coordination) funds the Pacific Northwest Aquatic Monitoring Program to provide a forum for coordination of aquatic monitoring efforts in the region to promote consistency in monitoring approaches and protocols; follow a scientific foundation; support monitoring policy and management objectives; and collect and present information in a manner that can be shared.

RME Strategy 2 (RPA Actions 52-55)

RPA Action 52 – Monitor and Evaluate Fish Performance within the FCRPS

The Action Agencies will monitor the following biological responses and/or environmental attributes involved in passage through the hydrosystem, and report these estimates on an annual basis:

1. *Monitor and evaluate salmonid dam survival rates for a subset of FCRPS projects.*

In 2013 studies to evaluate compliance with the Juvenile Salmon Dam Passage Performance Standards were conducted at Lower Monumental and Little Goose in the summer (Skalski et al. 2014). See RPA actions 23 and 24.

Survival rates from compliance tests at Bonneville, The Dalles and John Day dams for yearling Chinook, steelhead, and subyearling Chinook are reported under RPAs 18-20 in Tables 4-6.

BPA Project 1987-127-00 (Smolt Monitoring Program) gathered data on abundance, passage timing, system travel time and survival, and physical condition of smolts moving out of tributaries and past Snake and Columbia River hydro projects.

BPA Project 1989-107-00 (Statistical Support for Salmon) funded the University of Washington to provide software, technical assistance and guidance in mark-recapture study design and data analysis to tribal, state, and federal agencies.

BPA Project 1991-051-00 (Modeling and Evaluation Statistical Support for Lifecycle Studies) assisted other projects in statistical analysis of tag detection data.

BPA Project 1997-015-01 (Imnaha River Smolt Monitoring) tagged and monitored steelhead and Chinook smolts during outmigration from Imnaha.

BPA Project 2003-041-00 (Evaluate Delayed (Extra) Mortality Associated with Passage of Yearling Chinook Salmon through Snake River Dams) compared survival of yearling Chinook transported and released at McNary Reservoir with cohort traveling through four lower Snake dams.

2. *Monitor and evaluate juvenile salmonid in-river and system survival through the FCRPS, including estimates of differential post-Bonneville survival of transported fish relative to in-*

river fish (D-value), as needed. Monitor and evaluate adult salmonid system survival upstream through the FCRPS.

The 2008 FCRPS BiOp established a methodology to annually estimate system survival rates of listed adult salmonids through defined hydrosystem reaches based on PIT Tagged fish detections at Bonneville, McNary, and Lower Granite Dams with corrections for harvest and straying.

Long-term adult system survival performance is evaluated for five stocks using a 5-year rolling average of annual system survival estimates. Snake River spring/summer Chinook and Snake River steelhead are used as surrogates for Snake River sockeye and mid-Columbia steelhead. Results are reported in Section 1.

BPA Project 1993-029-00 (Survival Estimate for Passage through Snake and Columbia River Dams) NOAA Fisheries to produce annual survival estimates for yearling spring migrants over the Lower Granite Dam – Bonneville Dam and McNary Dam – Bonneville Dam reaches using PIT Tagged hatchery and wild groups.

BPA Project 1994-033-00 (Fish Passage Center) provided technical analysis, data summaries, graphic representations for the state, federal and tribal fishery managers.

BPA Project 1996-020-00 (Comparative Survival Study (CSS)) estimated smolt-to-adult survival indices for spring and summer stream type Chinook and summer steelhead originating above Lower Granite Dam.

3. *Monitor and evaluate adult salmonid system survival upstream through the FCRPS.*

In 2013, PIT detection was added to both ladders at The Dalles dam to improve estimates of conversion and reascension.

BPA Project 2005-002-00 (Lower Granite Dam Adult Trap Operations) collected and sampled adult salmonids at Lower Granite Dam for monitoring, multiple research studies, and hatchery operations.

BPA Project 1991-051-00 (Modeling and Evaluation Statistical Support for Lifecycle Studies) assisted other projects in statistical analysis of tag detection data.

BPA Project 2008-908-00 (FCRPS Water Studies & Passage of Adult Salmon & Steelhead) investigated sources of adult fish mortality and water management options in dry water years.

4. *Provide additional PIT Tag marking of Upper Columbia River populations to provide ESU specific estimates of juvenile and adult survival through the Federal mainstem dams.*

BPA Project 1987-127-00 (Smolt Monitoring Program) gathered data on abundance, passage timing, system travel time and survival, and physical condition of smolts moving out of tributaries and past Snake and Columbia River hydro projects.

BPA Project 1994-033-00 (Fish Passage Center) provided technical analysis, data summaries, graphic representations for the state, federal and tribal fishery managers.

BPA Project 1996-020-00 (Comparative Survival Study (CSS)) estimated smolt-to-adult survival indices for spring and summer stream type Chinook and summer

steelhead originating above Lower Granite Dam.

BPA Project 1993-029-00 (Survival Estimate for Passage through Snake and Columbia River Dams) funded NOAA Fisheries to produce annual survival estimates for yearling spring migrants over the Lower Granite Dam – Bonneville Dam and McNary Dam – Bonneville Dam reaches using PIT Tagged hatchery and wild groups.

BPA Project 2003-017-00 (Integrated Status and Effectiveness Monitoring Program (ISEMP)) implemented both status and trend monitoring (fish and habitat) and watershed-level action effectiveness monitoring in five IMWs throughout the Columbia River Basin. The IMWs continued in the Entiat River, Bridge Creek, and Lemhi River watersheds, while status and trend monitoring is implemented in the Wenatchee, John Day, and Lemhi river watersheds

5. *Assess the feasibility of PIT Tag marking of juvenile Snake River Sockeye Salmon for specific survival tracking of this ESU from the Stanley Basin to Lower Granite Dam and through the mainstem FCRPS projects.*

BPA Project 2010-076-00 (Characterizing migration and survival for juvenile Snake River sockeye salmon between the upper Salmon River basin and Lower Granite Dam) used PIT Tags and radio telemetry to determine locations of mortality between upper Salmon River and Lower Granite Dam.

BPA Project 1994-033-00 (Fish Passage Center) provided technical analysis, data summaries, graphic representations for the state, federal and tribal fishery managers.

BPA Project 1996-020-00 (Comparative Survival Study (CSS)) estimated smolt-to-adult survival indices for spring and summer stream type Chinook and summer steelhead originating above Lower Granite Dam.

6. *Develop an action plan for conducting hydrosystem status monitoring (analytical approaches, tagging needs, methods, and protocols) in ongoing collaboration with the State and Federal fishery agencies and Tribes. This will be done in coordination with status monitoring needs and strategies being developed for estuary/ocean, habitat, hatcheries, and harvest. (Initiate in FY2009).*

The Action Agencies and NOAA Fisheries developed the report “The Status and Needs of the Columbia Basin PIT Tag Information System as Related to FCRPS BiOp RME Requirement” (BPA et al. 2013). This report provides a review of the status and needs of PIT Tagging and detection capabilities and identifies needed assessments to optimize the use of PIT Tags supporting several hydro FCRPS BiOp RPA actions.

7. *Cooperate with NOAA Fisheries, US v Oregon parties, Confederated Tribes of the Colville Reservation, and other co-managers to (1) review relevant information and identify factors (migration timing, spatial distribution, etc.) that might explain the differential conversion rates (BON to MCN) observed for Upper Columbia River steelhead and spring Chinook salmon compared to Snake River steelhead and spring/summer Chinook salmon (see RPA Table 7 and **SCA - Adult Survival Estimates Appendix); (2) develop a monitoring plan to determine the most likely cause of these differential losses (considering the potential use of flat plate PIT Tag detectors in tributaries or fishery areas, additional adult detectors at The Dalles and John Day fishways, etc., to provide improved estimates of harvest or stray rates for improved conversion rate estimates in the future); and (3) implement the monitoring plan.*

Project 2008-908-00 (FCRPS Water Studies & Passage of Adult Salmon & Steelhead) was an ongoing study by the Colville Confederated Tribes to investigate adult salmon

and steelhead passage survival through the hydroelectric system and determine sources of adult fish mortality.

BPA Project 2008-105-00 (Selective Gear Deployment) compared efficiency of different gear types to minimize mortality of non-target species.

BPA Project 1994-033-00 (Fish Passage Center) provided technical analysis, data summaries, graphic representations for the state, federal and tribal fishery managers.

Monitoring adult passage counts is a cornerstone monitoring activity that must be performed on an annual basis. Adult fish counting is typically performed 16 hours per day, during daylight hours, by either video or visual counting methods, at all of the Corps projects that pass fish. Adult fish counting will continue at a minimum on the schedule presented in Table 8.

Adult fish counts were conducted as called for in Table 8 of the RPA with the following exceptions:

- At The Dalles, John Day, McNary and Ice Harbor Dams, adult fish were counted from April 1 through October 31, 2013.
- At Lower Granite, 24-hour counts were conducted from June 15 through September 30, 2013, rather than through August 31, 2013.

All changes were fully coordinated during development of the FPP and through the FPOM workgroup process. Results are available in the 2013 Annual Fish Passage Report (ACOE 2014b).

RPA Action 53 – Monitor and Evaluate Migration Characteristics and River Condition

The Action Agencies will monitor and evaluate the following biological and physical attributes of anadromous fish species migrating through the FCRPS on an annual basis.

1. *Monitor and estimate the abundance of smolts passing index dams.*

BPA Project 1991-051-00 (Modeling and Evaluation Statistical Support for Lifecycle Studies) assisted other projects in statistical analysis of tag detection data.

BPA Project 1987-127-00 (Smolt Monitoring Program) gathered data on abundance, passage timing, system travel time and survival, and physical condition of smolts moving out of tributaries and past Snake and Columbia River hydro projects.

BPA Project 1994-033-00 (Fish Passage Center) provided technical analysis, data summaries, graphic representations for the state, federal and tribal fishery managers.

BPA Project 1991-029-00 (Research, monitoring, and evaluation of emerging issues and measures to recover the Snake River fall Chinook salmon ESU) conducted studies life history, early juvenile growth, interactions between wild and hatchery fish, and management measures to increase survival of fall-run Chinook.

2. *Monitor and describe the migration timing of smolts at index dams, identify potential*

problems, and evaluate implemented solutions.

BPA Project 1991-028-00 (PIT Tagging Wild Chinook) estimated parr-to-smolt survival for wild Snake River spring/summer Chinook above Lower Granite Dam.

BPA Project 1987-127-00 (Smolt Monitoring Program) gathered data on abundance, passage timing, system travel time and survival, and physical condition of smolts moving out of tributaries and past Snake and Columbia River hydro projects.

BPA Project 1994-033-00 (Fish Passage Center) provided technical analysis, data summaries, graphic representations for the state, federal and tribal fishery managers.

BPA Project 1996-020-00 (Comparative Survival Study (CSS)) estimated smolt-to-adult survival indices for spring and summer stream type Chinook and summer steelhead originating above Lower Granite Dam.

BPA Project 1991-029-00 conducted research, monitoring, and evaluation of emerging issues and measures to recover the Snake River fall Chinook salmon ESU including studies of life history, early juvenile growth, interactions between wild and hatchery fish, and management measures to increase survival of fall-run Chinook.

BPA Project 1993-029-00 (Survival Estimate for Passage through Snake and Columbia River Dams) funded NOAA Fisheries to produce annual survival estimates for yearling spring migrants over the Lower Granite Dam – Bonneville Dam and McNary Dam – Bonneville Dam reaches using PIT Tagged hatchery and wild groups.

BPA Project 1991-051-00 (Modeling and Evaluation Statistical Support for Lifecycle Studies) assisted other projects in statistical analysis of tag detection data.

3. *Monitor and document the condition (e.g., descaling and injury) of smolts at all dams with juvenile bypass systems, identify potential problems, and evaluate implemented solutions.*

The Corps tested gatewell egress and injury rates for potential replacement for the existing 10-inch orifices with 14-inch orifice and a broad crested weir as part of the Lower Granite Juvenile Bypass System upgrade (O'Connor et al. 2014).

BPA Project 1987-127-00 (Smolt Monitoring Program) gathered data on abundance, passage timing, system travel time and survival, and physical condition of smolts moving out of tributaries and past Snake and Columbia River hydro projects.

BPA Project 1994-033-00 (Fish Passage Center) provided technical analysis, data summaries, graphic representations for the state, federal and tribal fishery managers.

4. *Monitor and enumerate adult salmonids passing through fishways in the FCRPS, identify potential problems, evaluate implemented solutions.*

In 2013, the Corps again implemented its adult fish count program as detailed in the FPP. Results are available in the 2013 Annual Fish Passage Report: Columbia and Snake Rivers (USACE 2014).

Fishways were monitored on a regular basis, as per FPP specifications. Results are discussed in an annual Fishway Inspection Report prepared for each project.

Fishways were also inspected by representatives from NOAA Fisheries and other agencies. Results of those inspections are available at http://www.fpc.org/documents/Fishway_Inspection_Reports.html. See also the discussion of adult passage improvements under RPA Action 28 above.

The Corps initiated a two-year study to evaluate the effects of modifications at dams on adult salmon passage. Specific fish ladder modifications being evaluated include the lamprey flume at Bonneville Powerhouse II, effects of The Dalles Spillwall, north shore ladder improvements at John Day Dam, and McNary South Shore lamprey entrance (2014 only). The Corps also conducted a radio telemetry study of steelhead and spring Chinook passing Little Goose and Lower Granite dam in 2013 (Keefer and Caudill 2014). The study addressed fish ladder entrance evaluations at Little Goose Dam and evaluated adult passage delay due to spill operations (spillway weir operation and training spill pattern) during flows of 60-80 kcfs, and also evaluated fish ladder entrances and exits at Lower Granite. This study helped elucidate information on adult passage delay due to high temperature differentials in the ladder, and spill/turbine unit operation affecting attraction and egress into the ladder.

5. *In addition to current operations (generally April 10 - August 31), evaluate operation of the Bonneville (second powerhouse) PH2 corner collector from March 1 through start of spill as a potential means to provide a safer downstream passage route for steelhead kelts, and implement, if warranted.*

From 2008 – 2012, operation of the Corner Collector as a means to provide safer passage for downstream-migrating steelhead was evaluated. Based on these past evaluations, and in consultation with the Fish Passage Operations and Maintenance subcommittee, operation of the corner collector was determined in 2013 to provide a benefit. Annual operation of the Corner Collector has been incorporated into the Fish Passage Plan.

In 2013, the Bonneville Corner Collector was opened for steelhead Kelt passage on March 22, 2013. Normal spill operations began on April 10, 2013. This provided 19 additional days of downstream passage for steelhead kelts.

BPA Project 1994-033-00 (Fish Passage Center) provided technical analysis, data summaries, graphic representations for the state, federal and tribal fishery managers.

RPA Action 54 – Monitor and Evaluate Effects of Configuration and Operation Actions

The following will be conducted at specific projects for specific years as operations or configurations change, or new problems are identified.

1. *Monitor and evaluate the effects of existing spillways, modifications, and operations on smolt survival.*

Post-hoc analysis of passage data collected at Bonneville during 2008-2012 performance testing was done in 2013. One objective was to examine spillway survival by spillbay with a focus on those bays where erosion of the ogee or stilling basin immediately downstream had occurred. Analysis of survival data did not find differences in survival by spillbay at Bonneville Dam for yearling Chinook, subyearling Chinook, or steelhead.

Spillways at Lower Monumental and Little Goose Dams were evaluated in 2013 as part of the Juvenile Salmon Dam Passage Performance Standard compliance studies (Skalski et al. 2014).

BPA Project 1989-107-00 (Statistical Support for Salmon) funded the University of Washington to provide software, technical assistance and guidance in mark-recapture study design and data analysis to tribal, state, and federal agencies.

BPA Project 2003-041-00 (Evaluate Delayed (Extra) Mortality Associated with Passage of Yearling Chinook Salmon through Snake River Dams) compared survival of yearling Chinook transported and released at McNary Reservoir with cohort traveling through four lower Snake dams.

2. *Monitor and evaluate the effectiveness of traditional juvenile bypass systems and modifications to such, on smolt survival and condition.*

Bonneville Powerhouse II gatewell improvement prototype test conducted a biological evaluation 2013 to test the hypothesis that filling areas above the submerged travelling screen guides on both sides of a B2 gatewell would improve gatewell flow conditions thereby reducing fish mortality at the upper 1 percent peak efficiency turbine operation range. For additional details, refer to RPA 18.

Juvenile Bypass system at Lower Monumental and Little Goose Dams were evaluated in 2013 as part of the Juvenile Salmon Dam Passage Performance Standard compliance studies (Skalski et al. 2014).

BPA Project 1989-107-00 (Statistical Support for Salmon) funded the University of Washington to provide software, technical assistance and guidance in mark-recapture study design and data analysis to tribal, state, and federal agencies.

BPA Project 1993-029-00 (Survival Estimate for Passage through Snake and Columbia River Dams) funded NOAA Fisheries to produce annual survival estimates for yearling spring migrants over the Lower Granite Dam – Bonneville Dam and McNary Dam – Bonneville Dam reaches using PIT Tagged hatchery and wild groups.

3. *Monitor and evaluate the effectiveness of surface bypass structures and modifications on smolt survival and condition.*

Surface passage at Lower Monumental and Little Goose Dams were evaluated in 2013 as part of the Juvenile Salmon Dam Passage Performance Standard compliance studies (Skalski et al. 2014).

4. *Monitor and evaluate the effectiveness of turbine operations and modifications on smolt survival and condition.*

Passage data collected at Bonneville during 2010-2012 performance testing was analyzed in 2013 to examine survival for fish passing turbines operating within the 1 percent peak efficiency range and above the upper limit of the 1 percent operating range. In addition to analyzing fish survival data, work continued in 2013 to determine the safest operating range for fish passing through existing FCRPS turbines. Physical model studies and numerical model studies were conducted to further this understanding.

A Turbine Survival Program Phase II report was completed in 2013 which identifies the best target operating range for each project. The recommended target operating

ranges are based on maximizing turbine passage survival.

Turbine operations at Lower Monumental and Little Goose Dams were evaluated in 2013 as part of the Juvenile Salmon Dam Passage Performance Standard compliance studies (Skalski et al. 2014).

The Turbine Survival Program continued to develop a biological index test through computational fluid dynamics modeling and physical modeling at the Corps' Engineer Research and Development Center.

BPA Project 1989-107-00 (Statistical Support for Salmon) funded the University of Washington to provide software, technical assistance and guidance in mark-recapture study design and data analysis to tribal, state, and federal agencies.

5. *Monitor and evaluate overall dam passage with respect to modifications at projects (including forebay delay and survival).*

Two Corps projects (Lower Monumental and Little Goose) conducted passage and survival studies in 2013 which estimated forebay residence times and survival rates in the forebay. Results are presented under RPA Actions 23 and 24. Estimates of survival of yearling Chinook salmon and steelhead, derived using the Paired-Release Model, and estimates of median forebay residence time (Skalski et al. 2014) are provided below.

Table 21. Season-wide estimates of dam passage survival for yearling Chinook and steelhead.

Species	Lower Monumental		Little Goose	
	Survival (Percent)	Residence Time (Hours)	Survival (Percent)	Residence Time (Hours)
Subyearling Chinook	93.0 (1.1)	17.4 h	90.8 (1.4)	12.3 h

BPA Project 2003-041-00 (Evaluate Delayed (Extra) Mortality Associated with Passage of Yearling Chinook Salmon through Snake River Dams) compared survival of yearling Chinook transported and released at McNary Reservoir with cohort traveling through four lower Snake dams.

BPA Project 1987-127-00 (Smolt Monitoring Program) gathered data on abundance, passage timing, system travel time and survival, and physical condition of smolts moving out of tributaries and past Snake and Columbia River hydro projects.

BPA Project 1994-033-00 (Fish Passage Center) provided technical analysis, data summaries, graphic representations for the state, federal and tribal fishery managers.

BPA Project 1990-055-00 (Idaho Steelhead Monitoring and Evaluation Studies) gathered data on steelhead population dynamics, life-history, and genetics.

6. *Monitor and evaluate the effectiveness of the juvenile fish transportation program and modifications to operations.*

In 2013, the Action Agencies continued to make progress on monitoring and evaluating the effectiveness of the juvenile fish transportation program; this effort included seven BPA projects. Information resulting from the 2013 RME will enable

further progress in identifying the benefits of transportation and supporting adaptive management actions. Significant 2013 RME are as follows:

Spring Migrants

The Action Agencies continued research to determine the potential of transportation to increase adult returns of anadromous salmon. A PIT Tag study to evaluate weekly SARs for spring Chinook salmon and steelhead transported from Lower Granite Dam continued in 2013. More precise temporal transportation data should help clarify effects of transportation and relationships to environmental variables. Overall, ratio of SARs of transported to in-river migrating fish reported by NOAA Fisheries show that transport is a benefit throughout most of the season for spring migrants. The greatest transport benefit for wild Chinook salmon usually occurs after May 1, but in most years transport is beneficial by the third week of April. Another trend observed in the data is that SARs for in-river migrants tend to decrease throughout the season. This is consistent with the observation that while transport may be beneficial early in the season, it usually becomes even more beneficial later in the season.

Summer Migrants

In 2013, the Action Agencies continued implementing the 2007 fall Chinook salmon consensus proposal and long-term framework developed collaboratively with regional fish management agencies and Tribes. This intensive RME effort for subyearling fall Chinook salmon will help determine the appropriate management strategy to optimize adult returns. In 2013, NOAA Fisheries and USFWS drafted a method for an analysis report and analyzed two years of complete adult returns (2006 and 2008). The draft will be available for broad regional comment in 2014.

Steelhead Straying

The Corps continued a study in 2013 to identify potential modifications to barges or the barging process that would improve imprinting success and reduce straying in barge transported juvenile salmonids. In 2013 laboratory experiments were used to demonstrate that novel water source exposure for 1 to 12 hours had a significant effect on imprinting associated physiological markers and indicate potential solutions for barge operations in reducing straying. The overall goal of the study is to reduce or eliminate straying that may be the result of juvenile transportation while maintaining the consistent benefits of transportation observed for steelhead and Chinook salmon.

BPA Project 1994-033-00 (Fish Passage Center) provided technical analysis, data summaries, graphic representations for the state, federal and tribal fishery managers.

BPA Project 1996-020-00 (Comparative Survival Study (CSS)) estimated smolt-to-adult survival indices for spring and summer stream type Chinook and summer steelhead originating above Lower Granite Dam.

BPA Project 1990-055-00 (Idaho Steelhead Monitoring and Evaluation Studies) gathered data on steelhead population dynamics, life-history, and genetics.

BPA Project 2001-003-00 (Adult PIT Detector Installation) installed PIT Tag detection systems around the Columbia River Basin.

BPA Project 1993-029-00 (Survival Estimate for Passage through Snake and Columbia River Dams) funded NOAA Fisheries to produce annual survival estimates for yearling spring migrants over the Lower Granite Dam – Bonneville Dam and McNary Dam – Bonneville Dam reaches using PIT Tagged hatchery and wild groups.

BPA Project 1989-098-00 (Salmon Studies in Idaho Rivers) studied hatchery supplementation as a recovery tool for threatened stocks of spring/summer Chinook in Idaho rivers.

BPA Project 2003-041-00 (Evaluate Delayed (Extra) Mortality Associated with Passage of Yearling Chinook Salmon through Snake River Dams) compared survival of yearling Chinook transported and released at McNary Reservoir with cohort traveling through four lower Snake dams.

7. *Monitor and evaluate the effects of environmental conditions affecting juvenile fish survival.*

BPA Project 1987-127-00 (Smolt Monitoring Program) gathered data on abundance, passage timing, system travel time and survival, and physical condition of smolts moving out of tributaries and past Snake and Columbia River hydro projects.

BPA Project 1993-029-00 (Survival Estimate for Passage through Snake and Columbia River Dams) funded NOAA Fisheries to produce annual survival estimates for yearling spring migrants over the Lower Granite Dam – Bonneville Dam and McNary Dam – Bonneville Dam reaches using PIT Tagged hatchery and wild groups.

BPA Project 1994-033-00 (Fish Passage Center) provided technical analysis, data summaries, graphic representations for the state, federal and tribal fishery managers.

BPA Project 1996-020-00 (Comparative Survival Study (CSS)) estimated smolt-to-adult survival indices for spring and summer stream type Chinook and summer steelhead originating above Lower Granite Dam.

BPA Project 2003-041-00 (Evaluate Delayed (Extra) Mortality Associated with Passage of Yearling Chinook Salmon through Snake River Dams) compared survival of yearling

Chinook transported and released at McNary Reservoir with cohort traveling through four lower Snake dams.

BPA Project 1989-108-00 (Modeling and Evaluation Support/Columbia River Integrated Statistical Program) conducted data analyses to address questions related to fish passage in the Columbia River Basin.

8. *Monitor and evaluate the effectiveness of reducing predation toward improving juvenile fish survival.*

BPA Project 1990-077-00 (Development of System-wide Predator Control) continued the Northern Pikeminnow Management Program to reduce predation on juvenile salmonids by harvesting pikeminnow in FCRPS reservoirs and estuary.

BPA Project 2003-041-00 (Evaluate Delayed (Extra) Mortality Associated with Passage of Yearling Chinook Salmon through Snake River Dams) compared survival of yearling Chinook transported and released at McNary Reservoir with cohort

traveling through four lower Snake dams.

The Action Agencies continue to implement habitat and dam-based actions to reduce predation on juvenile and adult salmonids. See also RPA Actions 43 through 49 and 66 through 70 for detailed information on related activities.

9. *Investigate, evaluate and deploy alternative technologies and methodologies for fish passage and the RME Action.*

A Juvenile Salmon Acoustic Telemetry System transmitter design was completed in 2013 to allow new applications of study objectives and size ranges of fish that could be tagged, with decreased adverse tag effects. Prototype tags were evaluated both in the laboratory and field. Specific accomplishments in 2013 include developing an acoustic transmitter that can be injected instead of surgically implanted; demonstrated manufacturability by making 1000 tags in one month at Pacific Northwest National Laboratory; verified tag functions (same as current JSATS tag) in the field; and verified implantation protocols.

BPA Project 1983-319-00 (New Marking and Monitoring Technologies) funded NOAA Fisheries to develop new designs for fish tags and tag detection systems.

10. *Determine if actions directed at benefiting juveniles have an unintended effect on migrating adults (e.g., certain spill operations).*

The Corps initiated a two-year study to evaluate the effects of modifications at dams on adult salmon passage. Specific juvenile passage modifications being evaluated include The Dalles Dam Spillwall and the spillway weirs and new spill pattern at John Day Dam.

The spill pattern at Little Goose Dam was evaluated at the Corps' physical hydraulic model at the Corps' Engineer Research and Development Center for adjustments to minimize adult Chinook salmon delays observed in previous years with operation of the spillway weir for flows ranging up to 100 kcfs. In that evaluation, opening spillbay 8 first, rather than spillbays 2 and 3, proved to break up the spillway-weir-powered eddy that may have been a cause of adult passage delay. This change was implemented in the FPP for 2011 and this operation has continued through 2013. An adult passage radio-telemetry study was contracted in 2013 to assess the effects of the spill pattern adjustment with reporting in 2014.

BPA Project 1994-033-00 (Fish Passage Center) provided technical analysis, data summaries, graphic representations for the state, federal and tribal fishery managers.

11. *Install and maintain adult PIT Tag detectors in fish ladders at key dams in the FCRPS and evaluate adult survival (conversion rates).*

Temporary PIT detectors were installed in the north and east ladders at The Dalles Dam in 2013. These systems were originally intended to be temporary. However, they have higher than anticipated detection efficiencies (>98 percent) and appear to be durable and reliable, so will be maintained by the Corps as the long-term systems. (Permanent detectors are scheduled for installation in 2015).

BPA Project 2001-003-00 (Adult PIT Detector Installation) installed PIT Tag detection systems around the Columbia River Basin.

12. *Monitor and evaluate the effects of fish ladder operations and configurations on adult passage rates.*

The Corps initiated a two-year study to evaluate the effects of modifications at dams on adult salmon passage. Specific fish ladder modifications being evaluated include the lamprey flume at Bonneville Powerhouse II (2013-2014), the north shore ladder at John Day Dam (2013-2014) and a new lamprey entrance at McNary Dam's south shore fish ladder (2014 only).

The Corps conducted a radio telemetry study of steelhead and spring Chinook passing Little Goose and Lower Granite dam in 2013 (Clabough et al. 2014). The study addressed fish ladder entrance monitoring at Little Goose and Lower Granite Dams. This study helped elucidate information on adult passage delay due to high temperature differentials in the ladder, and spill/turbine unit operations affecting attraction and egress into the ladder.

In 2013, video monitoring occurred at the raised picketed lead sections of counting stations at McNary and Ice Harbor dams for determining impacts to migrating salmon. In addition, newly-installed lamprey orifices in control section weir walls at Little Goose and Lower Granite dams, were video-monitored for negative impacts on salmon passage (Thompson et al. 2014).

BPA Project 2003-041-00 (Evaluate Delayed (Extra) Mortality Associated with Passage of Yearling Chinook Salmon through Snake River Dams) compared survival of yearling Chinook transported and released at McNary Reservoir with cohort traveling through four lower Snake dams.

BPA Project 1994-033-00 (Fish Passage Center) provided technical analysis, data summaries, graphic representations for the state, federal and tribal fishery managers.

13. *In addition to the current sluiceway operation (generally April 1–November 30), evaluate operation of The Dalles Dam sluiceway from March 1–March 31 and from December 1–December 15 as a potential means to provide a safer fallback passage route for overwintering steelhead and kelts, implement if warranted.*

Results from two years of evaluations of downstream passage through The Dalles Dam sluiceway by overwintering summer steelhead and outmigrating steelhead kelts indicated that there are large enough benefits (0.9 percent of a 6 percent target for Snake River B-run steelhead) to justify operating this route early and to keep this surface route open later, March 1 to 15 December (Tackley and Clugston 2011). In 2013, the sluiceway was operated March 1 – 31 and December 1- 15 to provide safer passage conditions for overwintering steelhead and steelhead kelts.

14. *Investigate surface-flow outlets during wintertime to provide safer fallback opportunity for over wintering steelhead (need will be determined by results of further research).*

A direct injury and survival study comparing the turbine and spillway weir passage routes for adult steelhead at McNary Dam was attempted in 2013, but was delayed until 2014 due to a poor steelhead return year which limited the availability of study fish.

RPA Action 55 – Investigate Hydro Critical Uncertainties and Investigate New Technologies

The Action Agencies will fund selected research directed at resolving critical uncertainties that are pivotal in lifecycle model analyses. Specific actions include:

1. *Investigate and quantify delayed differential effects (D-value) associated with the transportation of smolts in the FCRPS, as needed. (Initiate in FY 2007–2009 Projects).*

The Corps held a regional workshop on the potential selectivity of juvenile bypass systems in June 2013 and several presenters provided data and associated analyses addressing the question of whether bypass systems are selective for specific traits (e.g., length). Overall, there appeared to be evidence of selectivity in bypass systems from multiple researchers and some presented information suggesting there was either no selectivity or the selectivity was not thought to be biologically meaningful. At the conclusion of the workshop broad consensus was that this issue deserved more attention and that it is a critical uncertainty in the operation of the FCRPS.

Several multiyear research studies continue to assess and estimate differential delayed effects associated with the transportation of juvenile salmon and steelhead. The parameter D is the ratio of post Bonneville survival of barged and in-river migrants. Other indices of transportation benefit provide more direct and readily interpretable results, including various transport-to-in-river migrant ratios such as TIR and ratio of smolt to adult return of transported to in river migrating fish indices.

BPA Project 1994-033-00 (Fish Passage Center) provided technical analysis, data summaries, graphic representations for the state, federal and tribal fishery managers.

BPA Project 1996-020-00 (Comparative Survival Study (CSS)) estimated smolt-to-adult survival indices for spring and summer stream type Chinook and summer steelhead originating above Lower Granite Dam.

BPA Project 1991-028-00 (PIT Tagging Wild Chinook) estimated parr-to-smolt survival for wild Snake River spring/summer Chinook above Lower Granite Dam.

BPA Project 1989-098-00 (Salmon Studies in Idaho Rivers) studied hatchery supplementation as a recovery tool for threatened stocks of spring/summer Chinook in Idaho rivers.

2. *Investigate the post-Bonneville mortality effect of changes in fish arrival timing and transportation to below Bonneville. (Initiate in FY 2007-2009).*

BPA Project 1991-028-00 (Pit Tagging Wild Chinook) estimated parr-to-smolt survival for wild Snake River spring/summer Chinook above Lower Granite Dam.

BPA Project 2003-041-00 (Evaluate Delayed (Extra) Mortality Associated with Passage of Yearling Chinook Salmon through Snake River Dams) compared survival of yearling

Chinook transported and released at McNary Reservoir with cohort traveling through four lower Snake dams.

BPA Project 1994-033-00 (Fish Passage Center) provided technical analysis, data

summaries, graphic representations for the state, federal and tribal fishery managers.

BPA Project 1993-029-00 (Survival Estimate for Passage through Snake and Columbia River Dams) funded NOAA Fisheries to produce annual survival estimates for yearling spring migrants over the Lower Granite Dam – Bonneville Dam and McNary Dam – Bonneville Dam reaches using PIT Tagged hatchery and wild groups.

BPA Project 1991-051-00 (Modeling and Evaluation Statistical Support for Lifecycle Studies) assisted other projects in statistical analysis of tag detection data.

BPA Project 1987-127-00 (Smolt Monitoring Program) gathered data on abundance, passage timing, system travel time and survival, and physical condition of smolts moving out of tributaries and past Snake and Columbia River hydro projects.

3. *Conduct a workshop every other year with members of the Independent Scientific Advisory Board (ISAB) to review current research and monitoring approaches on post Bonneville mortality for transported and non-transported fish. (Initiate in FY 2009).*

The Corps commissioned a synopsis and literature review of differential delayed mortality, identified critical uncertainties, and sponsored the Snake River Basin Differential Delayed Mortality Workshop in May 2011. A draft report was produced and sent to regional fish managers for review and comment. Results from the synopsis were presented at the Corps Annual AFEP review in December 2011. The final report (Anderson et al. 2012) was sent to the ISAB for review in the spring of 2012. A workshop was not conducted in 2013; relatively little new information had become available since the 2011 workshop.

4. *Investigate, describe and quantify key characteristics of the early life history of Snake River Fall Chinook Salmon in the mainstem Snake, Columbia, and Clearwater rivers. (Initiate in FY 2007-2009 Project).*

BPA Project 2002-032-00 (Snake River Fall Chinook Salmon Life History Investigations) studied effects of reservoir conditions and water management on juvenile fall Chinook behavior, survival and life history.

BPA Project 1991-029-00 (Research, monitoring and evaluation of emerging issues and measures to recover the Snake River fall Chinook salmon ESU) tagged wild subyearling fall Chinook and analyzes subsequent detection data to estimate survival, growth, describe run timing and life history attributes, and evaluate the effectiveness of summer spill.

BPA Project 1987-127-00 (Smolt Monitoring Program) gathered data on abundance, passage timing, system travel time and survival, and physical condition of smolts moving out of tributaries and past Snake and Columbia River hydro projects.

BPA Project 1994-033-00 (Fish Passage Center) provided technical analysis, data summaries, graphic representations for the state, federal and tribal fishery managers.

BPA Project 1996-020-00 (Comparative Survival Study (CSS)) estimated smolt-to-adult survival indices for spring and summer stream type Chinook and summer steelhead originating above Lower Granite Dam.

BPA Project 1989-107-00 (Statistical Support for Salmon) provided software,

technical assistance and guidance in mark-recapture study design and data analysis to tribal, state, and federal agencies.

BPA Project 1989-108-00 (Modeling and Evaluation Support/Columbia River Integrated Statistical Program) conducted data analyses to address questions related to fish passage in the Columbia River Basin.

5. *Complete analysis and reporting of a multi-year (2000-2007) investigation on the effects of adult passage experience in the FCRPS on pre-spawning mortality (2008). Following reporting, SRWG will review the results and provide a recommendation on the need and nature of future research. Future research will be coordinated through the Regional Forum.*

This action was completed in 2008.

6. *Continue development of state-of-the-art turbine units to obtain improved fish passage survival through turbines with the goal of using these new units in all future turbine rehabilitation or replacement programs.*

Development of designs for replacement turbine runners at Ice Harbor Dam continued through 2013 and the fixed blade design was completed in 2013. The Kaplan runner design will be completed in 2014 and fabrication of both runners will begin in 2014. Reducing nadir pressure in new turbine runners to reduce the risk of barotrauma to

passing salmonids is one of the driving design criteria and current development shows promise in the Ice Harbor runners (Trumbo et al. 2013b).

7. *Investigate feasibility of developing PIT Tag detectors for spillways and turbines.*

In 2013, the Corps continued to develop an Engineering Documentation Report that will include an evaluation of alternatives considered in developing a prototype Spillway PIT Tag Monitoring Project. The Corps will work with NOAA Fisheries and other regional resource management offices in developing the report. Plans for prototype Spillway PIT Tag detectors at Lower Granite Dam were refined in 2013.

Additionally in 2013, the Corps developed an alternative spillway/surface outlet PIT Antenna monitoring system. A contract was awarded to design and build a prototype "hydrofoil" antenna in 2013 that was installed and tested in late 2013 and early 2014.

BPA project 1983-319-00 (New Marking and Monitoring Technologies) funded NOAA Fisheries to develop new designs for fish tags and tag detection systems.

8. *Evaluate new tagging technologies for use in improving the accuracy and assessing delayed or indirect hydro effects on juvenile or adult fish.*

BPA Project 1983-319-00 (New Marking and Monitoring Technologies) funded NOAA Fisheries to develop new designs for fish tags and tag detection systems.

BPA Project 1989-107-00 (Statistical Support for Salmon) provided software, technical assistance and guidance in mark-recapture study design and data analysis to tribal, state, and federal agencies.

9. *Assess the feasibility of developing PIT Tag detectors for use in natal streams and tributaries, or other locations, as appropriate to support more comprehensive and integrated All-H*

monitoring designs and assessments of stray rates.

BPA Project 1983-319-00 (NOAA Fisheries New Marking and Monitoring Technologies) is the primary project affiliated with this subaction. This project continued work on the spillway PIT tag system and instream interrogation systems.

RME Strategy 3 (RPA Actions 56-57)

RPA Action 56 – Monitor and Evaluate Tributary Habitat Conditions and Limiting Factors

The Action Agencies will:

1. *Implement research in select areas of the pilot study basins (Wenatchee, Methow and Entiat river basins in the Upper Columbia River, the Lemhi and South Fork Salmon river basins, and the John Day River Basin) to quantify the relationships between habitat conditions and fish productivity (limiting factors) to improve the development and parameterization of models used in the planning and implementation of habitat projects. These studies will be coordinated with the influence of hatchery programs in these habitat areas.*

Reclamation's Methow IMW Study continued in 2013 and has three parts: (1) Development of a methodology to organize monitoring around an aquatic trophic production model and a life-cycle model; (2) Assessment of treatment effects on fish production in the Middle Methow River using the model to guide the field designs; and (3) Calibration and assessment of the model to support evaluations of limiting factors (Bellmore et al. 2013).

Reclamation's Methow River Population Studies assessed fish populations for abundance, density, and biomass in 10 side channels and two tributaries (Beaver and Wolf creeks) of the Methow River. The pre-treatment monitoring results will be used to calibrate the full trophic production model. Pre-treatment fish population estimates for Middle Methow River side channels and tributaries are available in: Methow and Columbia Rivers Studies, Washington—Summary of Data Collection, Comparison of Database Structure and Habitat Protocols, and Impact of Additional PIT Tag Interrogation Systems to Survival Estimates, 2008-2012 (Martens et al. 2013).

Reclamation's Aquatic Respiration Study provided a feasible means of assessing how ecosystems respond to habitat treatments and their impacts on gross primary productivity and ecosystem respiration. The study results are used to calibrate the primary production portion of the trophic production model.

Reclamation's 2D Hydraulic Model Development was used for habitat treatment design and construction. The RME program will use the 2D model results to calibrate simpler hydraulic models developed by Reclamation's Technical Service Center in 2014. These simpler hydraulic models based on a geomorphic classification system are intended to allow the use of the calibrated trophic production model in other subbasins of the Columbia River. Problems with the calibration of a temperature model as conceived were encountered in 2013. In 2014 a 1D temperature model from another source coupled with finer resolution temperature logger data will be used to parameterize the trophic production model. The project was planned in 2013 and will begin in 2014.

Reclamation Project R10-PG-10-445 (Integrative Data Modeling, Analyst and Management Activities) with USGS developed a model from first principles to quantify the relationships between habitat conditions and fish productivity (limiting factors) in the Methow. The first peer-reviewed paper is scheduled for publication in early 2014. This project will be continued in 2014-2016 through funding with USGS Forest and Rangeland Ecosystem Science Center. This project also funded the collection of the aquatic metabolism data to parameterize the primary production portion of the model. Reclamation will develop model validation datasets to parameterize the model for typical Columbia Basin geomorphic reach types; this validation exercise will demonstrate the Basin-wide applicability of the model.

Reclamation Project R08-PG-17-887 (Mainstem Methow Habitat Effectiveness Monitoring) with USGS Columbia River Research Laboratory continued to collect pre- and post-floodplain treatment fish production data to help parameterize the model.

BPA Project 1989-098-00 (Salmon Studies in Idaho Rivers-Idaho Department of Fish and Game (IDFG)) assessed the use of hatchery Chinook salmon to restore or augment natural populations, and to evaluate the effects of supplementation on the survival and fitness of existing natural populations. The program has collected data from 30 streams throughout Idaho.

BPA Project 1990-055-00 (Idaho Steelhead Monitoring and Evaluation Studies) monitored and evaluated the status of wild steelhead populations in the Clearwater and Salmon River drainages.

BPA Project 1998-016-00 (Escapement and Productivity of Spring Chinook and Steelhead) provided basin-wide status and trend data for steelhead and spring Chinook in the John Day River Basin.

BPA Project 2003-017-00 (Integrated Status and Effectiveness Monitoring Program (ISEMP)) implemented both status and trend monitoring (fish and habitat) and watershed-level action effectiveness monitoring in five IMWs throughout the Columbia River Basin. The IMWs continued in the Entiat River, Bridge Creek, and Lemhi River watersheds, while status and trend monitoring is implemented in the Wenatchee, John Day, and Lemhi river watersheds.

BPA Project 2008-471-00 (Upper Columbia Nutrient Supplementation) quantified and evaluated nutrient status and availability in the Twisp River, a tributary to the Methow River.

BPA Project 2010-034-00 (Upper Columbia Spring Chinook and Steelhead Juvenile and Adult Abundance, Productivity and Spatial Structure Monitoring) evaluated precision and accuracy of smolt monitoring and the precision of redd counts for both steelhead and spring Chinook, estimate the proportion of hatchery steelhead, and evaluate the accuracy of the steelhead spawning ground survey design in Upper Columbia Rivers.

BPA Project 2011-006-00 (Columbia Habitat and Monitoring Program (CHaMP)) developed and implemented a standardized habitat monitoring program covering at least one population per MPG for habitat status and trend to support habitat and fish relationship development used in limiting factor assessments and for planning and evaluation of habitat actions.

2. *Implement habitat status and trend monitoring as a component of the pilot studies in the Wenatchee, Methow and Entiat river basins in the Upper Columbia River, the Lemhi and South Fork Salmon river basins, and the John Day River Basin. (Initiate in FY 2007-2009 Projects, annually review and modify annually to ensure that these projects continue to provide a means of evaluating the effectiveness of tributary mitigation actions.)*

BPA Project 2003-017-00 (Integrated Status and Effectiveness Monitoring Program) (ISEMP)) continued to support habitat status and trend monitoring through watershed-level action effectiveness studies (IMWs) in the John Day (Bridge Creek), Entiat, and Lemhi and ongoing habitat status and trends monitoring in the Wenatchee.

BPA Project 2008-471-00 (Upper Columbia Nutrient Supplementation) quantified and evaluated nutrient status and availability in the Twisp River, a tributary to the Methow River. This project monitors and tracks nutrients and food within a watershed in the Methow River Basin and will contribute, along with CHaMP and Reclamation data, to habitat status and trend monitoring within the Methow River Basin.

BPA Project 2011-006-00 (Columbia Habitat and Monitoring Program) developed and implemented a standardized habitat monitoring program for habitat status and trend (including the 6 basins identified in this RPA subaction) to support habitat and fish relationship development used in limiting factor assessments and for planning and evaluation of habitat actions.

3. *Facilitate and participate in an ongoing collaboration process to develop a regional strategy for limited habitat status and trend monitoring for key ESA fish populations. This monitoring strategy will be coordinated with the status monitoring needs and strategies being developed for hydropower, habitat, hatchery, harvest, and estuary/ocean.*

BPA Project 2003-017-00 (Integrated Status and Effectiveness Monitoring Program) (ISEMP)) continued to work collaboratively with the region on the development of protocols and new technologies, indicators, sample designs, analytical, data management and communication tools and skills, and restoration experiments that support the development of a region-wide Research, Monitoring and Evaluation (RME) strategy to assess the status of anadromous salmonid populations, their tributary habitat and restoration and management actions.

BPA Project 2003-022-00 (Okanogan Basin Monitoring & Evaluation Program) measured habitat conditions and steelhead natural production in the Okanogan River Basin. The project also consolidated information related to sockeye and Chinook salmon. Okanogan Basin Monitoring and Evaluation Program data are used to help identify limiting factors, support adaptive management, prioritize and select restoration actions, manage local fisheries, and develop new restoration actions.

BPA Project 2004-002-00 (Pacific Northwest Aquatic Monitoring Program Coordination) funded the Pacific Northwest Aquatic Monitoring Program to provide a forum for coordination of aquatic monitoring efforts in the region to promote consistency in monitoring approaches and protocols; follow a scientific foundation; support monitoring policy and management objectives; and collect and present information in a manner that can be shared.

BPA Project 2009-004-00 (Monitoring Recovery Trends in Key Spring Chinook Habitat Variables and Validation of Population Viability Indicators) assessed the status and

trend of stream habitat conditions in the upper Grande Ronde River and Catherine Creek to evaluate the potential of freshwater habitat restoration in aggregate, applied in a spatially diffused manner to these basins, to improve the viability of spring Chinook salmon populations.

BPA Project 2011-006-00 (Columbia Habitat and Monitoring Program) continued to develop and implement a standardized habitat monitoring program for habitat status and trend (consistent with the ASMS regional collaborative strategy and ISRP review) to support habitat and fish relationship development used in limiting factor assessments and for planning and evaluation of habitat actions.

RPA Action 57 – Evaluate the Effectiveness of Tributary Habitat Actions

The Action Agencies will evaluate the effectiveness of habitat actions through RME projects that support the testing and further development of relationships and models used for estimating habitat benefits. These evaluations will be coordinated with hatchery effectiveness studies.

1. *Action effectiveness pilot studies in the Entiat River Basin to study treatments to improve channel complexity and fish productivity.*

BPA Project 2003-017-00 (Integrated Status and Effectiveness Monitoring Program) determined the effectiveness of restoration at improving Chinook and steelhead freshwater productivity for the Entiat River IMW. The primary restoration action to be tested is active instream modifications via engineered structures that increase habitat complexity and diversity by creating large pools and off-channel areas.

BPA Project 2010-034-00 (Upper Columbia Spring Chinook and Steelhead Juvenile and Adult Abundance, Productivity and Spatial Structure Monitoring) evaluated precision and accuracy of smolt monitoring and the precision of red counts for both steelhead and spring Chinook, estimated the proportion of hatchery steelhead, and evaluated the accuracy of the steelhead spawning ground survey design in Upper Columbia Rivers. The application of identical fish monitoring protocols/methods in the Entiat benefit directly from this project.

BPA Project 2011-006-00 (Columbia Habitat and Monitoring Program) developed preliminary summaries of habitat quality indices for the Entiat River Basin. See RPA Subactions 56.1, 56.2, and 56.3 for further descriptions of CHaMP. Although CHaMP has only collected one year of habitat data within the Entiat River Basin, over time it will document changes in habitat conditions at the basin, assessment unit, and site scales. This will allow researchers to assess the effects of restoration actions on habitat conditions at three spatial scales.

2. *Pilot study in the Lemhi River Basin to study treatments to reduce entrainment and provide better fish passage flow conditions.*

BPA Project 2003-017-00 (Integrated Status and Effectiveness Monitoring Program) evaluated the effectiveness of reconnecting numerous small tributaries to the mainstem Lemhi River for the Lemhi IMW. While tributary reconnections are the major restoration focus, the Lemhi River IMW also evaluates additional habitat actions including channel modifications, riparian fencing, diversion removals and screening, and side-channel development.

BPA Project 2011-006-00 (Columbia Habitat and Monitoring Program) developed and continued to implement a standardized habitat monitoring program for habitat status and trend that included the Lemhi.

3. *Action effectiveness pilot studies in Bridge Creek of the John Day River Basin to study treatments of channel incision and its effects on passage, channel complexity, and consequentially fish productivity.*

BPA Project 1998-016-00 (Escapement and Productivity of Spring Chinook and Steelhead) provided basin-wide status and trend data for anadromous salmonids in the John Day River Basin.

BPA Project 2003-017-00 (Integrated Status and Effectiveness Monitoring Program) examined the effects of restoration actions on aggrading incised stream channels and restoring floodplain connectivity on steelhead growth, survival, abundance, and production. Restoration is aimed at causing aggradation of the incised stream channels by installing a series of instream beaver dam support structures, (vertical wood post driven into the stream bottom) designed to assist beaver in the construction of stable, longer-lasting dams.

BPA Project 2011-006-00 (Columbia Habitat and Monitoring Program) developed and implemented a standardized habitat monitoring program for habitat status and trend to support habitat and fish relationship development used in limiting factor assessments and for planning and evaluation of habitat actions, preliminary summaries of habitat quality indices for the John Day River Basin.

4. *Project and watershed level assessments of habitat, habitat restoration and fish productivity in the Wenatchee, Methow, and John Day basins.*

Reclamation Project R08-PG-17-887 (Mainstem Methow River Habitat Effectiveness Monitoring) with USGS (CRRL) continued to collect pre- and post-floodplain treatment fish production data. Three publications reported the success of a passage project on Beaver Creek: Colonization of steelhead (*Oncorhynchus mykiss*) after barrier removal in a tributary to the Methow River, Washington (Weigel et al. 2013); Colonization of Steelhead in a Natal Stream after barrier removal (Weigel 2013a); and Fluvial rainbow trout contribute to the colonization of steelhead (*Oncorhynchus mykiss*) in a small stream (Weigel et al. 2013b). Re-treatment fish population estimates for Middle Methow River side channels and tributaries are forthcoming in early 2014.

Reclamation Project R10-PG-10-445 (Integrative Data Modeling, Analyst and Management Activities) with USGS develops a model from first principles to assess the effectiveness of habitat treatments in the Methow River Basin. The first peer-reviewed paper is scheduled for publication in early 2014. This project will be continued in 2014-2016 through funding with USGS Forest and Rangeland Ecosystem Science Center.

BPA Project 2003-017-00 (Integrated Status and Effectiveness Monitoring Program) examined the effects of restoration actions on aggrading incised stream channels and restoring floodplain connectivity on steelhead growth, survival, abundance, and production in Bridge Creek, John Day Basin. Restoration is aimed at causing aggradation of the incised stream channels by installing a series of instream beaver dam support structures, (vertical wood post driven into the stream bottom) designed to assist beaver in the construction of stable, longer-lasting dams.

BPA Project 2010-034-00 (Upper Columbia Spring Chinook and Steelhead Juvenile and Adult Abundance, Productivity and Spatial Structure Monitoring) evaluated precision and accuracy of smolt monitoring and the precision of redd counts for both steelhead and spring Chinook, estimated the proportion of hatchery steelhead, and

evaluated the accuracy of the steelhead spawning ground survey design in Upper Columbia Rivers. The application of fish monitoring protocols/methods in the Wenatchee and Methow benefit directly from this project.

BPA Project 2011-006-00 (Columbia Habitat and Monitoring Program) developed and implemented a standardized habitat monitoring program for habitat status and trend to support habitat and fish relationship development used in limiting factor assessments and for planning and evaluation of habitat.

5. *Action Agencies will convene a regional technical group to develop an initial set of relationships in FY 2008, and then annually convene the group to expand and refine models relating habitat actions to ecosystem function and salmon survival by incorporating research and monitoring results and other relevant information.*

BPA Project 2004-002-00 (Pacific Northwest Aquatic Monitoring Program Coordination) funded the Pacific Northwest Aquatic Monitoring Program providing a forum for coordination of aquatic monitoring efforts in the region to promote consistency in monitoring approaches and protocols; follow a scientific foundation; support monitoring policy and management objectives; and collect and present information in a manner that can be shared. Reclamation's Interagency Agreement with USGS (IA R13-PG-10-428) also provides funding for PNAMP. PNAMP work supported development of modeling approaches through products that provided more accessible data and standardized metadata.

BPA Project 2009-004-00 (Monitoring Recovery Trends in Key Spring Chinook Habitat Variables and Validation of Population Viability Indicators) monitored to identify areas that have depressed populations within a subbasin in the Columbia, and establish habitat conditions for these populations at different scales.

BPA Project 2003-017-00 (Integrated Status and Effectiveness Monitoring Program) held workgroup meetings to discuss fish and habitat monitoring modeling approaches.

BPA Project 2012-001-00 (AMIP Salmonid Life Cycle Model Support) collaboratively worked with several regional entities on fish and habitat relationships and associated life cycle modeling approaches.

RME Strategy 4 (RPA Actions 58 – 61)

RPA Action 58 – Monitor and Evaluate Fish Performance in the Estuary and Plume

The Action Agencies will monitor biological responses and/or environmental attributes, and report in the following areas:

1. *Monitor and evaluate smolt survival and/or fitness in select reaches from Bonneville Dam through the estuary.*

BPA Project 2003-007-00 (Lower Columbia River Estuary Ecosystem Monitoring) collected data on juvenile salmonid lipid content at monitoring sites throughout the LCRE. Lipid content can be an indicator of smolt fitness or condition.

AFEP Project EST-P-09-01 (Evaluation of Life History Diversity, Habitat Connectivity,

and Survival Benefits Associated with Habitat Restoration Actions in the Lower Columbia River and Estuary) further developed a conceptual and numerical species-habitat model that incorporates both onsite benefits of habitat actions (i.e., juvenile salmonids entering and occupying restored habitats) and offsite benefits of habitat actions (i.e., juvenile salmonids that do not enter the site, but benefit from resources exported from the site in the form of detritus and prey). Completed a laboratory experiment to determine the relationship between fish tissue accretion/degradation and habitat conditions as reflected in various food quantity levels. This study was a proof of concept toward establishing physiological measure(s) to quantify benefits that juvenile salmon obtain from habitat restoration projects in the lower Columbia River and estuary.

2. *Develop an index and monitor and evaluate life history diversity of salmonid populations at representative locations in the estuary.*

AFEP Project EST-P-09-01 (Evaluation of Life History Diversity, Habitat Connectivity, and Survival Benefits Associated with Habitat Restoration Actions in the Lower Columbia River and Estuary) further developed an early life history diversity index for juvenile salmon and steelhead in the lower Columbia River and estuary. Factors of diversity include species, forklength and time of capture; and incorporates fish abundance, richness, and evenness. This index can be applied to compare changes in life history diversity at the same locale, but across time (e.g., status and trends) or across space (e.g., different locales, or habitats). It has application as a high-level indicator to track trends in the status of the recovery of salmon and steelhead populations in the Columbia River basin. This methodology was published in Johnson et al. 2014.

3. *Monitor and evaluate juvenile salmonid growth rates and prey resources at representative locations in the estuary and plume.*

BPA Project 1989-107-00 (Statistical Support for Salmon) developed the initial study designs for the National Marine Fisheries Service (NOAA Fisheries) and University of

Washington Snake River survival studies of 1993 to present. Since then, survival investigations have been extended to the use of balloon, radio, and acoustic tags.

BPA Project 1998-014-00 (Ocean Survival of Salmonids) collected information regarding juvenile salmonid growth (IGF-1) rates from Canada-USA Shelf study to compare juvenile salmonid growth rates with environmental measurements in the plume. This project also evaluated and reported (annually) prey abundance estimates for the Columbia River plume and northern California current based on productivity measurements.

BPA Project 2003-007-00 (Lower Columbia River Estuary Ecosystem Monitoring) provided dissolved oxygen, temperature, and conductivity data at habitat and fish monitoring locations and collects data on juvenile salmonid prey resources throughout the LCRE through the Estuary Partnership in conjunction with USGS. The Corps' Multi-Scale Action Effectiveness Research in the lower Columbia River and estuary (LCRE) (AFEP EST-P-11-01) intensively monitored and evaluated prey resources and juvenile salmonid consumption at Sandy River Delta (in Reach G of the estuary).

BPA Project 2003-009-00 (Canada-USA Shelf Salmon Survival Study) assessed the effects of ocean conditions on the production of Columbia River Basin salmon. The information generated in this study is intended to map the ocean conditions that

determine the growth and survival of Pacific salmon along the west coast of North America from southern British Columbia to southeast Alaska, and to identify which stocks of Columbia River salmon forage in these areas.

AVS-P-08-01 Project EST-P-10-01 (The contribution of tidal fluvial habitats in the Columbia River Estuary to the recovery of diverse salmon ESUs) evaluated otolith derived growth estimates of juvenile Chinook salmon at main-stem back-water and confluence habitats across the tidal, fluvial portion of the estuary (reaches C – H).

4. *Monitor and evaluate temporal and spatial species composition, abundance, and foraging rates of juvenile salmonid predators at representative locations in the estuary and plume.*

BPA Project 1998-014-00 (Ocean Survival of Salmonids) monitored avian predator densities and forage fish abundances in the Columbia River plume.

AFEP Project AVS-P-08-01 and AVS-P-08-02 (Avian Predation Research, Monitoring, and Evaluation) monitored predation impacts by Caspian terns and Double-crested cormorants in 2013 by examination of diet content (to estimate amount of juvenile salmon consumed by species) and recovery of Passive Integrated Transponder (PIT) tags to estimate predation impact by ESU/DPS.

RPA Action 59 – Monitor and Evaluate Migration Characteristics and Estuary/Ocean Conditions

The Action Agencies will monitor and evaluate selected ecological attributes of the estuary, which include the following or equivalent:

1. *Map bathymetry and topography of the estuary as needed for RM&E.*

BPA Project 2003-007-00 (Lower Columbia River and Estuary Ecosystem Monitoring) contributed to developing a seamless elevation dataset for the LCRE. This dataset represents the most up-to-date, comprehensive, and highest resolution elevation

dataset (including high-resolution light detection and ranging data) that has been generated for mapping bathymetry and topography in the LCRE.

2. *Establish a hierarchical habitat classification system based on hydrogeomorphology, ground-truth it with vegetation cover monitoring data, and map existing habitats.*

BPA Project 2003-007-00 (Lower Columbia River and Estuary Ecosystem Monitoring) supports multiple efforts in the estuary by mapping ecosystem processes to specific locations in the estuary to better organize current efforts (habitat actions and RME), as well as better predict how the LCRE landscape will evolve over time.

3. *Develop an index of habitat connectivity and apply it to each of the eight reaches of the study area.*

AFEP Project EST-P-09-01 (Evaluation of Life History Diversity, Habitat Connectivity, and Survival Benefits Associated with Habitat Restoration Actions in the Lower Columbia River and Estuary) further developed an Area Time Inundation Index model during 2013. The area time inundation index model characterizes spatial and temporal inundation patterns; and integrates modeled or scenario-based hourly water-surface elevation data and terrain elevation data to evaluate habitat connectivity. Hydrological metrics include inundation frequency, duration, maximum area, and maximum frequency area. Model can inform evaluation of proposed

restoration sites; e.g., determine trade-offs between water-surface elevation and habitat opportunity, contrast alternative restoration designs, predict impacts of altered flow regimes, and estimate nutrient and biomass fluxes.

4. *Evaluate migration through and use of a subset of various shallow-water habitats from Bonneville Dam to the mouth toward understanding specific habitat use and relative importance to juvenile salmonids.*

BPA Project 2004-002-00 (Pacific Northwest Aquatic Monitoring Program Coordination) funded the Pacific Northwest Aquatic Monitoring Program to provide a forum for coordination of aquatic monitoring efforts in the region to promote consistency in monitoring approaches and protocols; follow a scientific foundation; support monitoring policy and management objectives; and collect and present information in a manner that can be shared. For example, standards for data sharing from PNAMP were adopted and incorporated into Oncor.

AVS-P-08-01 Project EST-P-10-01 (The contribution of tidal fluvial habitats in the Columbia River Estuary to the recovery of diverse salmon ESUs) sampled outmigrating juvenile salmon biweekly to monthly at a long-term beach-seine monitoring site near the estuary mouth; collected data on fish species composition, abundance, and life histories (size and timing); and archived Chinook salmon genetics and otolith samples for future analysis. This project also covered installation of PIT detectors and monitored migration distances and timing and wetland residency of PIT tagged juvenile salmonids entering each of four wetland channels (Russian Island, Woody Island, Wallace Island, Lower Sauvie Island) in 2013. Field study also focused on development of equipment, methods and protocols for sampling shallow and deeper water habitats in off-channel areas of the Columbia River.

AVS-P-08-01 Project EST-P-11-01 (Multi-Scale Salmon Ecosystem Action Effectiveness Monitoring and Research in the Lower Columbia River and Estuary) sampled juvenile salmon at Sturgeon Lake and Gilbert Lake to investigate juvenile salmon presence in off-channel, floodplain habitats. Data include fish species composition, abundance, and life history (size and timing).

5. *Monitor habitat conditions periodically, including water surface elevation, vegetation cover, plant community structure, primary and secondary productivity, substrate characteristics, dissolved oxygen, temperature, and conductivity, at representative locations in the estuary as established through RM&E.*

BPA Project 2003-007-00 (Lower Columbia River Estuary Ecosystem Monitoring) assessed annual trends in habitat status at restoration and reference sites and has been the primary contributor to habitat monitoring throughout the LCRE.

BPA Project 1998-014-00 (Ocean Survival of Salmonids) provided status and trends information relevant to the LCRE in the Climatological Atlas for the Columbia River plume and estuary. This information is synthesized into a variety of indicators that have been combined with data on adult returns over time and are now used to update annual predictions of returning adult salmonids.

BPA Project 2004-002-00 (Pacific Northwest Aquatic Monitoring Program Coordination) funded the Pacific Northwest Aquatic Monitoring Program to provide a forum for coordination of aquatic monitoring efforts in the region to promote consistency in monitoring approaches and protocols; follow a scientific foundation; support monitoring policy and management objectives; and collect and present

information in a manner that can be shared.

AVS-P-08-01 Project EST-P-11-01 (Multi-Scale Salmon Ecosystem Action Effectiveness Monitoring and Research in the Lower Columbia River and Estuary) investigated water surface elevation and temperature at four sites in the Sandy River delta; sampling Post Office Lake (channel cross-sections, sediment accretion, ground surface elevation, water surface elevation and photo points) to establish pre-construction site conditions; and investigated fish community assemblages at Sturgeon Lake, a floodplain lake next to the Columbia River. Sampling informed pre-restoration site conditions and use by juvenile salmon.

RPA Action 60 – Monitor and Evaluate Habitat Actions in the Estuary

The Action Agencies will monitor and evaluate the effects of a representative set of habitat projects in the estuary, as follows:

1. *Develop a limited number of reference sites for typical habitats (e.g., tidal swamp, marsh, island, and tributary delta to use in action effectiveness evaluations).*

BPA Project 2003-007-00 (Lower Columbia River Estuary Ecosystem Monitoring) assessed annual trends and reference sites and has been the primary contributor to habitat monitoring throughout the LCRE. Reference sites are used to inform restoration design and as a comparison for action effectiveness studies.

AFEP Project EST-P-09-01 (Evaluation of Life History Diversity, Habitat Connectivity, and Survival Benefits Associated with Habitat Restoration Actions in the Lower Columbia River and Estuary) completed a Synthesis of Environmental and Plant Community Data for Tidal Wetland Restoration Planning in the Lower Columbia River and Estuary. Environmental and plant community data collected at 55 tidal wetlands and 3 newly restored sites in the lower Columbia River and estuary between 2005 and 2011 were analyzed. Synthesis provides environmental and plant community data in tabular form to support ecosystem restoration; specifically improvements in tidal wetland restoration and creation planning and design by providing reference site elevations and coincident plant community requirements.

2. *Evaluate the effects of selected individual habitat restoration actions at project sites relative to reference sites and evaluate post-restoration trajectories based on project-specific goals and objectives.*

BPA Project 2003-011-00 (Lower Columbia River/Estuary Habitat Restoration) intensively monitored water surface elevation, bathymetry and topography, substrate, vegetation composition and percent cover, and juvenile salmon density at three sites where tidal reconnections were restored. This project evaluates the effectiveness of restoration projects.

AVS-P-08-01 Project EST-P-11-01 (Multi-Scale Salmon Ecosystem Action Effectiveness Monitoring and Research in the Lower Columbia River and Estuary) investigated water surface elevation and temperature at four sites in the Sandy River delta; sampling Post Office Lake (channel cross-sections, sediment accretion, ground surface elevation, water surface elevation and photo points) to establish pre-construction site conditions; and investigated fish community assemblages at Sturgeon Lake, a floodplain lake to the Columbia River. Sampling informed pre-restoration site conditions and use by juvenile salmon.

3. *Develop and implement a methodology to estimate the cumulative effects of habitat*

conservation and restoration projects in terms of cause-and-effect relationships between ecosystem and controlling factors, structures, and processes affecting salmon habitats and performance.

AFEP Project EST-P-09-01 (Evaluation of Life History Diversity, Habitat Connectivity, and Survival Benefits Associated with Habitat Restoration Actions in the Lower Columbia River and Estuary) completed an evidence based evaluation of the cumulative beneficial effects of habitat restoration on juvenile salmon in the LCRE. Two hypothesis were tested: (1) habitat-based indicators of ecosystem controlling factors, processes, and structures show positive effects from restoration actions; and (2) fish-based indicators of ecosystem processes and functions show positive effects from habitats undergoing restoration. Analyses provided strong support that habitat restoration in the LCRE is benefiting juvenile salmon (directly) during access to restored shallow-water areas and (indirectly) during active transit of main-stem river habitats. In general, tidal wetlands in the LCRE support juvenile salmon, including interior basin salmon. The beneficial effect of tidal wetlands would be expected to increase over time as existing restoration projects mature and new ones are implemented.

AFEP Project EST-P-12-01 (Synthesis and Evaluation of Research, Monitoring, and Restoration Project Data in the Lower Columbia River and Estuary) developed a web-based, geospatial data management and analysis system (called "Oncor") for research, monitoring and evaluation (RME) data. Development included (1) coordination with agencies and regional stakeholders to establish key analysis questions and database needs; (2) database construction; (3) analysis and synthesis of data (fish, vegetation, photo points, water surface elevation, water temperature, and sediment accretion); and (4) formulation of data reduction procedures and data exchange templates for nine monitoring indicators.

AFEP Project EST-P-12-01 (Synthesis and Evaluation of Research, Monitoring, and Restoration Project Data in the Lower Columbia River and Estuary) undertook habitat restoration and related RME which was adaptively managed under the Columbia Estuary Ecosystem Restoration Program (CEERP). This program provided critical guidance to regional managers, including action agencies and restoration practitioners; and was used to prioritize research and monitoring objectives, particularly action effectiveness evaluations. Together these programmatic work efforts provided a cumulative sum benefit to the Columbia Estuary Ecosystem Restoration Program by optimizing resource investments and focusing study designs on critical information gaps.

RPA Action 61 – Investigate Estuary/Ocean Critical Uncertainties

The Action Agencies will fund selected research direct at resolving critical uncertainties that are pivotal in understanding estuary and ocean effects.

1. *Continue work to define the ecological importance of the tidal freshwater, estuary, plume, and near shore ocean environments to the viability and recovery of listed salmonid populations in the Columbia River Basin.*

BPA Project 1989-107-00 (Statistical Support for Salmon) conducted additional tagging of hatchery populations to improve the resolution of watershed estimates of juvenile hydrosystem survival. The project has provided guidance and technical assistance in mark-recapture study design and data analysis to multiple tribal, state, and federal agencies. This project provides technical review of study designs in the estuary.

BPA Project 1998-014-00 (Ocean Survival of Salmonids) examined causal mechanisms affecting survival such as food-web structure and growth conditions in the plume and coastal ocean.

BPA Project 2003-007-00 (Lower Columbia River Estuary Ecosystem Monitoring) monitored juvenile salmon use of shallow-water habitats in Reaches A-H. This project analyzed salmonid densities, fish community composition, salmonid age-size structure, genetic stock identity, prey availability/salmon diet, residence times, spatial and temporal distribution, growth rates and habitat characteristics.

BPA Project 2003-009-00 (Canada-USA Shelf Salmon Survival Study) investigated habitat use in the nearshore ocean that was used to analyze the relative ecological importance of this environment.

AVS-P-08-01 Project EST-P-10-01 (The contribution of tidal fluvial habitats in the Columbia River Estuary to the recovery of diverse salmon ESUs) analyzed and synthesized results from 2010-2013 estuary studies. Summarized data for: salmon habitat use and genetic stock composition in reach F habitats; temporal variations in fish community structure and life history of out-migrant salmon near the estuary mouth; stock sources, travel times, and residency of PIT tagged salmon entering selected wetland tidal channels in reaches B, C, and F; Otolith-derived growth estimates for juvenile Chinook salmon collected at main-stem, back-water, and confluence habitats across the tidal fluvial estuary (Reaches C through H); Chinook salmon diet composition and instantaneous ration at main-stem and back-channel habitats in Reaches D and H (selected months March 2010 to September 2011); Otolith derived growth and survival estimates of adult spawning populations from two lower tributaries (Lewis River, Willamette River), two main-stem sites (Ives Island and Hanford Reach), and two upper Columbia River tributaries (Methow River and Wenatchee River); and shallow habitat opportunity modeling, including a new methodology based on depth criteria thresholds adjusted for biogenergetic (temperature), salinity, and velocity conditions.

2. *Continue work to define the causal mechanisms and migration/behavior characteristics affecting survival of juvenile salmon during their first weeks in the ocean.*

BPA Project 2003-009-00 (Canada-USA Shelf Study) examined causal mechanisms affecting survival such as food-web structure and growth conditions in the plume and coastal ocean.

BPA Project 1998-014-00 (Ocean Survival of Salmonids) examined causal mechanisms affecting survival such as food-web structure and growth conditions in the plume and coastal ocean.

3. *Investigate the importance of early life history of salmon populations in tidal freshwater of the lower Columbia River.*

BPA Project 2003-007-00 (Lower Columbia River Estuary Ecosystem Monitoring) monitored salmonid density, fish community composition, salmonid age-size structure, genetic stock identity, prey availability, residence times, spatial and temporal distribution, growth rates, and habitat characteristics throughout the LCRE to further investigate the importance of early life history diversity.

BPA Project 1989-107-00 (Statistical Support for Salmon) provided statistical support to the other projects supporting this RPA subaction.

AVS-P-08-01 Project EST-P-10-01 (The contribution of tidal fluvial habitats in the Columbia River Estuary to the recovery of diverse salmon ESUs) sampled outmigrating juvenile salmon at a long-term beach-seine monitoring site near the estuary mouth to determine fish species composition, abundance, and life histories (size and timing). This project also covered the installation of PIT detectors and monitored migration distances and timing and wetland residency of PIT tagged juvenile salmonids entering wetland channels at four sites.

4. *Continue development of a hydrodynamic numerical model for the estuary and plume to support critical uncertainties investigations.*

BPA Project 1998-014-00 (Ocean Survival of Salmonids) collected information regarding juvenile salmonid growth (IGF-1) rates from Canada-USA Shelf study to compare juvenile salmonid growth rates with environmental measurements in the plume. Annually evaluates and reports prey abundance estimates for the Columbia River plume and northern California current based on productivity measurements.

AVS-P-08-01 Project EST-P-10-01 (The contribution of tidal fluvial habitats in the Columbia River Estuary to the recovery of diverse salmon ESUs) further developed shallow water habitat opportunity model, including a new methodology for characterizing habitat opportunity based on depth criteria thresholds adjusted for biogenergetic (temperature), salinity, and velocity conditions.

RME Strategy 5 (RPA Action 62)

RPA Action 62 – Fund Selected Harvest Investigations

The Action Agencies will fund selected harvest investigations linked to FCRPS interests:

1. *Evaluate the feasibility of obtaining PIT Tag recoveries between Bonneville and McNary dams to determine whether recoveries can help refine estimates of in-river harvest rates and stray rates used to assess adult survival rates.*

BPA Project 2008-502-00 (Expanded Tribal Catch Sampling (CRITFC)) improved the monitoring and catch sampling of the Zone 6 tribal fisheries by increasing the collection of tribal catch data through increased sample rates and employing the use of additional data collection methods.

BPA Project 2008-508-00 (Power Analysis Catch Sampling Rates (CRITFC)) evaluated run timing and upstream migration mortality of adult Chinook and sockeye salmon and steelhead through PIT Tagging at Bonneville Dam.

2. *Evaluate methods to develop or expand use of selective fishing methods and gear.*

BPA Project 2008-105-00 (Selective Gear Deployment (Colville Confederated Tribes)) continued use of selective fishing gear to harvest non-sensitive salmon species (hatchery-origin summer Chinook and natural-origin sockeye) for tribal utilization while simultaneously releasing ESA-listed sensitive salmon stocks (i.e., spring Chinook and summer steelhead) and natural origin summer Chinook. The project is a continuation of project 2007-249-00 Evaluate Live Capture Gear, which ended in 2011.

BPA Project 1993-060-00 (Select Area Fisheries Enhancement (WDFW, ODFW,

Clatsop Co.)) continued investigation and implementation of the use of off-channel terminal fishing locations in concert with hatchery rearing and acclimation protocols to offer harvest opportunities when conventional mainstem fisheries are constrained or eliminated because of ESA limitations.

3. *Evaluate post-release mortality rates for selected fisheries.*

BPA Project 2008-105-00 (Deployment of Live Capture Gear) has ceased evaluating post-release mortality rates, and did not do so in 2013.

4. *Support coded-wire tagging and coded-wire tag recovery operations that inform survival, straying, and harvest rates of hatchery fish by stock, rearing facility, release treatment, and location.*

BPA Project 1982-013-01 (Coded Wire Tag-Pacific States Marine Fisheries Commission (PSMFC)) covered operation of the regional CWT database (the Regional Mark Information System), catch sampling and recovery of CWT and PIT Tags from commercial and sport fisheries, spawning ground surveys, and lab extraction of CWTs.

BPA Project 1982-013-02 (Coded Wire Tag-Oregon Department of Fish & Wildlife (ODFW)) funded adipose fin clip and insertion of CWTs and lab extraction of CWTs by ODFW.

BPA Project 1982-013-03 (Coded Wire Tag-U.S. Fish & Wildlife Service (USFWS)) funded adipose fin clip and insertion of CWTs and lab extraction of CWTs by WDFW.

BPA Project 1982-013-04 (Coded Wire Tag-Washington Department of Fish & Wildlife (WDFW)) funded adipose fin clip and insertion of CWTs and lab extraction of CWTs by WDFW.

BPA Project 1983-350-03 (Nez Perce Tribal Hatchery Monitoring and Evaluation) monitored and evaluated hatchery and natural fish through PIT Tagging, weir operation and/or spawning ground surveys, screw trapping, habitat surveys, genetic analysis, and harvest monitoring.

BPA Project 1988-053-03 (Hood River Production Monitoring and Evaluation-Warm Springs) implemented, monitored, and evaluated actions in the Hood River Master Plans for consistency with Hood River Production Program goals.

BPA Project 1995-063-25 (Yakima River Monitoring and Evaluation-Yakima/Klickitat Fisheries Project (YKFP)) monitored and evaluated activities under this project for the Yakima River Subbasin assigned to the Yakama Nation.

BPA Project 1997-015-01 (Imnaha River Smolt Monitoring (Nez Perce)) tagged and monitored steelhead and Chinook smolts during outmigration from Imnaha.

BPA Project 2002-060-00 (Nez Perce Harvest Monitoring on Snake and Clearwater Rivers) designed sampling strategies to provide greater data precision in treaty catch reports and exploitation rates during select Nez Perce fishery seasons.

BPA Project 2010-036-00 (Lower Columbia Coded Wire Tag Recovery Project (WDFW)) funded catch sampling and recovery of CWT and PIT Tags from commercial and sport fisheries, spawning ground surveys, management of the WDFW trap, weirs, and surveys and spawning ground surveys (SGS) databases, and escapement

analysis.

5. *Investigate the feasibility of genetic stock identification monitoring techniques.*

BPA Project 1983-350-03 (Nez Perce Tribal Hatchery Monitoring & Evaluation) monitored and evaluated for hatchery and natural fish through PIT Tagging, weir operation and/or spawning ground surveys, screw trapping, habitat surveys, genetic analysis, and harvest monitoring.

BPA Project 1989-096-00 (Genetic Monitoring and Evaluation Program for Salmon and Steelhead (ODFW, NOAA Fisheries)) monitored genetic changes associated with hatchery propagation in multiple Snake River subbasins for Chinook salmon and steelhead and derives estimates of reproductive success for individual families and groups of fish.

BPA Project 1989-098-00 (Salmon Studies in Idaho Rivers-Idaho Department of Fish & Game (IDFG)) analyzed DNA from adult and juvenile Chinook salmon for parentage analysis and genetic monitoring.

BPA Project 1990-055-00 (Idaho Steelhead Monitoring and Evaluation (IDFG)) monitored and evaluated the status and trends of wild steelhead populations in Idaho.

BPA Project 1991-073-00 (Idaho Natural Production Monitoring and Evaluation (IDFG)) monitored trends in abundance, productivity, spatial structure, and diversity for spring/summer Chinook salmon and steelhead trout in the Salmon, Clearwater, and minor middle Snake tributaries in the Idaho portion of Hells Canyon, as well as for the Snake River spring/summer Chinook ESU.

BPA Project 1995-063-25 (Yakama River Monitoring and Evaluation-Yakima/Klickitat Fisheries Project (YKFP)) collected genetic data samples to detect significant genetic changes in extinction risk, within-stock genetic variability, between-stock genetic variability, and domestication selection.

BPA Project 1996-043-00 (Johnson Creek Artificial Propagation Enhancement (NPT)) quantified 38 key performance measures, which are being standardized throughout the Columbia River Basin, and contributed to regional RME efforts addressing six major categories: (1) abundance, (2) survival-productivity, (3) distribution, (4) genetic, (5) life history, and (6) habitat.

BPA Project 1997-015-01 (Imnaha River Smolt Monitoring (NPT)) tagged and monitored steelhead and Chinook smolts during outmigration from the Imnaha River.

BPA Project 1997-030-00 (Chinook Salmon Adult Abundance Monitoring (NPT)) monitored escapement of natural-origin spring/summer Chinook salmon (Snake River spring/summer Chinook ESU).

BPA Project 1997-038-00 (Listed Stock Chinook Salmon Gamete Preservation (NPT)) continued in a maintenance phase with no gamete collections in 2013. Samples stored at the Washington State University repository were monitored and securely maintained.

BPA Project 1998-007-02 (Grande Ronde Supplementation Operations and Maintenance and Monitoring and Evaluation on the Lostine River (NPT)) monitored

and evaluated the Chinook salmon conventional hatchery program for the Lostine River.

BPA Project 1998-016-00 (Escapement and Productivity of Spring Chinook and Steelhead (ODFW)) provided basin-wide status and trend data for anadromous salmonids in the John Day River Basin.

BPA Project 2002-030-00 (Salmon and Steelhead Progeny Markers (CTUIR)) took fin clips from returning adult steelhead, broodstock held at Minthorn Springs facility and juveniles collected for otolith extraction. Genetic information gathered is used for determining maternal origins in validation of a transgenerational mark.

BPA Project 2002-053-00 (Asotin Creek Salmon Population Assessment (WDFW)) collected DNA samples from adult steelhead and adult Chinook salmon when captured incidentally.

BPA Project 2003-054-00 (Evaluate the Relative Reproductive Success of Hatchery-Origin and Wild-Origin Steelhead Spawning Naturally in the Hood River (Oregon State University)) used gene expression profiling to identify potential traits that differ genetically between hatchery and wild fish.

BPA Project 2003-063-00 (Natural Reproductive Success and Demographic Effects of Hatchery-Origin Steelhead in Abernathy Creek, Washington (WDFW)) evaluated relative reproductive success between hatchery-origin and natural-origin steelhead trout, simultaneously investigating methods of operating a conservation hatchery and the effectiveness of integrated artificial production programs toward supporting naturally spawning populations.

BPA Project 2007-404-00 (Spring Chinook Captive Propagation-Oregon (ODFW, NPT)) maintained captive broodstock and evaluated growth, health, survival to maturation, age and size at maturation, fecundity and other characteristics for individuals of each brood year and of each experimental treatment group (eggs vs. parr and fully vs. partially covered tanks).

BPA Project 2008-907-00 (Genetic Assessment of Columbia River Stocks (CRITFC)) combined four interrelated projects from the Accords that address Single Nucleotide Polymorphism Discovery, Genetic Baseline Expansion, GSI to Evaluate Catch, and GSI of fishes passing Bonneville Dam.

BPA Project 2009-005-00 (Influence of Environment and Landscape on Salmon and Steelhead Genetics (CRITFC)) determined correlation of watershed characteristics such as elevation, barriers, migration distance, and temperature to genetic structure of Chinook salmon and steelhead populations, and tests for association of single nucleotide polymorphisms and gene expression results with traits of interest that are related to recovery of steelhead populations.

BPA Project 2010-026-00 (Chinook and Steelhead Genotyping for GSI at Lower Granite Dam (IDFG)) developed and maintained Columbia River basinwide single nucleotide polymorphism baselines for steelhead and Chinook salmon as well as develops and implements GSI techniques for Snake River steelhead and Chinook salmon monitoring.

BPA Project 2010-028-00 (Estimate Adult Steelhead Abundance in Small Streams Associated with Tucannon & Asotin Populations (WDFW)) collected tissue samples for

inclusion in Snake Basin genetic characterization of steelhead for future run reconstruction estimates at Lower Granite Dam (coordinated with Project 2010-026-00).

BPA Project 2010-030-00 (Provide Viable Salmonid Population Estimates for Yakima Steelhead MPG (YN,WDFW)) conducted biological and DNA sampling at the Chandler juvenile, and Prosser and Roza adult monitoring facilities, as well as analysis of steelhead DNA samples to improve the genetic profile for all four populations in the MPG.

BPA Project 2010-031-00 (Snake River Chinook and Steelhead Parental Based Tagging (IDFG)) genotyped approximately 16,500 samples (annually) to create the first parental genetic baselines for hatchery steelhead and Chinook salmon in the Snake River basin.

BPA Project 2010-032-00 (Imnaha River Steelhead Monitoring (NPT)) collected tissue samples from adult to describe the genetic stock structure, gene flow between spawning aggregates, and determine effective population size.

RME Strategy 6 (RPA Actions 63-65)

RPA Action 63 – Monitor Hatchery Effectiveness

The Action Agencies will continue to fund selected monitoring and evaluation of the effectiveness of Hatchery Actions. The evaluation of hatchery projects will be coordinated with the Tributary Habitat monitoring and evaluation program.

1. *Determine the effect that safety-net and conservation hatchery programs have on the viability and recovery of the targeted populations of salmon and steelhead. (Initiate in FY 2007–2009 Projects).*

Snake River Spring/Summer Chinook ESU and Steelhead DPS

BPA Project 1989-096-00 (Genetic Monitoring and Evaluation Program for Salmon and Steelhead) managed the genetic monitoring of Chinook salmon and steelhead populations in the Snake River Basin, with a particular focus on the effects of artificial propagation on both targeted and non-targeted populations.

BPA Project 1989-098-00 (Salmon Studies in Idaho Rivers-Idaho Department of Fish and Game) focused on collecting information on the Snake River Chinook ESU (Salmon River, which are listed under ESA and Clearwater River Chinook, which are not listed) to determine the benefits and risks of hatchery supplementation.

BPA Project 1996-043-00 (Johnson Creek Artificial Propagation Enhancement) has been ongoing since 1996 to evaluate the life cycle of natural- and hatchery-origin supplementation spring/summer Chinook salmon from Johnson Creek (part of the Snake River spring/summer Chinook ESU).

BPA Project 2010-057-00 (B-Run Steelhead Supplementation Effectiveness Research) research is linked to RPA Action 41, which focuses on B-Run steelhead supplementation effectiveness research to better address the abundance, productivity, spatial structure, and diversity of B-Run steelhead in the Clearwater River Basin.

BPA Project 1992-026-04 (Grande Ronde Early Life History of Spring Chinook and Steelhead) focused on the Snake River ESU and DPS on the Grande Ronde River populations of Chinook salmon and summer steelhead. The objectives of this study are to collect or derive information pertaining to juvenile salmon migration and survival patterns both within and outside the Grande Ronde River Basin.

BPA Project 1998-007-02 (Grande Ronde Supplementation Operation and Maintenance, and Monitoring and Evaluation on Lostine River) was initiated to monitor and evaluate the Chinook salmon conventional hatchery program for the Lostine River and the SRCP and conduct the monitoring and evaluation of juvenile acclimation and adult returns for the Grande Ronde Basin Spring Chinook Captive Broodstock Program.

BPA Projects 1998-007-03 (Grande Ronde Supplementation Operation and Maintenance on Catherine Creek/Upper Grande Ronde River) and 1998-007-04 (Grande Ronde Spring Chinook on Lostine/Catherine Creek/ Upper Grande Ronde Rivers) reported on fish culture activity (holding and spawning of adults, rearing juveniles, fish health monitoring, and redd surveys) for these programs, which are run in conjunction with the Lower Snake River Compensation Plan. These projects are associated with this subaction because they also collect spawner (redd count) information.

BPA Project 1998-016-00 (Escapement and productivity of spring Chinook and steelhead) collected information on the status, trends, and distribution of spawning activity, juvenile salmonids, and aquatic habitat conditions within the John Day River Basin. This project also collected information on steelhead (mid-Columbia River steelhead DPS) and Chinook salmon (non-listed mid-Columbia Chinook ESU) in the John Day River. This project is important because there are no hatchery fish released into the basin and therefore this basin can be as a comparison reference condition.

BPA Project 2007-083-00 (Grande Ronde Supplementation Monitoring and Evaluation on Catherine Creek/Upper Grande Ronde River) monitored and evaluated supplementation of endemic spring Chinook salmon in Catherine Creek and the upper Grande Ronde River, which are part of the Snake River spring/summer Chinook ESU. This study continued to collect important information on abundance, productivity, and life history attributes of Snake River Chinook ESU and steelhead DPS.

BPA Project 2010-042-00 (Tucannon Expanded PIT Tagging) is focused on increasing the detection of PIT Tagged steelhead (Snake River steelhead DPS) and spring Chinook salmon (Snake River spring/summer Chinook ESU) that enter the river upon return as adults. Increased detection will assist managers in determining abundance and origin of primarily steelhead (Chinook redd count and carcass surveys are much more effective than steelhead surveys) entering the Tucannon River and detect fish that may stray into the river.

Snake River Sockeye Salmon ESU

BPA Project 2007-402-00 (Snake River Sockeye Salmon Captive Broodstock) is intended to utilize captive broodstock technology to conserve the population's unique genetics of the Snake River sockeye salmon ESU. The long-term goal is to reach interim abundance guidelines for delisting and provide for sport and tribal harvest.

Lower Columbia River Chum Salmon ESU

BPA Project 2008-710-00 (Development of an Integrated strategy for Chum Salmon Restoration in the tributaries below Bonneville Dam) goals include: (1) reintroduction of chum salmon (that are part of the lower Columbia River chum salmon ESU) into Duncan Creek by providing off-channel high-quality spawning and incubation areas; and (2) simultaneously evaluation of natural recolonization, direct adult supplementation, and hatchery fed-fry supplementation.

Basin-wide

Efforts to facilitate the formation of a regional workgroup (currently designated the Columbia River Hatchery Effects Evaluation Team (CRHEET)) to coordinate monitoring of regional hatchery effectiveness, as well as implementation of the recommendations made by the Ad Hoc Supplementation Work Group are on hold while NOAA Fisheries completes the ESA consultations on FCRPS mitigation hatcheries (see AMIP Amendment 6 of this document).

2. *Determine the effect that implemented hatchery reform actions have on the recovery of targeted salmon and steelhead populations.*

Upper Columbia River Steelhead DPS

BPA Project 1993-056-00 (Advance Hatchery Reform Research) advanced hatchery reform throughout the Columbia River Basin by developing fish culture solutions that enable use of locally derived broodstocks for steelhead in hatcheries with rearing environments that preclude standard culture practices.

Snake River Spring Summer Chinook ESU and Steelhead DPS

BPA Project 2010-042-00 (Tucannon Expanded PIT Tagging) and 2010-050-00 (Evaluation of the Tucannon Endemic Program), addressed this RPA subaction regarding steelhead and Chinook populations in the Tucannon River (Snake River spring summer Chinook ESU and steelhead DPS).

RPA Action 64 – Investigate Hatchery Critical Uncertainties

The Action Agencies will continue to fund selected research directed at resolving artificial propagation critical uncertainties:

1. *Continue to estimate the relative reproductive success of hatchery-origin salmon and steelhead compared to reproductive success of their natural-origin counterparts for ESA-listed spring/summer Chinook population in the Upper Grande Ronde, Lostine River, and Catherine Creek; listed spring Chinook in the Wenatchee River; and listed steelhead in the Hood River. Continue to fund the ongoing relative reproductive success feasibility study for Snake River fall Chinook to completion in 2009.*

Snake River Steelhead DPS

BPA Project 1989-096-00 (Genetic Monitoring and Evaluation Program for Salmon and Steelhead) collected information on adult returns, age class, and genetic pedigree analysis that enabled the researchers to estimate reproductive success in hatchery- and natural-origin fish in three river basins (Lostine River, Catherine Creek, and upper Grande Ronde River).

Upper Columbia Spring Chinook ESU

BPA Project 2003-039-00 (Monitoring and Evaluation Reproductive Success and Survival in Wenatchee River) continued to quantitatively evaluate the Reproductive Success and Survival (RSS) of naturally spawning hatchery- and natural-origin spring Chinook salmon in the Wenatchee River (upper Columbia River spring Chinook ESU).

BPA Project 2007-083-00 (Grande Ronde Supplementation Monitoring and Evaluation on Catherine Creek/Upper Grande Ronde River) continued to monitor and evaluate supplementation of endemic spring Chinook salmon in Catherine Creek and the upper Grande Ronde River, which are part of the Snake River spring/summer Chinook ESU. This study continues to collect important information on abundance, productivity, and life history attributes of Snake River Chinook ESU and steelhead DPS.

Lower Columbia River Steelhead DPS

BPA Project 2003-054-00 (Evaluate the Relative Reproductive Success of Hatchery-Origin and Wild-Origin Steelhead Spawning Naturally in the Hood River) evaluated the Reproductive Success and Survival of hatchery-versus natural-origin steelhead in the Hood River (lower Columbia River steelhead DPS). Information collected primarily consisted of genetic sampling of returning adults passing Powerdale Dam (now removed). In 2013, the project continued to investigate mechanisms of domestication.

2. *Determine if properly designed intervention programs using artificial production make a net positive contribution to recovery of listed populations.*

Snake River Fall Chinook ESU

BPA Project 1990-005-00 (Umatilla Hatchery Monitoring and Evaluation) concerns fall Chinook salmon (Snake River fall Chinook ESU). The primary goal of this project is to monitor and evaluate different rearing and release scenarios by documenting travel time and survival from release to Three Mile Dam (Umatilla River Basin) and Columbia River dams.

BPA Project 2010-031-00 (Snake River Chinook and Steelhead Parental Based Tagging) continued to develop and evaluate a new genetic technology called, PBT, that can serve as a versatile tool for mass marking of steelhead and Chinook salmon in the Snake River Basin (Snake River spring/summer Chinook ESU and steelhead DPS). It is anticipated that this tool will have the capability to address aspects of hatchery reform, salmonid life history, harvest patterns, and trait heritability.

BPA Project 1997-030-00 (Chinook Salmon Adult Abundance Monitoring) continued to monitor escapement of natural-origin spring/summer Chinook salmon (Snake River spring/summer Chinook ESU). Escapement is estimated using dual frequency identification sonar (DIDSON) technology. Validation monitoring of DIDSON target counts with underwater optical cameras occurs for the purpose of species identification. The information collected from this project has shown success in using a monitoring system that could potentially be used in other remote areas, where logistical concerns prevent regular surveys. This stream (Secesh River) is particularly important because it has the potential to be used as a reference stream.

BPA Project 1997-015-01 (Imnaha River Smolt Monitoring) continued to monitor spring Chinook salmon and steelhead (Snake River spring/summer Chinook ESU and

steelhead DPS) emigrating from the Imnaha River and report the real-time information to the FPC.

BPA Project 2010-032-00 (Imnaha River Steelhead *Oncorhynchus mykiss* Adult Monitoring Project) continued to provide status information on Snake River steelhead in the Imnaha River Subbasin. In addition to population viability monitoring, a sub-goal is to ensure that the information can be used to inform the co-managers on potential fisheries.

Mid-Columbia Steelhead DPS

BPA Project 2000-039-00 (Walla Walla River Basin Monitoring and Evaluation) continued to provide ecological information in support of adaptive management for ESA recovery, population restoration, conservation, and preservation of cultural, social, and economic salmonid resources.

BPA Project 2007-299-00 (Investigation of Relative Reproductive Success of Stray Hatchery & Wild Steelhead & Influence of Hatchery Strays on Natural Productivity in Deschutes) continued to assess the effects that naturally spawning hatchery steelhead have on the viability of their wild steelhead counterparts in the Deschutes River Basin (mid-Columbia steelhead DPS).

BPA Project 1990-005-00 (Umatilla Hatchery Monitoring and Evaluation concerns steelhead (mid-Columbia steelhead DPS) continued to monitor and assess juvenile migration timing and survival of hatchery smolts to Three Mile Falls Dam and Columbia River dams.

Lower Columbia River Chinook ESU and Steelhead DPS

BPA Project 1988-053-03 (Hood River Production Monitoring and Evaluation-Warm Springs) continued to collect information concerning the winter steelhead (lower Columbia River steelhead DPS) hatchery program and environmental information. Information collected includes migration timing and survival.

BPA Project 1988-053-04 (Hood River Pelton Ladder Evaluation Studies) continued to collect information related to the Hood River Production Program. This project collects information to estimate juvenile production with screw traps; harvest (all species); natural production of steelhead; natural production of cutthroat; natural production of bull trout; migration timing and other life history traits for adult summer and winter steelhead (lower Columbia River steelhead DPS), jack and adult spring and fall Chinook salmon, and coho. For hatchery production, for broodstock information collection includes; number of juveniles released and post release survival. The information collected through this project is important for understanding the effects of hatchery programs on natural populations.

BPA Project 1988-053-15 (Parkdale NOAA Fisheries Comparative Hatchery Study) continued to implement one of the Hood River Production Program's objectives to "provide co-managers with the best available information for determining a long-term biologically sound and cost-effective spring Chinook salmon (lower Columbia River Chinook ESU) production strategy for the Hood River Basin that balances harvest needs with ecological considerations." The objective of this evaluation is to conduct a multi-year (2008-2018) comparative study of Hood River spring Chinook reared at three different hatchery facilities prior to being moved to the West Fork Hood River for final acclimation and release.

BPA Project 2003-050-00 (Evaluate the Reproductive Success of Wild and Hatchery Steelhead in Natural and Hatchery Environments) continued to investigate interactions and comparative reproductive success of wild and hatchery origin steelhead trout in Forks Creek, a tributary of the Willapa River in southwest Washington. The overall objective was to determine the factors influencing reproductive success in wild and hatchery-origin steelhead in natural and hatchery environments.

BPA Project 2003-063-00 (Natural Reproductive Success and Demographic Effects of Hatchery-Origin Steelhead in Abernathy Creek, Washington) continued to assess natural reproductive success and mean relative fitness of hatchery-origin and natural-origin steelhead (lower Columbia River steelhead DPS) in Abernathy Creek, Washington, and to assess the overall demographic effects of hatchery fish.

Mid-Columbia Spring Chinook ESU (Non-listed)

BPA Project 1995-063-25 (Yakima River Monitoring and Evaluation-YKFP) focuses on Yakima River spring Chinook salmon (mid-Columbia spring Chinook salmon ESU) which are not listed under the ESA. The goal of the project is to monitor, evaluate, and conduct research related to the YKFP. The project includes research occurring over many facets of artificial supplementation. The project has targeted research regarding relative reproductive success, ecological interactions between non-target taxa of concern and hatchery-origin salmon, effects of domestication on predation and competitive dominance, reproductive ecology, and effects of predation on natural production.

BPA Project 2002-031-00 (Growth modulation in salmon supplementation) continued to compare the physiology and development of naturally rearing wild and hatchery-reared spring Chinook in the Yakima River Basin (mid-Columbia River spring Chinook ESU).

BPA Project 2008-458-00 (Upper-Columbia River Steelhead Kelt Reconditioning Project) continued to increase the abundance of naturally-produced Upper Columbia River steelhead on natural spawning grounds by as much as 10 percent through the use of kelt reconditioning.

Multiple DPS of Steelhead

BPA Project 2007-401-00 (Kelt reconditioning and reproductive success evaluation research) continued to develop steelhead kelt reconditioning and release strategies to increase depressed populations. Fish used as part of this project originate from Okanogan River Basin (upper Columbia River steelhead DPS), Yakima River Basin (mid-Columbia River steelhead DPS), and the Snake River Basin (Snake River steelhead DPS). To test the efficacy of utilizing steelhead kelt reconditioning as a management and recovery tool, different scenarios were investigated ranging from little intervention (collect and return fish to river) to high intensity (collect and feed fish in captivity until re-maturation).

- In collaboration with the other entities responsible for steelhead mitigation in the Methow River, BPA will fund a new relative reproductive success study for ESA-listed steelhead in the Methow River. BPA will also fund a new relative reproductive success study for listed fall Chinook in the Snake River. NOAA Fisheries will provide technical assistance to the Action Agencies in development of conceptual study designs suitable for use by the Action Agencies in obtaining a contractor to implement the new studies.*

For this subaction, projects are being funded to support RME for the specific populations described within the subaction.

Information needed to support this RPA subaction includes uncertainty research, including metrics such as abundance, origin, genotype, and age structure.

In the following section, a summary of the projects that are covering this RPA subaction is discussed.

Snake River Fall Chinook ESU

BPA Project 2003-060-00 (Evaluate the Relative Reproductive Success of Wild and Hatchery Origin Snake River Fall Chinook Spawners Upstream of Lower Granite Dam) continued to address components of this RPA subaction. After it was determined in 2011 that BPA Project 2003-060-00 (Evaluate the Relative Reproductive Success of Wild and Hatchery Origin Snake River Fall Chinook Spawners Upstream of Lower Granite Dam) would be infeasible to implement at this time. A letter dated February 2, 2012, was sent to BPA from NOAA Fisheries concerning monitoring needs associated with satisfying RPA Actions 64 and 65 as they relate to Snake River fall Chinook salmon. The monitoring actions associated with the letter are consistent with the two HGMPs that cover Snake River fall Chinook salmon, from the WDFW and the NPT. The letter from NOAA Fisheries identifies alternative actions that will satisfy the states that the intent of RPA Actions 64 and 65 with regards to Snake River fall Chinook. Research questions addressed in this project include investigation of release site fidelity and fall back at Lower Granite Dam.

Upper Columbia Steelhead DPS

BPA Project 2010-033-00 (Study Reproductive Success of Hatchery and Natural Origin Steelhead in the Methow) continued to monitor and evaluate reproductive success of Methow River steelhead (upper Columbia River steelhead DPS) and a suite of demographic characteristics. Differences in the run-timing, spawn-timing, age-composition, length-at-age, sex-ratio, and spawning distribution are measured between hatchery- and natural-origin fish that may explain differences in relative reproductive success if it occurs.

RPA Action 65 – Investigate Hatchery Critical Uncertainties

The Action Agencies will fund research directed at resolving critical uncertainties:

1. *In the mainstem Snake River above the Lower Granite Dam, estimate the effectiveness/fitness in nature of hatchery-origin fall Chinook salmon from federally funded Snake River hatchery programs relative to natural origin Snake River fall Chinook.*

Snake River Fall Chinook ESU

BPA Project 1991-029-00 (RME of emerging issues and measures to recover the Snake River fall Chinook salmon ESU) continued to collect data that is intended to inform the management and recovery of fall Chinook salmon (Snake River fall Chinook ESU). Research includes monitoring of redd counts, spawning site use, parr growth and survival, post-release performance of hatchery-origin fish through the Snake and Columbia rivers, comparison of different hatchery release strategies, and growth and food habits of Snake River fall Chinook salmon.

2. *Estimate fall Chinook hatchery program effects on the productivity of the fall Chinook salmon ESU.*

BPA Project 1991-029-00 (RME of emerging issues and measures to recover the Snake River fall Chinook salmon ESU) conducted RME associated with management and recovery of fall Chinook salmon (Snake River fall Chinook ESU). Research includes monitoring of redd counts, spawning site use, parr growth and survival, post-release performance of hatchery-origin fish through the Snake and Columbia rivers, comparison of different hatchery release strategies, and growth and food habits of Snake River fall Chinook salmon.

BPA Project 1983-350-03 (Nez Perce Tribal Hatchery Monitoring and Evaluation) includes the monitoring and evaluation of hatchery and natural fish. This project is involved in PIT Tagging, weir Operation and spawning ground surveys, and screw trap monitoring among other monitoring and evaluation activities.

BPA Project 1998-010-04 (Monitor and Evaluate Performance of Juvenile Snake River Fall Chinook Salmon from Fall Chinook Acclimation Project) evaluated the success of fall Chinook supplementation above Lower Granite Dam and informs management decisions for the future conservation and perpetuation of naturally spawning populations of fall Chinook salmon in the Snake and Clearwater Rivers above Lower Granite Dam.

3. *NOAA Fisheries will provide technical assistance to the Action Agencies in development of conceptual study designs suitable for use by the Action Agencies in obtaining a contractor to implement new studies.*

NOAA Fisheries and other regional technical experts provided technical assistance to BPA in 2010 to support development of targeted solicitations for the new Snake River fall Chinook salmon relative reproductive success study and any additional study or studies needed to estimate the effects of the fall Chinook hatchery programs on productivity of the ESU. In addition, there has been associated monitoring and evaluation under development in order to meet and satisfy research needs identified in the HGMP. The Action Agencies and NOAA Fisheries have agreed that there are necessary prerequisite studies which need to be conducted prior to the implementation of a relative reproductive success study or other studies of hatchery effects in SRFC.

RME Strategy 7 (RPA Actions 66-70)

RPA Action 66 – Monitor and Evaluate the Caspian Tern Population in the Columbia River Estuary

The Action Agencies will monitor the tern population in the estuary and its impacts on outmigrating juvenile salmonids, as well as the effectiveness of the Caspian tern management plan.

One BPA project was continued to fully address this RPA subaction. BPA Project 1997-024-00 (Avian Predation on Juvenile Salmonids) provided for the monitoring of the Caspian tern colony on East Sand Island. Colony size, reproduction rates, diet composition, and predation rates were monitored to determine the effect of the colony on juvenile salmon.

RPA Action 67 – Monitor and Evaluate the Double-Crested Cormorant Population in the Columbia River Estuary

The Action Agencies will monitor the cormorant population in the estuary and its impacts on outmigrating juvenile salmonids and develop and implement a management plan to decrease predation rates, if warranted.

In 2013, the double-crested cormorant colony on East Sand Island was monitored and dispersal, flight patterns were investigated. Colony size, reproduction rates, diet composition, and predation rates were monitored to determine the effect of the colony on juvenile salmon. Dispersal patterns were investigated to elucidate where the East Sand Island colony might relocate to, if habitat was limited.

RPA Action 68 – Monitor and Evaluate Inland Avian Predators

The Action Agencies will monitor avian predator populations in the Mid-Columbia River and evaluate their impacts on outmigrating juvenile salmonids and develop and implement a management plan to decrease predations rates, if warranted.

Monitoring and evaluation of avian predation on the Columbia Plateau, by the Corps and Reclamation focused on select Caspian tern and gull colonies in 2013 to support development of an Inland Avian Predation Management Plan. The Inland Avian Predation Management Plan developed by the Action Agencies, including evaluation of potential management scenarios, was released in October 2013 for public and agency review and subsequently finalized in January 2014. A draft report discussing 2013 RME results was released in April 2014 for regional review (Roby et al. 2014).

RPA Action 69 Monitoring Related to Marine Mammal Predation

1. *Estimate overall sea lion abundance immediately below Bonneville Dam. (Initiate in FY 2007 – 2010 Projects).*

From January 4 to May 31, 2013, the Corps continued to visually monitor the abundance of California and Steller sea lions in the Bonneville Dam tailrace observation area. In addition, BPA Project No. 2008-004-00 (Sea Lion Nonlethal Hazing and Monitoring) estimated general sea lion abundance while conducting in-river hazing on sea lions. See the discussion in Section 1 of this report for more detail.

2. *Monitor the spatial and temporal distribution of sea lion predation attempts and estimate predation rates. (Initiate in FY 2007-2010 Projects).*

In 2013, the Corps continued land-based visual observations to monitor sea lion predation on adult salmonids, white sturgeon, and lamprey in the Bonneville Dam tailrace observation area. The Corps also monitored the date and location of individual sea lion predation events. BPA Project No. 2008-004-00 (Sea Lion Nonlethal Hazing and Monitoring) observed the total number of sea lion predation events and recorded their location and time. See the discussion in Section 1 of this report for more detail.

3. *Monitor the effectiveness of deterrent actions (e.g., exclusion gates, acoustics, harassment and other measures) and their timing of application on spring runs of anadromous fish passing Bonneville Dam. (Initiate in FY 2007-2010 Projects).*

The effectiveness of deterrent actions and the timing of application on spring runs

were determined in 2013 through BPA- and Corps-funded efforts.

RPA Action 70 – Monitoring Related to Piscivorous (Fish) Predation

A comprehensive list of all actions implemented by the Action Agencies for RPA Action 70 is included in Section 3.

The Action Agencies will:

1. *Continue to update and estimate the cumulative benefits of sustained removals of northern pikeminnow since 1990.*

BPA Project 1990-077-00 (Development of System-wide Predator Control (PSMFC)) continued the Northern Pikeminnow Management Program which is a basin-wide program to harvest northern pikeminnow (*Ptychocheilus oregonensis*) that was started in 1991 to reduce predation by northern pikeminnow on juvenile salmonids during their emigration to the ocean.

2. *Continue to evaluate if inter- and intra-compensation is occurring.*

BPA Project 1990-077-00 (Development of System-wide Predator Control (PSMFC)) encompasses the Northern Pikeminnow Management Program which is a basin-wide program to harvest northern pikeminnow (*Ptychocheilus oregonensis*) that was started in 1991 to reduce predation by northern pikeminnow on juvenile salmonids during their emigration to the ocean.

3. *Evaluate the benefit of additional removals and resultant increase in exploitation rate's effect on reduction in predator mortality since the 2004 program incentive increase.*

BPA Project 2008-719-00 (Research Non-Indigenous Actions (USGS)) documented the food habits of non-native predators in the lower Columbia River during the late summer and fall to assess the role of juvenile American shad in their diets and any impacts on their health and condition, and assessed the potential efficacy of localized reductions of smallmouth bass for predation control.

4. *Develop a study plan to review, evaluate, and develop strategies to reduce non-indigenous piscivorous predation.*

BPA Project 1990-077-00 (Development of System-wide Predator Control (PSMFC)) encompasses the Northern Pikeminnow Management Program, which is a basin-wide program to harvest northern pikeminnow (*Ptychocheilus oregonensis*), that was started in 1991 to reduce predation by northern pikeminnow on juvenile salmonids during their emigration to the ocean.

RME Strategy 8 (RPA Actions 71 – 72)

RPA Action 71 – Coordination

The Action Agencies will coordinate RM&E activities with other Federal, State and Tribal agencies on an ongoing annual basis, including:

1. *Organizing and supporting the Corps AFEP.*

The Corps has, since 1952, sponsored biological studies in an integrated, applied

research program. These RME studies are managed under the AFEP. In 2013, the Corps again implemented the AFEP program. The primary activity was the development and selection of experimental designs and methodologies of research projects to be carried out in 2014. This process was extensively coordinated with other Federal agencies, States, and tribal interests through their involvement in the SRWG, which met several times throughout the planning year. In December 2013, an annual review, open to all interested parties, was held to present the results of AFEP funded research conducted during the year.

The AFEP program also includes the FFDRWG, which provides ongoing review of fish facility design activities. The FPOM Workgroup is outside of AFEP and provides ongoing review of operational activities related to fish passage. All Federal, State, and tribal fishery agencies are invited to participate in the quarterly FFDRWG meetings and monthly FPOM meetings.

2. *Supporting and participating in the Council's Columbia River Basin Fish and Wildlife Program project planning and review efforts.*

BPA continued to work with the NPCC in coordinating BPA's Fish and Wildlife Program and the FCRPS BiOp to achieve an integrated program. Achievements beyond the annual review of projects and budgets included the review and update of the Fish and Wildlife Program, the collaborative Fish Tagging Forum, and the Geographic Review of habitat work (see <http://www.nwcouncil.org/fw/reviews/> for more detailed information on review efforts).

3. *Supporting the standardization and coordination of tagging and monitoring efforts through participation and leadership in regional coordination forums such as PNAMP.*

Under BPA Project 2004-002-00 (Pacific Northwest Aquatic Monitoring Program), and Reclamation Project 4930, funding for PNAMP was provided for facilitation, technical support and a collaborative forum for the standardization and coordination of fish and habitat monitoring. PNAMP continued promoting integration of monitoring resources and building several tools to support monitoring in 2013.

4. *Working with regional monitoring agencies to develop, cooperatively fund, and implement standard metrics, business practices, and information collection and reporting tools needed to cooperatively track and report on the status of regional fish improvement and fish monitoring projects.*

BPA Projects 1988-108-04 (StreamNet – Coordinated Information System/Northwest Environmental Database (NED) managed by PNAMP staff at the USGS continued to support the implementation of the Coordinated Assessments Projects through PNAMP, CBFWA, and StreamNet to develop standard data exchange templates across the

Northwest for the indicators of adult spawner abundance and juvenile salmonid out-migrant production. In addition, significant progress on advancing data exchange for Hatchery indicators was initiated in 2013.

BPA Project 2004-002-00 (Pacific Northwest Aquatic Monitoring Program Coordination) continued the Pacific Northwest Aquatic Monitoring Program's Coordinated Assessments Project, in collaboration with Columbia Basin Fish & Wildlife Authority (CBFWA) and StreamNet to develop integrated data-sharing for anadromous-fish-related data among the co-managers (state fish and wildlife agencies and tribes) and Action Agencies of the Columbia River Basin. Reclamation's

Interagency Agreement with USGS (IA R13-PG-10-428) also provides funding to PNAMP.

BPA Project 2007-083-00 (Grande Ronde Supplementation Monitoring and Evaluation on Catherine Creek/upper Grande Ronde River) supported CTUIR participation in the Coordinated Assessments workshops.

BPA Project 2003-007-00 (Lower Columbia River Estuary Ecosystem Monitoring) continued BPA's participation in the PNAMP Integrated Status and Trends Monitoring (ISTM) project to discuss attributes necessary to develop a monitoring design using an area-based sample. To help standardize monitoring procedures, the Lower Columbia Estuary Program convened the Science Workgroup to standardize the application of the (Roegner et al. 2009) protocol (at www.monitoringmethods.org) in the project's protocol.

BPA Project 2003-017-00 (ISEMP) supported development of the data dictionaries in www.monitoringmethods.org related to habitat classifications. The ISEMP project also played a critical role in supporting the PNAMP ISTM project in development of the Master Sample which is now being managed under the www.monitoringresources.org Sample Designer tool.

BPA Project 2003-022-00 (Okanogan Basin Monitoring & Evaluation Program - OBMEP) continued BPA's participation in the PNAMP steering committee and supported development of the data dictionaries in [monitoringmethods.org](http://www.monitoringmethods.org) related to habitat classifications and attended the Coordinated Assessments workshops resulting in the development of their data management strategy to exchange fish abundance data.

BPA Project 2008-507-00 (CRITFC's Tribal Data Network Accord Project) was implemented to demonstrate implementation of coordination and standardization tools through evaluation and application of handheld technologies for data capture (e.g., the Digital Pen).

BPA Project 2011-006-00 (Columbia Habitat and Monitoring Program - Pilot (CHaMP-P)) developed and implemented a standardized habitat monitoring program for habitat status and trend to support habitat and fish relationship development used in limiting factor assessments and for planning and evaluation of habitat actions.

5. *Coordinating the further development and implementation of Hydrosystem, Tributary Habitat, Estuary/Ocean, Harvest, Hatchery, and Predation RM&E through leadership and participation in ongoing collaboration and review processes and workgroups.*

BPA Project 2003-017-00 (Integrated Status and Effectiveness Monitoring Program (ISEMP) provided extensive coordination of the development and implementation of tributary habitat RME in the pilot watersheds.

BPA Project 2004-002-00 (The Pacific Northwest Aquatic Monitoring Program Coordination Project) supported regional coordination and standardization of fish population and habitat monitoring programs in 2013.

6. *Coordinating implementation with other appropriate regional collaboration processes. This includes coordination related to statutory provisions for the Federal government (BPA/Council), voluntary coordination among Federal agencies (Federal Caucus), and coordination with regional processes for Federal/non-Federal engagement (Technical Management Team (TMT), System Configuration Team (SCT), PNAMP, Northwest*

Environmental Data- Network (NED), and others.

The Action Agencies actively participated in regional forums and accomplishing this subaction through subactions 71.1-71.5 above. Coordination related to statutory provisions for the federal government (BPA/NPCC), federal agencies (Federal Caucus), and coordination with regional processes for federal/non-federal engagement (TMT, SCT, PNAMP) continued to support the FCRPS BiOp.

AMIP Category III required a coordinated monitoring strategy to be completed at the end of 2009. The Anadromous Salmonid Monitoring Strategy (ASMS) was completed in 2009 and outlined distinctions in monitoring requirements for the FCRPS BiOp and other regulatory needs to support ESA recovery monitoring needs. This work continued to support planning and implementation of monitoring in 2013.

RPA Action 72 – Data Management

The Action Agencies will ensure that the information obtained under the auspices of the FCRPS RM&E Program is archived in appropriate data management systems.

1. *Continue to work with regional Federal, State and Tribal agencies to establish a coordinated and standardized information system network to support the RM&E program and related performance assessments. The coordination of this development will occur primarily through leadership, participation, and joint funding support in regional coordination forums such as the NED workgroup, and PNAMP and the ongoing RM&E pilot studies in the Wenatchee River, John Day River, Upper Salmon River, and Columbia River Estuary. (Initiate in FY 2007- 2009 Projects).*

BPA Project 1988-108-04 (StreamNet – Coordinated Information System/Northwest Environmental Database) managed by StreamNet Staff at the PSMFC. The USGS continued to support the implementation of the Coordinated Assessments Projects by PNAMP, CBFWA, and StreamNet to develop standard data exchange templates across the Northwest for the indicators of adult spawner abundance and juvenile salmonid out-migrant production.

BPA Project 1989-062-01 (Annual Work Plan for Columbia Basin Fish and Wildlife Authority (CBFWA)) led and facilitated the Coordinated Assessments with PNAMP and StreamNet to continue efforts to map data flow for priority FCRPS BiOp fish and habitat data for agencies at the project level consistent with ongoing methods used by the NOAA Fisheries Northwest Fisheries Science Center in the Salmon Population Summary Database. This project was completed in 2013 with future funding for this position provided by an EPA Grant with the States and tribes.

BPA Project 1990-080-00 (Columbia Basin PIT Tag Information) manages the PTAGIS data system which is operated and maintained at <http://www.ptagis.org/ptagis>. PTAGIS continued to further develop exchange format to ensure PIT tag data is consumable other data systems and integrated into other tag management systems, like the Fishgen.net data system for genetics management. PIT Tags are primarily used for hydro system and tributary survival assessments, as well as tributary assessments of population adult return abundance and diversity to help assess viable salmon population attributes of spawner abundance, adult productivity, spatial distribution, and diversity.

BPA Project 1996-019-00 (Data Access in Real Time (DART)) supported ISEMP and PTAGIS in development of software to rapidly assess PIT Tag array detections for population adult escapement which could be supported across the basin.

BPA Project 2003-007-00 (Lower Columbia River Estuary Ecosystem Monitoring Program) supported development of data exchange templates and standard data entry forms to exchange estuary monitoring data with the U.S. Army Corps' Oncor database being developed by the Corps. In addition, the Lower Columbia River Estuary Partnership (LCREP) further developed its website to display the Columbia River estuary habitat classification and Catena GIS data at <http://maps.lcrep.org>.

BPA Project 2003-017-00 (Integrated Status and Effectiveness Monitoring Program) integrated data management efforts with project 2011-006-00 and 1988-108-04 to replace the STEM data system.

BPA Project 2003-022-00 (Okanogan Basin Monitoring & Evaluation Program) continued to develop a needs assessment to upgrade the database software, but to create a comprehensive data management system that includes tools for data storage, data collection, quality assurance/quality control (QA/QC) of the data, and analysis and reporting.

BPA Project 2004-002-00 (Pacific Northwest Aquatic Monitoring Program Coordination) continued the mission of NED in PNAMP through regional coordination of the Data Management Leadership team (DMLT). PNAMP further developed the Monitoring Resources tools to facilitate standards in protocol and location documentation at www.monitoringresources.org. Reclamation's Interagency Agreement with USGS (1A R13-PG-10-428) also provided funding for PNAMP to support Monitoring Resources Tool Development.

BPA Project 2008-507-00 (Tribal Data Network) explored use of digital pens to support improved data transfer and QA/QC to biologist to improve data exchange processes, in addition to providing parallel by project 1998-031-00.

BPA Project 2011-006-00 (Columbia Habitat and Monitoring Program). through CHaMP, led the way in protocol documentation in the www.monitoringmethods.org tool to demonstrate the level of information required to support metadata development with creation of standard data entry forms for rapid exchange of data from the field to the data systems.

AFEP Project EST-P-12-01 (Synthesis and Evaluation of Research, Monitoring, and Restoration Project Data in the Lower Columbia River and Estuary) developed RME project database ("Oncor") in coordination with regional managers, including the Estuary Partnership Science Work Group which is represented by state and federal agencies, tribal nations and non-governmental organizations managing habitat restoration in the lower Columbia River estuary. Product development included data exchange templates, data reduction protocols and field, data collection protocols.

2. *Contribute funding for data system components that support the information management needs of individual Hydrosystem, Tributary Habitat, Estuary/Ocean, Harvest, Hatchery, and Predation RM&E. (Initiate in FY 2007-2009 Projects).*

AFEP Project EST-P-12-01 (Synthesis and Evaluation of Research, Monitoring, and Restoration Project Data in the Lower Columbia River and Estuary) developed a web-based, geospatial data management and analysis system (called "Oncor") for research, monitoring and evaluation (RME) data. Development included (1) coordination with agencies and regional stakeholders to establish key analysis questions and database needs; (2) database construction; (3) analysis and synthesis of data (fish, vegetation, photo points, water surface elevation, water temperature,

and sediment accretion); and (4) formulation of data reduction procedures and data exchange templates for nine monitoring indicators.

BPA Projects 1988-108-04 (StreamNet – Coordinated Information System/Northwest Environmental Database (NED) managed by StreamNet Staff at the PSMFC USGS continued to support the implementation of the Coordinated Assessments process by PNAMP, CBFWA, and StreamNet to develop standard data exchange templates across the Northwest for the indicators of adult spawner abundance and juvenile salmonid out-migrant production.

BPA Project 1989-062-01 (Annual Work Plan for CBFWA) managed by PNAMP staff at the USGS, continued to support the implementation of the Coordinated Assessments Projects through PNAMP, CBFWA, and StreamNet to develop standard data exchange templates across the Northwest for the indicators of adult spawner abundance and juvenile salmonid out-migrant production. This project was completed in 2013 with future funding for this position provided by an EPA grant with the States and tribes.

BPA Project 1990-080-00 (Columbia Basin PIT Tag Information) managed the PTAGIS data system which is operated and maintained at <http://www.ptagis.org/ptagis>. PTAGIS continued to further develop exchange format to ensure PIT tag data is consumable other data systems and integrated into other tag management systems, like the Fishgen.net data system for genetics management. PIT-tags are primarily used for hydro system and tributary survival assessments, as well as tributary assessments of population adult return abundance and diversity to help assess viable salmon population attributes of spawner abundance, adult productivity, spatial distribution, and diversity).

BPA Project 1996-019-00 (Data Access in Real Time (DART)) supported ISEMP and PTAGIS in development of software to rapidly assess PIT Tag array detections for population adult escapement which could be supported across the basin.

BPA Project 1997-015-01 (Imnaha River Smolt Monitoring) provided the FPC's SMP with tributary specific emigration data from the Imnaha River. It continued a collection of a time series data set for Chinook salmon and steelhead smolt arrival and survival information to mainstem dams.

BPA Project 2003-017-00 (Integrated Status and Effectiveness Monitoring Program) integrated data management efforts with project 2011-006-00 and 1988-108-04 to replace the STEM data system.

BPA Project 2004-002-00 (Pacific Northwest Aquatic Monitoring Program Coordination) continued the mission of NED in PNAMP through regional coordination of the Data Management Leadership team (DMLT). PNAMP further developed the Monitoring Resources tools to facilitate standards in protocol and location documentation at www.monitoringresources.org. Reclamation's Interagency Agreement with USGS (1A R13-PG-10-428) also provided funding for PNAMP to support Monitoring Resources Tool Development.

BPA Project 2008-507-00 (Tribal Data Network) explored use of digital pens to support improved data transfer and QA/QC to biologist to improve data exchange processes, in addition to providing parallel support in BPA Project 1998-031-00.

BPA Project 2011-006-00 (Columbia Habitat and Monitoring Program), through CHaMP, led the way in protocol documentation in the www.monitoringmethods.org

tool to demonstrate the level of information required to support metadata development with creation of standard data entry forms for rapid exchange of data from the field to the data systems.

Reclamation Project R11 AC 17 061 (Building an Integrated Data Harvester and Analysis Software for the Methow Basin) with the University of Idaho and the Methow Salmon Recovery Fund (Cooperative Agreement R09-AC-10045) (Methow Data Management Support) both continued projects funded through Methow Salmon Recovery Fund and Washington State University to create a pilot data management tool for the Methow IMW.

3. *Participate in Northwest regional coordination and collaboration efforts such as the current PNAMP and NED efforts to develop and implement a regional management strategy for water, fish and habitat data. (Initiate in FY 2007-2009 Projects).*

BPA Projects 1988-108-04 (StreamNet – Coordinated Information System/Northwest Environmental Database (NED) managed by PNAMP staff at the USGS continued to support the implementation of the Coordinated Assessments Projects through PNAMP, CBFWA, and StreamNet to develop standard data exchange templates across the Northwest for the indicators of adult spawner abundance and juvenile salmonid out-migrant production.

BPA Project 2003-007-00 (Lower Columbia River Estuary Ecosystem Monitoring Program) supported development of data exchange templates and standard data entry forms to exchange estuary monitoring data with the Oncor database being developed by the Corps. In addition, LCEP further developed its website to display the Columbia River estuary habitat classification and Catena GIS data at <http://maps.lcrep.org/>.

BPA Project 2004-002-00 (Pacific Northwest Aquatic Monitoring Program Coordination) continued the mission of NED in PNAMP through regional coordination of the Data Management Leadership team (DMLT). PNAMP further developed the Monitoring Resources tools to facilitate standards in protocol and location documentation at www.monitoringresources.org. Reclamation's Interagency Agreement with USGS (1A R13-PG-10-428) also provided funding for PNAMP to support Monitoring Resources Tool Development.

BPA Project 2008-507-00 (Tribal Data Network) explored use of digital pens to support improved data transfer and QA/QC to biologist to improve data exchange processes, in addition to providing support in BPA Project 1992-031-00.

BPA Project 2011-006-00 (Columbia Habitat and Monitoring Program) through CHaMP led the way in protocol documentation in the www.monitoringmethods.org tool to demonstrate the level of information required to support metadata development with creation of standard data entry forms for rapid exchange of data from the field to the data systems.

RME Strategy 9 (RPA Action 73)

RPA Action 73 – Implementation and Compliance Monitoring

The Action Agencies will use the project-level detail contained in the Action Agencies' Biological Opinion databases to track results and assess our progress in meeting programmatic level

performance targets. This performance tracking will be reported through annual progress reports and the comprehensive reports scheduled for 2013 and 2016.

1. *Annually monitor the successful implementation of projects through standard procedures and requirements of contract oversight and management, and review of project deliverables and final reports.*

BPA Project 2010-075-00 (Upper Columbia Implementation and Action Effectiveness Monitoring) implemented a pilot for compliance monitoring to help validate that Pisces-compliant Katz metrics are reported accurately and to provide recommendations to improve restoration project metric guidance to project sponsors.

2. *Maintain project and action level details for planning and reporting purposes. This approach will provide the most up-to-date information about the status of actions and projects being implemented.*

The Corps, with assistance from BPA, began development of tools with Sitka Technologies for tracking planned restoration activities. Ongoing work continued in 2013 to support further development of the tools outside the estuary to help plan and coordinate future restoration and monitoring actions.

To further support coordination and planning within the Action Agencies and beyond, of monitoring projects that support the FCRPS BiOp, BPA contracted PNAMP through Project 2008-727-00 which was consolidated into contract 2004-002-00 to develop a www.monitoringresources.org "Monitoring Explorer" tool.

3. *Maintain a comprehensive habitat project tracking system where relevant project information is contained in an accessible comprehensive data system. The data system will contain project level information that is needed for both implementation and effectiveness monitoring. The system will include the set of minimum metrics and metadata for RM&E data design listed in Data Management Needs for Regional Project Tracking to Support Implementation and Effectiveness Monitoring (Katz et al. 2006). (Initiate in FY 2008).*

The Action Agencies have recorded project implementation and associated metric information for tributary habitat actions since implementation of tributary habitat actions became part of the FCRPS BiOp RPA in 2000. Examples of these data are presented in Section 3 for RPA Actions 35 and 37. These data for BPA and Reclamation currently are tracked in BPA's Pisces contracting database and reported in the Taurus database at www.cbfish.org for BPA-funded restoration actions. Actions for which Reclamation provides technical assistance are tracked in a separate Reclamation database.

BPA developed an automated report through the Taurus system to annually provide habitat restoration action information to the NOAA Fisheries Pacific Coast Salmon Recovery Fund system. The automated exchange of that information was completed in 2012 and occurs annually to fully comply with this RPA. The list of BPA metrics and relationships to the NOAA Fisheries system is available at <http://www.cbfish.org/WorkElement.mvc/Landing>.

Lastly, Project 2010-075-00 (Upper Columbia Project-Scale Action Effectiveness Monitoring), implemented a pilot for compliance monitoring to help validate that Pisces-compliant Katz metrics are reported accurately and to provide recommendations to improve restoration project metric guidance to project sponsors.

Adaptive Management Implementation Plan (AMIP) Actions

In September 2009, the FCRPS 2008 BiOp was enhanced through an Adaptive Management Implementation Plan, which includes accelerated actions, additional research related to fish status and climate change, and precautionary use of biological triggers and contingency plans in case there is an unexpected, significant fish decline. The original AMIP actions and six new implementation actions that were amended to the AMIP were incorporated into the NOAA Fisheries 2010 Supplemental BiOp. The following table provides information on BiOp AMIP actions implemented by NOAA Fisheries and the Action Agencies as of 2013. Information on the status of continuing or ongoing actions follows the table.

Table 22. Status of AMIP Actions for 2013.

AMIP Ref	Action Description	Status
AMIP Category: II Acceleration & Enhancement of RPA Mitigation Actions		
II. A	Estuary Habitat Improvement & Memorandum of Agreement on Columbia River Estuary Actions with State of Washington	See Section II. A following this table.
II. B	<p>Reintroduction</p> <p><i>The NWFSC is now initiating an evaluation of additional opportunities for reintroduction of listed fish in areas downstream of Chief Joseph Dam and the Hells Canyon Complex. The NWFSC will examine the potential benefits of additional reintroductions, considering locations where reintroduction will advance recovery and further lower the risk of extinction.</i></p> <ul style="list-style-type: none"> • <i>The NWFSC will evaluate the conditions under which reintroduction would be a robust strategy and describe the relative costs and benefits in this and other situations.</i> • <i>The NWFSC will evaluate the costs and benefits of the alternative reintroduction strategies and techniques.</i> <p><i>The NWFSC will complete a report outlining potential reintroduction projects in the Columbia Basin by December 2010. This report will guide both decisions regarding which Long-term Contingency Actions should be implemented if a trigger is tripped and actions taken to implement recovery plans. This report will be discussed with the federal agencies and the Regional Implementation Oversight Group (RIOG).</i></p>	<p>This action is completed. NOAA Fisheries developed a manuscript on principles of reintroduction for anadromous salmonids in collaboration with the Federal, State and Tribal members of the Recovery Science Implementation Team (McClure et al. 2011) at http://www.salmonrecovery.gov/Files/2011%20APR%20files/New%20Folder%203/McClure_et_al_2011_Reintro_gnrl_prncpls_v5_final_review_draft_100411.pdf</p>
II. C	<p>Predator & Invasive Species Controls</p> <p><i>The Action Agencies and NOAA Fisheries will move forward in the three highest priority areas to establish baseline information for future predator control activities:</i></p> <ol style="list-style-type: none"> 1. <i>Shad: document the influence of juvenile shad on the growth and condition of introduced predators in the fall as they (the predators) prepare for overwintering</i> 2. <i>Catfish: document the distribution and predation rates of channel catfish</i> 3. <i>Smallmouth bass: document whether removals of smallmouth bass in areas of intense predation could reduce the mortality of juvenile salmonids</i> <p><i>For these three priority approaches and in order to accelerate implementation of the RPA, by November 2009 BPA will develop a research study design proposal, and will promptly request an expedited review of the proposal by the Independent Scientific Review Panel (ISRP) to accelerate field implementation. The Action Agencies will implement the research study during the next field season(s), anticipated by December 2010. Once this research supports a specific management strategy, the Action Agencies could implement site-specific removals of smallmouth bass and could exclude adult American shad from upper mainstem dams as early as the following migration season.</i></p>	<p>The action was completed on schedule in 2010.</p>
II. D	Spill	See Section II. D following this table.

AMIP Category: III Enhanced Research Monitoring & Evaluation		
	<i>Collaborate with state and tribal co-managers to develop a shared Columbia Basin Monitoring Strategy. The goal of the collaboration is to develop an efficient salmon and steelhead monitoring framework and implementation strategy that will support viable salmonid populations and habitat and hatchery effectiveness monitoring needs, including those of the 2008 BiOp and RPA, recovery plans, regional fisheries management objectives, and other programs. This collaborative process will be completed in December, 2009.</i>	A monitoring strategy was completed on schedule in 2009. The ISRP's review of the Anadromous Salmonid Monitoring Strategy (ASMS) was subsequently completed in February 2011 (ISRP and ISAB 2011) is found at http://www.salmonrecovery.gov/Files/2011%20APR%20files/New%20Folder%203/ISRP_ISAB_2011-1.pdf .
III. A	Enhanced Life-Cycle Monitoring for Evaluation of Contingencies	See Section III. A following this table.
III. B	Adult Status & Trend Monitoring <i>By December 2011, NOAA Fisheries will improve existing adult status and trend monitoring to obtain adult natural spawner abundance and full life-cycle productivity estimates, with known statistical certainty and power, for additional ESA-listed populations. These improvements will better inform decisions regarding which Rapid Response Actions and Long-term Contingency Actions will be taken if a trigger is tripped, as well as ongoing viability assessments. Additionally, by December 2010, NOAA Fisheries will develop mechanisms for the timely and efficient reporting and dissemination of these data, in order to ensure they can provide for the early detection of regional or population specific changes in status.</i>	Mechanisms for data reporting and dissemination were completed on schedule in 2010. NOAA Fisheries' NWFSC created the Salmon Population Summary database, which is available online at https://www.webapps.nwfsc.noaa.gov/apex/f?p=238:home:0 to disseminate data to enable early detection of regional population specific changes in status.
III. C	Juvenile Status & Trend Monitoring	The strategy was completed on schedule in 2010. Consistent with ISRP comments, in 2011 BPA proceeded with partial implementation and evaluation for CHaMP and associated paired fish population monitoring.
III. D	Habitat Condition Status & Trend Monitoring	In 2011, BPA proceeded with partial implementation and evaluation of CHaMP consistent with ISRP comments
III. E	Intensively Monitored Watersheds <i>The Action Agencies are implementing IMWs under RPA Actions 56 and 57 for fish status monitoring and habitat effectiveness monitoring in the John Day, Wenatchee, Entiat, Methow, Lemhi, and South Fork Salmon basins. NOAA Fisheries funds five additional or complementary IMWs in interior subbasins in Idaho (Upper Potlatch River, Lemhi River); Oregon (Upper Middle Fork John Day River); and Washington (Yakima River, Asotin Creek). The Action Agencies' IMWs have been through independent science evaluation and review by the NPCC. Under the RPA provisions, enhancements to these efforts are already planned or underway.</i> <i>As part of an enhanced commitment to IMWs, by September, 2010, NOAA Fisheries and the Action Agencies will complete an analysis of existing IMWs to ensure:</i> <ol style="list-style-type: none"> 1. <i>Timely funding and implementation of intensive habitat actions to ensure, where practical, an adequate treatment effect</i> 2. <i>Sufficiently diverse representation of IMWs (geographically and with respect to limiting factors) and appropriate monitoring (e.g., temperature, flow) to detect climate change impacts</i> 3. <i>Results are applicable to future habitat planning and for the implementation of Rapid Response Actions</i> <i>This review will inform the prioritization of BPA placeholder funds budgeted for IMWs, as well as the allocation of new or re-focused NOAA Fisheries funds (e.g., distributed through the Pacific Coastal Salmon Recovery Fund). IMW updates will go through an independent science</i>	The action was completed on schedule in 2010 as documented in the Action Agencies/NOAA Fisheries/NPCC RME Workgroup "Recommendations for Implementing Research, Monitoring and Evaluation for the 2008 NOAA Fisheries FCRPS BiOp" (May 2010) consistent with the regional Anadromous Salmonid Monitoring Strategy. This documents is available at http://www.salmonrecovery.gov/Files/RME/RM&E%20Recommendations%20Report%20w%20revised%20Appendix.pdf .

	<i>review process and review by the NPCC. Results will be coordinated with the RIOG and reported annually to the region.</i>	
III. F	Climate Change Monitoring & Evaluation	See Section III. F following this table.
AMIP Category: IV Contingency Plans in Case of Early Warning or Significant Fish Declines		
IV. A.1.	<p>Early Warning Indicator for Chinook Salmon & Steelhead <i>The Action Agencies and NOAA Fisheries will develop, in coordination with the RIOG, at least one additional Early Warning Indicator by December, 2010, which may be revised pending additional analyses and discussion. Specifically, the additional Early Warning Indicator(s) would evaluate whether a species is likely to have substantially reduced abundance (and productivity) in the future based on two years of adult return information, preliminary biological information, and environmental indicators or known environmental disasters. These indicators may include, but are not limited to, low jack counts or numbers of juvenile outmigrants (biological), indicators of ocean conditions predicting very low abundance of adult returns for recent outmigrants (environmental indicators), or wide-spread forest fires, increased distribution and virulence of pathogens, new invasive species, prolonged severe droughts, etc. environmental disasters). Unlike the interim Early Warning Indicators, which evaluates information at the species level, the additional Early Warning Indicators may use information more representative of effects on major population groups (MPGs), important management units (e.g., A-run vs. B-Run Snake River steelhead, or key populations). Responses to impacts affecting a specific MPG or subset of populations would be tailored to the appropriate scale.</i></p>	The action was completed in 2011. The NWFSC developed a forecasting tool that satisfies this requirement.
IV. A.2.	<p>Significant Decline Trigger for Chinook Salmon & Steelhead <i>The Action Agencies and NOAA Fisheries, in coordination with the RIOG, will further improve the Significant Decline Trigger no later than December 2010 by incorporating a metric indicative of trend.</i></p>	The action was completed in 2010. The approach developed by NWFSC, NOAA and AA staff was adopted and memorialized in a letter from L. Bodi, BPA, to Barry Thom, NOAA on 12/23/10.
IV. A.3.	Contingency Plan Implementation for Snake River Sockeye Salmon	See Section IV. A. 3 following this table.
IV.B	<p>Rapid Response Actions – Hydro, Predator Control, Harvest, Safety Net Hatchery Programs <i>Within 90 days of NOAA Fisheries determining that a significant decline trigger has been tripped, the Action Agencies, in coordination with NOAA Fisheries and the RIOG, will assess alternative Rapid Response Actions and determine which action(s) will be implemented. The Rapid Response Actions will be implemented as soon as practicable after a decision is made, and not later than 12 months after a Significant Decline Trigger is tripped. Most, if not all, Rapid Response Actions will be temporary in nature.</i></p> <p><i>By December 2011, the Action Agencies and NOAA Fisheries will develop a Rapid Response Plan, which will include a detailed description of these potential Rapid Response Actions together with implementation milestones.</i></p>	The Rapid Response Plan addressed all actions at left and was finalized on schedule in 2011 (ACOE et al. 2012). The Plan was subsequently modified to incorporate comments and was delivered to NOAA Fisheries on February 7, 2012. The plan is available at https://www.salmonrecovery.gov/Files/2011%20APR%20files/2011_RRandLTC_Plan.pdf
IV. C	<p>Long-Term Contingency Action – Hydro, Reintroduction, Predator Control, Harvest, Conservation Hatcheries, Hatchery Reform, John Day Reservoir Operation at MOP, Breaching Lower Snake River Dams: Within four to six months of a Significant Decline trigger being tripped, the Action Agencies (in coordination with NOAA Fisheries, the RIOG and other regional parties) will conduct an All-H Diagnosis and life-cycle model analysis to determine if the Rapid Response Action(s) are likely to be sufficient or if Long-term Contingency Actions will need to be implemented, and if so, what Long-term Contingency Actions are appropriate for implementation. If necessary, the Long-term Contingency Actions</p>	The Long-Term Contingency Plan that addresses actions 1 through 6 (left) (Phase II Hydro Actions, Reintroduction, Predator Control, Harvest, Conservation Hatcheries, Hatchery Reform) of this action was completed on schedule in 2011 (ACOE et al. 2012) at https://www.salmonrecovery.gov/Files/2011_APR_files/2011_RRandLTC_Plan.pdf .

	<p>will then be implemented as soon as practicable thereafter. Unlike the Rapid Response Actions, all of which have been determined to be implementable within 1 to 12 months of a triggering event, each Long-Term Contingency Action has a unique timeline for implementation depending on its complexity.</p> <p><i>By December 2011, the Action Agencies and NOAA Fisheries will develop a Long-term Contingency Plan, which will include a detailed description of potential Long-term Contingency Actions, a selection process and implementation milestones for the following potential Long-term contingency actions as further described in the AMIP:</i></p> <ol style="list-style-type: none"> 1. Phase II Hydro Actions 2. Reintroduction 3. Predator Control 4. Harvest 5. Conservation Hatcheries 6. Hatchery Reform 7. John Day Reservoir at Minimum Operating Pool from April – June. 8. Breaching Lower Snake River Dams: <i>By March, 2010, the Corps in coordination with NOAA Fisheries and the other Action Agencies will complete a “Study Plan” for breaching of lower Snake River dams.</i> 	<p>The Corps submitted the final plan of study for the John Day Minimum Operating Pool (action 7 left) to NOAA Fisheries on July 26, 2012. The plan is available at https://www.salmonrecovery.gov/Files/BiologicalOpinions/2012/JDA%20MOP%20Final%20Plan%20of%20Study%20with%20letter%20comments%20and%20responses%20(071112).pdf</p> <p>The Corps completed the study plan for the breaching of lower Snake River dams in 2010 (action 8 left). The plan is available at http://www.nww.usace.army.mil/Library/DamBreachingPlanofStudy.aspx.</p>
AMIP Category: Amendments		
Amendment 1	<p>Identify the use and location of adult salmon thermal refugia in Lower Columbia and Lower Snake Rivers</p> <p><i>Under RPA Action 55 the Action Agencies will undertake selected hydrosystem research to resolve critical uncertainties. As part of this action, by June 2012, the Corps will complete a report to identify the use and location of adult salmon thermal refugia in the lower Columbia and lower Snake Rivers using existing information on adult migration, temperature monitoring data, and modeling efforts. Additional investigation or action may be warranted based on the results of this report.</i></p>	<p>The Corps completed the Location and Use of Adult Salmon Thermal Refugia in the Lower Columbia and Lower Snake Rivers FCRPS Pools report in 2012. The report is available at https://www.salmonrecovery.gov/Files/BiologicalOpinions/2010/Thermal%20refugia%20report%20Feb%2014%202013.pdf</p>
Amendment 2	Assess feasibility of adding adult PIT Tag detection systems at The Dalles Dam and John Day Dam.	See Amendment 2 following the table.
Amendment 3	Action Agencies to provide temperature data for NOAA's regional temperature database.	See Amendment 3 following the table.
Amendment 4	Action Agencies to provide tributary habitat effectiveness study data for NOAA's regional climate change database.	See Amendment 4 following the table.
Amendment 5	Action Agencies will provide available invasive species and site-specific toxicology information for consideration by the expert panels.	See Amendment 5 following the table.
Amendment 6	Action Agencies will assist NOAA to develop or modify existing studies that address the Ad Hoc Supplementation Workgroup Recommendations Report.	See Amendment 6 following the table.

AMIP Category II – Acceleration and Enhancement of RPA Mitigation Actions (Actions A-D) Ongoing Actions

II. A. Estuary Habitat Improvement & Memorandum of Agreement on Columbia River Estuary Actions with State of Washington

Under RPA Actions 36 and 37, the Action Agencies are implementing a major program of estuary habitat restoration and research. The Washington Estuary Memorandum of Agreement will enhance this effort significantly by identifying and describing estuary projects and augmenting the suite of RPA actions in the 2008 RPA. In selecting the projects for inclusion in the Washington Estuary Memorandum of Agreement, an initial suite of potential projects was evaluated by Washington Department of Fish and Wildlife (WDFW) scientists for biological benefits and certainty of success using the scientific methodology described in the RPA (Actions 36 and 37). As a result of this evaluation, an additional 21 projects were selected for implementation.

Acceleration & Enhancement of RPA Mitigation Actions (Actions A-D) II. A. Estuary Habitat Improvement & Memorandum of Agreement on Columbia River Estuary Actions with State of Washington: Under RPA Actions 36 and 37, the Action Agencies are implementing a major program of estuary habitat restoration and research. The Washington Estuary Memorandum of Agreement will enhance this effort significantly by identifying and describing estuary projects and augmenting the suite of RPA actions in the 2008 RPA. In selecting the projects for inclusion in the Washington Estuary Memorandum of Agreement, an initial suite of potential projects was evaluated by Washington Department of Fish and Wildlife (WDFW) scientists for biological benefits and certainty of success using the scientific methodology described in the RPA (Actions 36 and 37). As a result of this evaluation, an additional 21 projects were selected for implementation.

The MOA was executed by parties on September 16, 2009. The estuary program was accelerated in 2013; see the discussion in RPA 37 for information on habitat actions.

II. D. Spill

Spring Spill: *Assess data from previous years and discuss with the RIOG parties each year to inform transport/spill operation decisions for the subsequent year. There is no longer a presumptive spill/transport operation for the spring RPA action 29.*

This process was carried out in 2011 as specified in the AMIP.

Summer Spill: *To further enhance the summer spill program, the Action Agencies will develop an appropriate safeguard, based on adult returns, that continues summer spill at the Snake River projects through August 31, during the subsequent juvenile outmigration. Using this trigger, low abundance of naturally-produced Snake River fall Chinook in one year would trigger spill through August 31 at the Snake River projects the following year, regardless of the number of juveniles collected. The Agencies will coordinate with the RIOG in developing the trigger, to be in place for the 2010 juvenile fish migration.*

Completed on schedule in 2010. Consistent with this AMIP requirement, a June 11, 2010 letter from Witt Anderson to Barry Thom indicated that spill would continue through August 31 only in years following a year in which 400 or fewer natural-origin adult Snake River fall Chinook salmon are counted at Lower Granite Dam. However, pursuant to the opinion and order from the United States District Court for the District of Oregon, dated August 2, 2011, the Action Agencies continued summer spill at the Snake River projects through August 31 in prior years, consistent with the Court's previous spill orders.

AMIP Category III – Enhanced Research Monitoring & Evaluation (Actions A-F) Ongoing Actions

Collaborate with state and tribal co-managers to develop a shared Columbia Basin Monitoring Strategy. The goal of the collaboration is to develop an efficient salmon and steelhead monitoring framework and implementation strategy that will support viable salmonid populations and habitat and hatchery effectiveness monitoring needs, including those of the 2008 BiOp and RPA, recovery plans, regional fisheries management objectives, and other programs. This collaborative process will be completed in December, 2009.

III. A. Enhanced Lifecycle Monitoring for Evaluation of Contingencies

Starting in 2010, NOAA Fisheries and the Action Agencies will jointly fund and implement updates to the existing life cycle models. The updates to the life-cycle models will be implemented by December, 2012. These enhancements will be developed using the same approach as for the COMPASS model, a transparent process and independent science peer review. Results will be discussed with the RIOG and reported annually to the region.

The life cycle modeling project began in 2010 and continued through 2012. The model development group consists of scientists from state (IDFG, WDFW, ODFW), tribal (CRITFC, Nez Perce), and federal (NOAA, USGS, BOR, USFWS) agencies. The group completed a document in December 2012 that described model developments and presented model results. This document was publicly reviewed and then presented to the ISAB for review in June 2013. The model development group met quarterly and continues to meet and make progress. The modeling has made progress in the following areas:

1. Modeling of hatchery-wild interactions based on ongoing analyses,
2. Incorporating habitat relationships into life cycle models,
3. Continued development of hydro scenarios for rapid response and long-term contingency planning, including initiation of COMPASS recalibrations and construct for John Day Dam drawdown and lower Snake River dam breaching,
4. Steelhead and subyearling Chinook salmon life-history characterizations,
5. Estuary and ocean survival, and
6. Climate change scenario characterizations.

III. F. Climate Change Monitoring & Evaluation

This AMIP Action enhances or clarifies other RPA actions as follows:

1. *RPA Action 2 requires the inclusion of new climate change research findings in the Action Agencies' annual progress reports NOAA Fisheries will annually provide the Action Agencies with a literature review relevant to the implementation of the RPA.*

On September 29, 2014, NOAA Fisheries provided the Action Agencies with a Northwest Fisheries Science Center review of new literature on climate science and oceanographic conditions relevant to Columbia River Basin salmonids (see Appendix A).

2. *Consistent with RPA Actions 56-61, data on habitat conditions and action effectiveness will be collected during ongoing and enhanced tributary habitat and ocean research. By December 2011,*

the Action Agencies and NOAA Fisheries will ensure that this information is appropriately managed in a database allowing changes to be tracked over time.

The action is ongoing. BPA funded the creation of the CHaMP data system for tributary habitat status and trend monitoring associated with RPAs 56 and 57 at <http://www.champmonitoring.org>. BPA and NOAA Fisheries' NWFSC funded tributary habitat action effectiveness monitoring for RPA 56 and 57, the ISEMP Project 2003-017-00, found at <http://www.nwfsc.noaa.gov/research/divisions/cbd/mathbio/isemp/index.cfm>, which tracks and manages data in the Status and Trend Effectiveness Monitoring Databank at <https://www.webapps.nwfsc.noaa.gov>.

For estuarine habitat data, the Corps funded the AFEP "Synthesis and Evaluation" project with Battelle's Pacific Northwest Labs for the development of the data system to track and maintain BPA habitat status and trends and action effectiveness. In the estuary, BPA also co-funds a site of the Science and Technology University Research Network within the Center for Coastal Margin Observation & Prediction. Data related to food web and water quality (flow, temperature, dissolved oxygen, pH, plankton (nontoxic or pharmaceutical)) is stored at <http://www.stccmop.org/saturn>.

For ocean habitat conditions, data from BPA and NOAA Fisheries' NWFSC Project 1998-014-00 (Ocean Survival of Salmonids) may be found at the NOAA Fisheries' Ocean Indicators Tool (<http://www.nwfsc.noaa.gov/research/divisions/fed/oeip/a-ecinhome.cfm>). Additional data on ocean conditions for the BPA-funded "Canada-USA Shelf Salmon Survival Study," conducted with the Canadian Department of Fisheries and Oceans (DFO), are reported in the Pacific Region Oceanography Database at <http://www.pac.dfo-mpo.gc.ca/science/oceans/data-donnees/index-eng.htm>.

- 3. Under RPA Actions 35-57, the Action Agencies will use the new climate change information to guide tributary and estuary habitat project selection and prioritization and other aspects of adaptive management.*

The action is ongoing. The 2011 and 2012 reviews of new climate change literature provided by NOAA Fisheries under AMIP Action III.F (AMIP pg. 25) were shared with the tributary habitat Expert Panels in advance of the workshops held in 2012 on the Expert Panel Website.

The Action Agencies are also tracking juvenile fish status and trends at monitoring sites throughout the estuary to support the early detection of substantial changes in abundance, productivity, or survival over time. These trends may be correlated with trends of habitat indicators (e.g., temperature); and by tracking habitat status and trends (including water quality and temperature) at monitoring sites throughout the estuary to detect changes in baseline conditions over time. These may be correlated with status and trends of juvenile fish densities.

- 4. Under RPA Action 7, the Action Agencies investigate the impacts of possible climate change scenarios on listed salmon and steelhead. As part of this effort, the Action Agencies will use new climate change information to improve regional hydrological models. In addition, the Action Agencies will review existing forecasting tools. As new procedures and techniques are identified with significant potential to reduce forecast error and improve forecast reliability, the Action Agencies will review these with the RIOG and other interested parties.*

This action is ongoing. The results of the work from the three agencies are available in three major reports and a summary report as part of the Climate and Hydrology Datasets for use in the RMJOC Agencies' Longer-Term Planning Studies at <http://www.bpa.gov/power/pgf/HydrPNW.shtml>. Reclamation, BPA, and the Corps engaged

in a collaborative effort to focus on how water supply changes due to climate change could impact the Columbia River Basin and the operation of federal dams in the future. The RMJOC's four-part climate change reports were completed in 2011. The report titles and dates completed are:

Part I – Future Climate and Hydrology Datasets, dated December 2010;

Part II – Reservoir Operations Assessment for Reclamation Tributary Basins, January 2011;

Part III – Reservoir Operations Assessment: Columbia Basin Flood Control and Hydropower, May 2011; and

Part IV – Summary, Climate and Hydrology Datasets for Use in the River Management Joint Operating Committee (RMJOC) Agencies' Longer-Term Planning Studies, September 2011.

The reports can be found at <http://www.bpa.gov/power/pgf/HydrPNW.shtml>. BPA also solicited comments from stakeholders and the public on the Summary report in August 2011, and these are posted at:

<http://www.bpa.gov/applications/publiccomments/CommentList.aspx?ID=134>.

5. *Enhanced monitoring of adult status and trends, juvenile status and trends, habitat condition status and trend and IMWs (flows and temperature) will contribute to climate change assessments. Climate change information will be discussed with the RIOG and reported to the region annually.*

The action is ongoing. Enhanced monitoring in 2013 under AMIP III B, C, D, and E (adult, juvenile, habitat status, and IMWs) all support and contribute to climate change assessments. See these sections above for more information.

AMIP Category IV – Contingency Plans in Case of Early Warning or Significant Fish Declines

IV. A. Expanded Contingency Process

IV. A. 3. – Contingency Plan Implementation for Snake River Sockeye Salmon: *The Action Agencies will continue the safety net hatchery program; further expand the sockeye program (up to 1 million fish released as smolts); investigate the feasibility of transporting adults from Lower Granite Dam to Sawtooth Valley lakes or artificial production facilities; and investigate the highly variable juvenile mortality rates between Sawtooth Valley and Lower Granite Dam.*

This action is ongoing. BPA will continue to fund contingency actions for Snake River sockeye.

Contingency actions include the safety net hatchery program; construction, operation, and maintenance of the Springfield Sockeye Hatchery to expand smolt production up to one million smolts; and a multi-year investigation of the highly variable juvenile mortality rates between Sawtooth Valley and Lower Granite Dam. If necessary as a contingency action, the Action Agencies will fund transportation of adult sockeye from Lower Granite Dam to Sawtooth Valley lakes or artificial production facilities.

AMIP Category: Amendments with Ongoing Actions

Amendment 2

Under RPA Action 52, the Action Agencies will enhance fish population monitoring. As part of this action, in February 2011 the Corps will initiate a study at The Dalles and John Day Dams to determine a cost-effective adult PIT Tag detection system design and whether installation of PIT Tag detectors will improve inter-dam adult survival estimates. The study will be completed by December 2012. Following the results of the study, by April 2013, the Action Agencies will determine in coordination with NOAA Fisheries if one or both of these PIT Tag detectors substantially improve inter-dam adult loss estimates. If warranted, the Action Agencies will proceed to construction. Funding will be scheduled consistent with the RPA requirement and priorities for performance standard testing and achievement of these performance standards at the projects.

Adult PIT tag monitoring systems were installed at The Dalles Dam in 2013. These were originally intended to be temporary. However, since they proved to have very high detection efficiencies and appear to be durable and reliable, they will be maintained by the Corps as the long-term systems.

Amendment 3

Under RPA Action 15, the Action Agencies are providing water quality information and implement water quality measures to enhance fish survival and protect habitat. As part of this action, the Action Agencies will contribute to regional climate change impact evaluations by providing NOAA Fisheries past and future water temperature data from their existing monitoring stations, to be used as part of a regional temperature database. The Action Agencies will begin to provide data to NOAA Fisheries within 6 months following the establishment of a regional database and annually thereafter. NOAA Fisheries anticipates having a regional database established no later than 2012.

NOAA Fisheries and the Action Agencies are satisfying this requirement by submitting data developed for FCRPS BiOp RME to the USFS's Rocky Mountain Research stream and air temperature database (<http://www.fsJed.us/rm/boise/AWAE/projects/streamtemperature.shtml>). This project will provide a mapping tool to help those in the western U.S. organize temperature monitoring efforts.

Amendment 4

Under RPA Action 35, the Action Agencies are identifying tributary habitat projects for implementation and consider potential effects of climate change on limiting factors. As part of this action, the Action Agencies will continue to coordinate with NOAA Fisheries in its efforts to use existing tributary habitat effectiveness studies, IMWs, and the NOAA Fisheries enhanced lifecycle modeling to track climate change impacts. Starting in September 2011, the Action Agencies will annually provide NOAA Fisheries with study data to be used as part of a regional climate change database. After 2011, new climate change findings will be provided to the tributary habitat expert panels to apply and use to help identify and prioritize habitat improvement actions.

The Action Agencies continued to coordinate with NOAA in 2013 by sharing habitat effectiveness study results, IMW results, and life cycle model updates. As reported in the 2013 CE, climate change information was shared during the 2012 expert panel process and updates to these data will be shared during the 2016 expert panel process.

The NWFSC is currently developing enhanced lifecycle modeling capability with some funding assistance from the Action Agencies. The Action Agencies also continue to fund the development of climate data. When literature and results are made available by NOAA and

others, the Action Agencies review the information for its utility in implementing the tributary habitat program of work. The Action Agencies encourage⁷ the expert panels to consider climate impacts when evaluating habitat improvement actions and the effect on limiting factors. The Action Agencies regard the climate science research as limited in the ability to improve understanding of the impact of habitat actions in ameliorating for effects of climate impacts. Given this, the Action Agencies focus is on the ability of habitat actions to improve habitat condition and/or species and habitat resilience, believing that increased diversity and resilience can contribute to population persistence in the face of a changing climate. The Action Agencies have reviewed Beechie's decision support framework (Beechie et al. 2013) for evaluating whether habitat actions ameliorate effects of climate change. By looking at the types of actions funded by the tributary habitat program (e.g., riparian restoration, flow acquisition, water conservation, floodplain reconnection; dike, levee, and mine tailing removal; barrier removal; culvert replacement; road improvement and obliteration; establishment of conservation easements; land acquisition the Action Agencies can evaluate whether and to what degree the actions increase diversity or improve resilience as a function of ameliorating for effects from changes in flow quantity, timing, and duration; changes in precipitation patterns; changes in water and air temperature; and changes in vegetation composition.

Amendment 5

Under RPA Action 35, the Action Agencies are identifying tributary habitat projects for implementation based on the population specific overall habitat quality improvement identified in the RPA Action. As part of this action, after 2011, the Action Agencies will include as a consideration in the expert panel project evaluation process (1) the presence of invasive species and (2) site-specific toxicology issues, based on information made available by the appropriate state and Federal agencies.

The action was completed on schedule for the 2012 expert panels. The next expert panels will be held in 2016.

Amendment 6

Under RPA Action 64 and under the AMIP Hatchery Effects p. 22, the Action Agencies are supporting efforts to resolve hatchery critical uncertainties. As part of this effort, beginning in December 2010, the Action Agencies will assist NOAA Fisheries to further develop or modify existing studies that address the Ad Hoc Supplementation Workgroup Recommendations Report and that additionally address potential density-dependent impacts of FCRPS hatchery releases on listed species. These studies would provide support for future hatchery management actions to reduce potential adverse hatchery effects. By December 2010, the Action Agencies will work with NOAA Fisheries to convene a technical workgroup with fishery managers to discuss potential studies and potential management tools. The goal for the workgroup will be to complete its work by December 2011.

The CRHEET was proposed, in part, to respond to the AMIP requirement to convene a technical workgroup with fishery managers. NOAA Fisheries has postponed implementation of the CRHEET to allow for the undertaking of an extensive ESA consultation process on FCRPS mitigation hatchery programs (RPA 39). These consultations require significant involvement from many of the people proposed to participate in CRHEET. Recognizing this overlap, BPA agreed with NOAA Fisheries that CRHEET would best be informed by the outcomes of the consultations and so further development of CRHEET has been deferred.

⁷ *Beyond research to predict changes in timing of flow events; peak and base flows; shifts in air and water temperature; and changes in precipitation patterns the existing body of climate science work is limited insofar as its utility for examining the effect of habitat improvement actions in ameliorating for effects of climate change.*

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Trumbo et al. 2013a	Trumbo, B., M. Shutters, M. Ahmann, J. Renholds, S. Nelson and K. Crum. 2013. Statistical and Biological Study Design Options to Evaluate New Turbine Runners Designed for Safer Fish Passage at Ice Harbor Dam on the Lower Snake River, Washington. U.S. Army Corps of Engineers, Walla Walla District.
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Weigel 2013	Weigel, D.E. 2013. Colonization of steelhead (<i>Oncorhynchus mykiss</i>) after barrier removal in a tributary to the Methow River, Washington. Ph.D. dissertation, Natural Resources in the College of Graduate Studies, University of Idaho.
Weigel et al. 2013a	Weigel, D.E., P.J. Connolly, and M. Powell. 2013. Colonization of Steelhead in a Natal Stream after barrier removal. Transactions of the American Fisheries Society 142:920–930.
Weigel et al. 2013b	Weigel, D.E., P.J. Connolly, and M. Powell. 2013. Fluvial rainbow trout contribute to the colonization of steelhead (<i>Oncorhynchus mykiss</i>) in a small

In Text	Complete Title
	stream. Environ Biol Fish, on-line publication. November 2013, Springer.
Weiland et al. 2013	Weiland, M., J. Kim, B. Rayamajhi, C. Woodley, G. Ploskey, J. Rerecich, B. Eppard. 2013. Systematic Review of JSATS Passage and Survival Data at Bonneville and The Dalles Dams during Alternate Turbine and Spillbay Operations from 2008-2012. Presented at the 2013 Anadromous Fish Evaluation Program (AFEP) year review.

Acronyms

The “Action Agencies” refers to Bonneville Power Administration, the U.S. Army Corps of Engineers Northwestern Division, and the U.S. Bureau of Reclamation Pacific Northwest Region. Any references in this report to “we” or “us,” or to “our” activities, etc., refer collectively to these agencies.

AEM	Action Effectiveness Monitoring
AFEP	Anadromous Fish Evaluation Program
AMIP	Adaptive Management Implementation Plan
ASMS	Anadromous Salmonid Monitoring Strategy
BA	Biological Assessment
BiOp	Biological Opinion
BPA	Bonneville Power Administration
CBFWA	Columbia Basin Fish and Wildlife Authority
cfs	cubic feet per second
CEERP	Columbia Estuary Ecosystem Restoration Plan
water	two dimensional, longitudinal/vertical, hydrodynamic, and quality model
CHaMP	Columbia Habitat Monitoring Program
CLT	Columbia Land Trust
COMPASS	COMprehensive Fish PASSage Model
COP	Configuration and Operational Plan
Corps	U.S. Army Corps of Engineers
CRFG	Columbia River Forecast Group, formed by the Action Agencies
and	Fish Accord partners
CRHEET	Columbia River Hatchery Effects Evaluation Team
CRITFC	Columbia River Inter-tribal Fish Commission
CSS	Comparative Survival Study
CTCR	Confederated Tribes of the Colville Reservation
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CWT	coded wire tag
DART	Data Access In Real Time
DIDSON	dual frequency identification sonar
DMLT	Data Management Leadership Team
DPS	distinct population segment
ERTG	Expert Regional Technical Group
ESA	Endangered Species Act
ESP	Ensemble Streamflow Prediction
ESU	evolutionarily significant unit
FCRPS	Federal Columbia River Power System
FFDRWG	Fish Facility Design Review Workgroup
FOP	Fish Operations Plan
FPC	Fish Passage Center
FPOM	Fish Passage Operations and Maintenance Workgroup
FPP	Fish Passage Plan
GSI	genetic stock identification
HGMP	Hatchery and Genetic Management Plan
HQI	Habitat Quality Improvement
HRPP	Hood River Production Plan
IAPMP	Inland Avian Predation Management Plan
IDFG	Idaho Department of Fish and Game

IMW	intensively monitored watershed
ISAB	Independent Scientific Advisory Board
ISEMP	Integrated Status and Effectiveness Monitoring Program
ISRP	Independent Scientific Review Panel
ISTM	PNAMP's Integrated Status and Trends Monitoring program
kaf	thousand acre feet
kcfs	thousand cubic feet per second
km	kilometers
KMP	Kelt Management Plan
LCRE	Lower Columbia River Estuary
LCREP	Lower Columbia River Estuary Partnership
LGR	Lower Granite Dam
MAF	million acre-feet
MOP	minimum operating pool
MPG	major population group
NED	Northwest Environmental Database
NEPA	National Environmental Policy Act
NFH	National Fish Hatchery
NOAA Fisheries	Alternative designation for National Oceanic and Atmospheric Administration National Marine Fisheries Service
NPCC	Northwest Power and Conservation Council
NPMP	Northern Pikeminnow Management Program
NPT	Nez Perce Tribe
NTS	non-treaty storage
NTSA	Non-Treaty Storage Agreement
NWFSC	Northwest Fisheries Science Center
NWRFC	Northwest River Forecast Center
ODFW	Oregon Department of Fish and Wildlife
PH2	Second Powerhouse (Bonneville Dam)
PIT	Passive Integrated Transponder
PNAMP	Pacific Northwest Aquatic Monitoring Partnership
PNNL	Pacific Northwest National Laboratory
PSMFC	Pacific States Marine Fisheries Commission
PTAGIS	PIT Tag Information System
Reclamation	U.S. Bureau of Reclamation
RIOG	Regional Implementation Oversight Group
RME or RM&E	research, monitoring, and evaluation
RMJOC	River Management Joint Operating Committee
RPA	Reasonable and Prudent Alternative
RSS	Reproductive Success and Survival
SARs	smolt-to-adult return ratios
SBUS	Survival Benefit Units
SLED	sea lion exclusion device
SMP	Smolt Monitoring Program
SRFC	Snake River fall Chinook
SRWG	Studies Review Workgroup
SYSTDG	System Total Dissolved Gas
TDG	total dissolved gas
TMT	Technical Management Team
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VARQ	variable outflow flood control procedures
WDFW	Washington Department of Fish and Wildlife

WMP
YKFP
YN

Water Management Plan
Yakima/Klickitat Fisheries Project
Yakama Nation

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Appendix A – Literature Review for 2013 Citations for BiOp: Biological Effects of Climate Change

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Impacts of Climate Change on Columbia River Salmon

A review of the scientific literature published in 2013

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Summary

Climate Science Projections

A number of key new global and regional climate projections were released in 2013. Working Group I of the IPCC (Intergovernmental Panel on Climate Change) completed its contribution to the 5th IPCC Assessment Report, *Climate Change 2013: The Physical Science Basis* (IPCC 2013). Locally, two reports synthesize global modeling results for the Pacific Northwest: *Climate Change Impacts and Adaptation in Washington State* (Snover et al. 2013b), from the University of Washington Climate Impacts Group, and *Climate Variability and Change in the Past and Future* (Mote et al. 2013), from the Oregon Climate Change Research Institute.

A consequential change presented in the 5th IPCC assessment report is the introduction of four new carbon emission scenarios based on *representative concentration pathways* (RCPs 2.6, 4.5, 6, and 8.5). The lowest emissions scenario (RCP 2.6) assumes much more aggressive reductions in emissions than any previous scenario. Results from this report are very similar to those of previous reports when similar emissions scenarios are compared. However, the scenarios previously selected for downscaling by many climate modeling groups in the Pacific Northwest, including the University of Washington Climate Impacts Group, excluded the high-end emissions scenarios. Therefore, these reports reflect the mid-range of the new carbon emission scenarios (RCPs 4.5 and 6). Current downscaling efforts, such as the Integrated Scenarios of the Future Northwest Environment project, include the business-as-usual emissions scenario (RCP 8.5).

Under the RCP 8.5 scenario, Northwest air temperatures are expected to warm in all seasons, but the greatest warming is projected for summer (1.9-5.2°C in the 2041-2070 period). The range of annual warming between RCP scenarios 4.5 and 8.5 is 2.4-3.6°C. Precipitation projections across global climate models (GCMs) include both drier and wetter trends in all seasons and in annual precipitation, but most models project drier summers with the rest of the year being wetter (see Figure 2.6 in Mote et al. 2013).

At present, most of the Columbia River Basin is expected to shift to rain or mixed rain and snow by the 2080s. Peak snowmelt and peak flows in snow-dominated basins are projected to shift earlier, with some peak flows occurring in winter rather than spring. Flooding, landslide risk, and sediment flow increase due to intense winter rains. Decreased precipitation and warmer temperatures during summer lead to more extreme low flows across much of the Columbia River Basin (Hamlet et al. 2013).

A number of hydrological and temperature modeling results for individual basins within the Columbia River Basin focused on the Salmon River Basin in Idaho (Sridhar et al. 2013), the Santiam River Basin in Oregon (Surfleet and Tullos 2013b, a), and the Methow Valley in Washington (Bellmore et al. 2013). Finally, a groundwater model was developed for the Deschutes River Basin in Oregon (Waibel et al. 2013).

Retrospective Analyses

Retrospective analyses of climate trends over the past century or so in the Pacific Northwest generally identified patterns similar to those projected to result from greenhouse gas accumulation. A review of this literature for the National Climate Assessment, *Climate Variability and Change in the Past and the Future* (Mote et al. 2013), and *Technical Summary for Decision Makers* from the University of Washington Climate Impacts Group (Snover et al. 2013b), summarized the key findings. During 1895-2011, the Northwest warmed approximately 0.7°C (1.3°F) annually, with average air temperatures approximately the same in summer, but 1.1°C (2°F) higher in winter. There was no statistically significant long-term trend in precipitation (1895-2011), but analyses of shorter time-series did find trends of varying magnitude. Recent studies have found that not all streams respond to climate change in the same manner. The response depends on river management and study duration, as well as other factors.

Ocean Acidification and Hypoxia

Literature published in 2013 focused specifically on ocean acidification and hypoxia. Ocean acidification is clearly detected both on the outer coast and in Puget Sound, with acidity increases of 10-40% since 1800 (Feely et al. 2010 cited in Snover et al. 2013b). The aragonite saturation state has declined in surface water on the Oregon shelf from 1.0-4.7 in pre-industrial times to 0.66-3.9 in 2007-2011 (Harris et al. 2013). Complex trophic interactions lead to projected global ocean productivity decreases of 6.3% by the 2090s from increasing acidification, although primary production in the Arctic is expected to increase by 59% (Yool et al. 2013). A food web model of Puget Sound projected very limited impacts on salmon (Busch et al. 2013b).

In a study that focused specifically on the California Current, one group (Hauri et al. 2013) reported that aragonite undersaturation events along the shelf have quadrupled in number and lengthened in duration, and this trend will continue. Within about 20 years, the seafloor will be undersaturated most of the time, and when CO₂ levels reach 500 ppm, undersaturation will become basically permanent.

Much recent work has studied how localized levels of upwelling and productivity correlate with large-scale atmospheric processes such as the North Pacific High, North Pacific Gyre Oscillation, Pacific Decadal Oscillation, and El Niño, at both lower and higher trophic levels (Garcia-Reyes et al. 2013a; Hatch 2013; Lindegren et al. 2013). However, these dynamics are complex, and the pathways by which they influence salmon are not entirely clear and may change over time.

Estuarine habitat is likely to change with sea-level rise, and some detailed habitat mapping in 2013 helps to clarify where habitat might be gained and lost, which is crucial to long-term planning of habitat availability (Flitcroft et al. 2013).

Projected Impacts on Pacific Salmon

In general, the tenor of 2013 articles on climate change impacts to salmon is consistent with previous reports: conditions in a few cold-water locations might improve for certain life stages, but the vast majority of impacts are negative. These negative impacts are projected across Pacific salmon species, throughout the various life stages that occupy freshwater, and geographically across the west coast. Furthermore, many populations that are already highly impacted by other threats are also the most vulnerable to climate change. In 2013, two key papers quantified vulnerability or risk to specific populations: a detailed quantitative vulnerability analysis for steelhead over the entire Columbia River Basin (Wade et al. 2013), and a quantitative analysis of juvenile survival in the Lemhi River, Idaho, which compares the impact of water management options with climate change (Walters et al. 2013).

An additional qualitative analysis was conducted for Oregon coho populations (Wainwright and Weitkamp 2013), and spawn timing and juvenile growth impacts were analyzed for steelhead and Chinook salmon populations from Washington through California (Beer and Anderson 2013). Lastly, an important step in incorporating climate change into status assessments was completed for all salmonids in California (Katz et al. 2013).

Observed Impacts on Adult Migration and Spawning

Several key papers also documented challenges with the hydrosystem or for transportation relating to thermal conditions. New evidence documents temperature gradients up to 4°C within fish ladders at dams in the Columbia River that appeared to block migration by causing adult fish to reverse movement in ladders and fall back downstream (Caudill et al. 2013). Temperature-related fallback is a serious concern for fish managers under the present climate, but may become even more so when mitigating for rising river temperatures.

One mitigation strategy that has been proposed for avoiding thermal stress in rivers is to transport adult salmon upstream to spawning habitat. However, one case study showed fish failed to spawn following transportation (Mosser et al. 2013). Additional limitations might need to be placed on fisheries under warm water conditions because mortality rates are higher when temperature and handling stress interact (Gale et al. 2013). In addition to previously established influences of temperature and food availability on growth rates, some unexpected consequences of changing the thermal regime include altering sex ratios within age classes and age at maturity (Mizzau et al. 2013).

Interacting Stressors: Hypoxia, Contaminants, and Invasive Species

A significant challenge in assessing climate-change impacts is how to identify and characterize interacting stressors such as hypoxia, contaminants, and invasive species. Hypoxia, in particular, is likely to co-occur with ocean acidification and rising temperatures. The effects of hypoxia generally exacerbate thermal stress (Ellis et al. 2013), but in 2013, two review papers showed that tolerance of the two traits (as well as some others) can be correlated (Anttila et al. 2013b; Hasnain et al. 2013).

Contaminants are a persistent problem in Northwest watersheds, as elsewhere, and several studies indicate that with the projected intensification of winter storms (Conaway et al. 2013), transport of contaminants might increase. Two review papers showed that, in addition to increased contaminant loads, biological effects may grow more acute as contaminants interact with climate-related changes in factors such as temperature, flow, salinity, and pH (Hooper et al. 2013; Moe et al. 2013).

A major concern for Columbia River Basin salmon is the threat of invasions of warm-adapted species, which compete with or prey upon native salmon. American shad, brook trout, and brown trout all showed temperature-dependent responses consistent with greater future penetration across the Columbia River Basin; however, none of the work in 2013 included detailed projections for these non-native populations.

Ocean Conditions

A series of six papers report results on correlates of survival and migration characteristics for Columbia River juvenile salmon during their ocean stages (Burke et al. 2013a, b; Daly et al. 2013; Miller et al. 2013; Ralston et al. 2013; Sharma et al. 2013). These papers point to a full array of interacting physical and biological factors. Although they do not make specific projections, they do suggest salmon are highly vulnerable if ocean conditions decline systematically due to climate change.

A special issue of the journal *Conservation Biology* presented a number of papers exploring how climate change might be incorporated into decisions under the Endangered Species Act (Boughton and Pike 2013; Gregory et al. 2013; Jorgensen et al. 2013; McClure et al. 2013; Seney et al. 2013; Snover et al. 2013a; Walters et al. 2013). Generally, the uncertainty of climate projections is no longer a sufficient reason to omit them from listing and recovery planning decisions. These papers offer guidelines for progress.

In conclusion, new literature generally supports previous concerns that climate change will cause moderate to severe declines in salmon, especially when interacting factors are incorporated into the analysis (e.g., existing threats to populations, water diversion, accelerated mobilization of contaminants, hypoxia, and invasive species). Many populations are already heat stressed in either their tributary habitats or migration corridors.

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Objective and Methods

The goal of this review was to identify literature published in 2013 that is most relevant to prediction and mitigation of impacts of climate change on Columbia River salmon listed under the Endangered Species Act. Because almost anything that affects salmon is related to or altered in some way by changes in temperature, stream flow, or marine conditions, a large amount of literature related to this topic was necessarily excluded. In our literature search, we elected to focus on peer-reviewed scientific journals included in the *Web of Science* database, although we occasionally included highly influential grey literature. We sought to capture the most relevant papers by combining climatic and salmonid terms in search criteria. This excluded studies of general principles demonstrated in other taxa or within a broader context. In total, we reviewed over 1,300 papers, 195 of which were included in this summary.

Literature searches were conducted January and July 2014 using the Institute for Scientific Information (ISI) *Web of Science* indexing service. Each set of search criteria involved a new search, and results were compared with previous searches to identify missing topics. As a first step, we used specific search criteria that included a publication year of 2013, plus:

- 1) A topic that contained the terms climate,⁸ temperature, streamflow, flow, snowpack, precipitation, **or**⁹ PDO, **and** a topic that contained salmon, *Oncorhynchus*, or steelhead
- 2) A topic that contained climate, temperature, precipitation, streamflow **or** flow **and** a topic containing "Pacific Northwest"
- 3) A topic that contained the terms marine, sea level, hyporheic, **or** groundwater **and** climate, **and** salmon, *Oncorhynchus*, **or** steelhead
- 4) Topics that contained upwelling **or** estuary **and** climate **and** Pacific
- 5) A full text search that contained ocean acidification **or** California Current **or** Columbia River
- 6) A topic that contained prespaw mortality

This review is presented in two major parts, with the first considering changes to the physical environmental conditions that are important to salmon and that are projected to change with the climate; for example, air temperature, precipitation, snowpack, stream flow, stream temperature, and ocean conditions. We describe projections driven by global climate model (GCM) simulations, as well as historical trends and relationships among these environmental factors. In the second part, we summarize the literature on responses of salmon to these environmental factors, both projected and retrospective, in freshwater and marine environments.

⁸ The wildcard (*), was used to search using "climat*" to capture all forms of the word "climate."

⁹ Boolean operators used in the search are shown in boldface.

Physical Processes of Climate Change

In 2013, the Intergovernmental Panel on Climate Change (IPCC) completed its 5th Assessment Report (AR5) from Working Group I, *The Physical Science of Climate Change* (IPCC 2013). This contribution was based on models developed during Phase 5 of the Coupled Model Intercomparison Project (CMIP5). Projections in this report are based on new greenhouse gas emission scenarios defined in terms of representative concentration pathways (RCPs). An RCP is expressed as an increase in radiative forcing (energy from the sun absorbed by the earth) from pre-industrial values to the year 2100; RCP scenarios range 2.6-8.5 W/m². Most of these scenarios are roughly similar to those in previous reports, with one exception. The new report includes a novel, very low-emissions scenario with extremely aggressive reductions in carbon emissions and sequestration, such that emissions start declining in the 2020s (RCP 2.5). The upper emissions scenario (RCP 8.5), is approximately a “business-as-usual” scenario in which emissions continue to increase through the century, comparable to scenario A1FI in the 4th IPCC Assessment Report (AR4).

To interpret how these new results might change our understanding of climate change impacts in the Pacific Northwest, it is important to recognize that results from AR5 are very similar to those of AR4 when similar emissions scenarios are compared. However, scenarios selected from the AR4 by many climate modeling groups for downscaling in the Pacific Northwest did not include the high-end emission scenario (A1FI). Thus, downscaled models from these groups, which include those from the University of Washington Climate Impacts Group, reflect the mid-range RCP scenarios (RCPs 4.5 and 6).

Current downscaling efforts, such as the *Integrated Scenarios of the Future Northwest Environment* project do include the business-as-usual emissions scenario, RCP 8.5, as well as RCP 4.5 (which is similar to B1 from AR4). Thus projections from this effort will span a wider range of futures than those previously considered by the Climate Impacts Group (e.g., scenarios B1 and A1B or A2).

Projections for the Pacific Northwest

Climate

Two reports synthesize the new modeling results for the Pacific Northwest (Dalton et al. 2013; Snover et al. 2013b). Under emissions scenario RCP 8.5, air temperature in the Northwest is expected to increase in all seasons, but the greatest increase is projected for summer 2041-2070, at 1.9-5.2°C (3.4-9.4°F). The range of projected annual warming between RCP scenarios 4.5 and 8.5 is 2.4-3.6°C. Annual and seasonal precipitation might decrease or increase in the PNW (range 5-14%), depending on the model. However, annual changes are generally less than historical annual variation (historical SD = 14%; Mote et al. 2013); therefore, these changes will probably not be detectable for several decades at least. Most models project drier summers with the rest of the year being wetter. The driest summers were projected in models with the largest temperature increases.

Rupp et al. (2013) analyzed the performance of 41 GCMs compared to 20th century observations using a wide suite of metrics that tend to be important for impacts assessments. They ranked these models to provide a useful resource for applications in which a subset must be selected for further analysis, because not all the models can be used in impacts assessments (Rupp et al. 2013).

Across the Northern Hemisphere, the AR5 (IPCC 2013) projects the following ranges by 2081-2100, based on means of RCP scenarios 2.6-8.5: spring snow cover declines of 7-25%; glacier recessions of 15-85%; sea surface temperature increases of 1.1-3.6°C; global sea level increases of 11-38 inches; and global ocean pH decreases of 38 to 109%, which correspond to a drop in pH of 0.14-0.32.

Nationally, the climate of the United States is expected to change sufficiently that certain locations will occupy climate zones previously unknown in this country, including the “torrid” climate, which is hotter and drier than previous classifications based on the older projections. However, the overall climate type of the Pacific Northwest is not expected to change (Elguindi and Grundstein 2013).

Biases in general circulation models are corrected prior to downscaling, and thus do not affect impact assessments. However, we note that regional climate model reconstructions of 20th century climate for the Pacific Northwest tend to be wetter than observed (Kim et al. 2013). Multi-model ensembles continue to outperform individual “best models” in general and are better tools for impact assessments (Kim et al. 2013; Snover et al. 2013a). Another assessment of regional climate modeling capability found that the weather research and forecasting (WRF) model captured temperature extremes (showing the anthropogenic warming signal) much better than precipitation extremes (Duliere et al. 2013).

Stream Temperature and Flow

To assess ecosystem responses to a changing climate and their implications for salmon, further analysis is needed of the climatic variables output from general circulation and regional climate models (GCMs and RCMs). Such analyses include hydrological and stream temperature models. A comprehensive description of stream flows across the Columbia River Basin was conducted by the Climate Impacts Group several years ago under emissions scenarios A1B and B1, and their final report was published in 2013 (Hamlet et al. 2013). Two other modeling efforts covered the entire Columbia River Basin (Beer and Anderson 2013; Wade et al. 2013), but these were focused on impacts for salmon, and thus are discussed in the salmon impacts section.

A number of hydrological and temperature modeling efforts have focused on individual subbasins within the Columbia River Basin. These subbasins include the Salmon River in Idaho (Sridhar et al. 2013), Santiam River in Oregon (Surfleet and Tullos 2013b, a), and Methow Valley in Washington (Ficklin et al. 2013). Finally, a much-needed groundwater model was developed for the Deschutes Basin in Oregon (Waibel et al. 2013). Below I summarize the scope and general results from these projects.

Flow Projections—A database of historical and projected stream flow for the Columbia River Basin, known as the 2860 Project, has been available from the Climate Impacts Group for a few years. However, the final report documenting this project and synthesizing major findings was published in 2013 (Hamlet et al. 2013). The Climate Impacts Group analyzed two emissions scenarios from the AR4 (A1B and B1). Both scenarios were modeled using 10 general circulation models from CMIP3, and both were downscaled using two different statistical methods plus a third hybrid method.

In summary, these analyses show most of the Columbia River Basin shifting to rain or mixed rain-and-snow by the 2080s. Peak snowmelt and peak flows in snow-dominated basins are projected to shift earlier, with some peak flows occurring in

winter rather than spring. Flooding, landslide risk, and sediment flows increase due to intense winter rains. Precipitation decreases in summer, and warmer summer temperatures lead to more extreme low flows across much of the basin.

Projections of Subbasin Hydrology—Sridhar, Jin, et al. (2013) used the variable infiltration capacity (VIC) hydrology model in a new model of the Salmon River Basin, Idaho. They projected peak flows 10 d earlier and total flows and snow/water equivalent reduced by 3% over the next 90 years, which could increase drought risk (Sridhar et al. 2013). Surprisingly, drought in the Klamath Basin in California was projected to decrease in severity and intensity (Madadgar and Moradkhani 2013).

In a rain-dominated basin, the Santiam River in Oregon, a new analysis using the coupled groundwater and surface water flow model (GSFLOW) also confirmed previous projections: increases in runoff during fall and winter months and decreases in runoff during spring and summer. One-hundred-year floods are projected to decrease, but changes in low flows varied by subbasin, depending on groundwater input (Surfleet and Tullos 2013a). In the McKenzie River Basin, Oregon, a 2°C increase in temperature would decrease snowpack, especially between elevations of 1000 and 2000 m, and thereby reduce water storage capacity (Sproles et al. 2013).

The most dramatic floods and avalanches often result from rain-on-snow events, which primarily threaten the transient rain and snow basins. The transient band in the Santiam River basin is projected to rise from its current intermediate elevation of 350-1100 m, into higher elevations that are snow-dominated at present (Surfleet and Tullos 2013b).

Stream Temperature Projections—A new statistical model of stream temperatures in the Methow Valley combined hydrological results from a variable infiltration capacity (VIC) model with a statistical disaggregation technique. This approach allowed a novel combination of high temporal and spatial resolution with the long time-scale projections driven by general circulation models (Caldwell et al. 2013). These results project July warming of 0.8°C (\pm 1.9°C) to 2.8°C (\pm 4.7°C) by 2080. Confidence intervals on this projection are very wide because of the statistical methods used and limited existing data, and include cooling as a possible outcome (Caldwell et al. 2013). This is much less than warming predicted for the Sierra Nevada Basin (1.0-5.5°C for the A2 scenario by 2100), particularly in the southern portion of the basin. Interestingly, this latter study also tracked dissolved oxygen, which is projected to decline 10%, and sediment, which is projected to decline 50%; either or both could stress some species (Ficklin et al. 2013).

The implications of projected climatic change for stream flow and temperature depend in part on riparian vegetation, as demonstrated by Tetzlaff et al. (2013) in an analysis of a global collection of long-term ecological research sites in the North Watch Project. The role of riparian vegetation was also illustrated in a broader study (Davis et al. 2013). Studies have addressed general changes in landscape vegetation (e.g., Albright and Peterson 2013), and one study noted that floodplain vegetation might respond more to winter and spring precipitation than summer droughts (Bollman et al. 2013). However, riparian vegetation is generally not explicitly modeled in most stream-flow projections, except to test the ability of shading to mediate temperature rises.

Groundwater—Groundwater recharge plays a crucial role in moderating both stream flow and temperature, but groundwater processes have been difficult to model in many large-scale analyses (e.g., groundwater is not modeled by VIC). Nevertheless, an important differentiation can be made between basins with short and long groundwater flow paths (i.e., the amount of time between submersion and appearance in the stream or aquifer). Short groundwater flow paths, which are typical of headwater base flows, will be more affected by seasonal change in precipitation, whereas longer processes at the regional scale might be buffered by the fact that annual precipitation is not expected to change much (Waibel et al. 2013).

Retrospective Analyses: Terrestrial and Freshwater Conditions

Although long-term trends of general warming continued in 2013, El Niño Southern Oscillation (ENSO) was in a neutral state most of the year; thus 2013 was not an extreme year compared with the last decade. The North Pacific Ocean did reach a historic high temperature in 2013 due to weakened westerly winds, and on balance, global average sea surface temperature was among the 10 highest on record (Blunden and Arndt 2014). Nonetheless, local ocean conditions were relatively cool and productive, and forage fish such as anchovy and juvenile rockfish had relatively high abundances (Wells et al. 2013; Harvey and Garfield 2014).

Notably, ENSO plays a very significant role not only in Pacific Northwest climate, but in global temperature. An analysis of the influence on global climate of temperatures in the eastern tropical Pacific indicated that the preponderance of La Niña-like conditions over the past decade can explain the recent “hiatus” in the global warming trend. Kosaka and Xie (2013) conclude this is a just a normal product of natural variability and does not indicate abatement in the general trend produced by greenhouse gas emissions.

Pacific Northwest Climate Trends

Retrospective climate analyses of the Pacific Northwest generally find the same trends over the past century or so that are projected to result from greenhouse gas accumulation. A general review of this evidence was completed by Mote et al. (2013) for the U.S. Global Change Research Program National Climate Assessment. These findings were reiterated in *Climate Change Impacts and Adaptation in Washington State* from the UW Climate Impacts Group (Snover et al. 2013b).

In summary, the Pacific Northwest has warmed approximately 0.72°C (1.3°F) from 1895 to 2011, with mean air temperatures approximately the same in summers, but higher during winters (1.1°C, 2°F). There has been no statistically significant long-term trend in precipitation during this time. However, analyses of shorter time series did find trends of varying magnitude. Studies of stream flow and snowpack are shorter in magnitude, and hence have less ability to differentiate between long-term trends and natural variability in climate (such as the PDO), although several cited below are consistent with expected changes from climate change.

The coastal ocean has changed as well. Ocean acidification has clearly been detected on both the outer coast and in Puget Sound, with acidity increases of 10-40% since 1800 (Feely et al. 2010 cited in Snover et al 2013b). Sea levels actually declined at Astoria, Oregon, by 0.1 inches/decade during 1925-2008 and by 0.7 inches/decade at Neah Bay, Washington, during 1934-2008. However, Puget Sound rose 0.8 inches/decade at Seattle during 1900-2008, and the Salish Sea rose 0.4 inches/decade at Friday Harbor during 1934-2008 (Snover et al. 2013b). Retrospective analyses of sea surface temperature showed varying trends across the California Current.

Individual studies of the general patterns reported here include the following analyses of glacial retreat, snowfall, precipitation, and stream flow and temperature.

Glacial Retreat and Snowfall—Glacial retreat in western North America over the last 100 years is unique in the climate record since the Little Ice Age, and shows a clear signal of anthropogenic forcing (Malcomb and Wiles 2013). Durre et al. (2013) analyzed an extended database of snow-depth and snowfall records to compare recent 30-year means (1981-2010) with those of an earlier 30-year period (1971-2000). The more recent "normal" period exhibited fewer days with snow on the ground, less total annual snowfall across much of the contiguous United States, and drier conditions (annually) over much of the Pacific Northwest.

Precipitation—In comparing periods without temporal overlap, 1950-1979 vs. 1980-2009, the Pacific Northwest west of the Cascade Mountain Range was drier in the recent period based on daily precipitation records. The greatest differences occurred during winters (January-March), which were ~30-40% drier. Summers (July-September) were ~30% drier across a slightly smaller spatial extent, with spring and fall showing less dramatic differences (Higgins and Kousky 2013). These patterns were especially strong during La Niña years.

However, the impact of ENSO in the Pacific Northwest may have changed in recent decades. Yu and Zou (2013) reported that a shift in the signature of recent El Niño events toward the central Pacific, compared with its more eastern-Pacific historic signature, has shifted the jetstream southward, causing drier conditions in much of the United States, including the Pacific Northwest. They suggest that this could explain the recent extended droughts. Deforestation in the Amazon has also been linked to reductions in precipitation in the Pacific Northwest and Sierra Nevada Mountains (Medvigy et al. 2013).

In a provocative study of a potential bias in our perspective on historical changes in Pacific Northwest precipitation, Luce et al. (2013) proposed that we have systematically underestimated precipitation declines at high elevations. They contend that an elevation bias in precipitation is a predicted characteristic of weaker westerly winds, and might explain many observed trends that show declining stream flow.

Wildfires—Wildfires have profound effects on streams, driving major shifts in scouring flows and nutrient and sediment loads for up to 4 years, and affecting community composition from benthic algae to fish (Verkaik et al. 2013). But a paleoecological perspective demonstrates that wildfires can also be the driver of sudden and relatively permanent shifts in vegetation more suited to a warmer climate (Gavin et al. 2013).

Stream Flows

In an analysis that takes into account the influence of geology and drainage patterns on the response of streamflow to changes in precipitation and temperature, Safeeq et al (2013) analyzed historical patterns in streamflow from 1950-2010 across the western U.S. They identified the types of watersheds most sensitive to climate warming. Summer flows from snow-dominated watersheds with deep groundwater sources showed the strongest effects. However, spring flows were most sensitive in snow-dominated watersheds that drain rapidly.

On tribal lands in the Columbia River Basin, peak stream flows have declined and advanced to earlier in the season, November 100-year floods have increased, and low flows have intensified (Dittmer 2013). Variation in these patterns across sites within the Columbia River Basin is driven by variation in physical factors (e.g., elevation) as well as anthropogenic factors such as flow regulation. Similar to results reported last year (Isaak et al. 2012), a new study of seven basins from 1950 to 2011 compared trends in flow from above and below major dams. They found that headwater sites showed the expected signature of climate change (earlier peak flows), but no consistent shift appeared below dams (Hatcher and Jones 2013).

A majority of GCM and RCMs project that winter precipitation in the Pacific Northwest will increase and will consist of more intense precipitation events. Combined with the transition of many basins from snow-dominated to transitional or rain-dominated weather patterns, more streams will likely be exposed to winter flooding. The risk of winter flooding for salmon is largely in that eggs are scoured out of their protective nests or that shifting sediment reduces oxygen availability.

Two studies explored the risk of winter scour and flooding in the Salmon River Basin in Idaho and found relatively low risk for incubating eggs (Goode et al. 2013; McKean and Tonina 2013). Changes in streambed grain size depend crucially on sediment input, and hence could have negative or positive impacts on fish habitat (Neupane and Yager 2013). Changing flow levels also alter the relative proportion and total quantity of fish habitat, which might alter the impact of certain human actions such as adding riprap to stabilize shorelines (Jorgensen et al. 2013). Effects on stream flow represent one aspect for which evaluation of impacts under climate change might differ from those under the current climate. Such evaluations may influence regulating agencies in terms of their permitting decisions.

Stream Temperatures

A different way of thinking about warming temperatures at a given site is the elevation or latitude at which a certain thermal threshold is reached. Such a metric is useful for determining range limits and predicting range shifts. Using an analytical method, Isaak and Rieman (2013) surmised that isotherms on steep slopes (2-10% slope), such as many of the headwater streams in the Columbia Basin, will respond to a warming rate of 0.1-0.2°C/decade by shifting 0.13-1.3 km/decade, with shifts of 1.3-25 km/decade in flatter areas. Thus warming of 2°C could cause a shift of up to 143 km in a potential range limit.

All general circulation models and nearly all downscaled temperature projections anticipate a warmer climate. Because many populations of cold-water fish are already heat stressed, much research has focused on actions that can reduce local temperatures or provide thermal refugia. However, thermal refugia are generally not well characterized at present, because they often require very fine-scale thermal and groundwater maps. For the most part, such maps are not available or have not been fully analyzed. A first step toward better understanding of thermal refugia includes characterization of current spatial and temporal variability.

Thermal Refugia—A review of information on thermal refugia in the Columbia and lower Snake Rivers was produced by the U.S. Army Corps of Engineers (2013). This report 1) compared available temperatures in the mainstem and tributaries, 2) described the thermal profile of the Dworshak Reservoir and 3) described evidence of thermal refuge use from archival temperature-recording tags on individual migrating adult Chinook and steelhead. Of the seven tributaries for which they had sufficient data to compare, they found that the Clearwater River at Spalding and at Lewiston were substantially cooler than the Lower Granite pool and the Snake River at Anatone (reflecting cooling from Dworshak), but other tributaries were fairly similar to the mainstem (Umatilla was a little cooler) or warmer. Thus the only real source of cool water identified was the Dworshak reservoir.

Modeling of thermal gradients within reservoirs in the lower Snake River found relatively shallow temperature gradients (~4°C from 1 to 30 m depth) in all but the Lower Granite pool, again due to cold water from Dworshak releases. But the cold water from these releases does not have a large effect below Lower Granite Dam. Cool refugia in the reach from Bonneville to McNary Dam were identified, especially Deschutes and Little White Salmon Rivers. Studies of Chinook salmon showed that use of thermal refuge increased dramatically when mainstem temperature exceeded 21°C.

A study of the temporal characteristics of thermal refugia in Quebec found that the stability of these refugia depends on whether they are generated by groundwater input or cold-water tributary inflow. Groundwater cooling tended to follow patterns in seasonal mean discharge, whereas cold-water tributaries were more consistent from year to year (Dugdale et al. 2013). Cold-water tributaries can be predicted locally to some extent by landscape characteristics (Monk et al. 2013), as can more general hydrologic characteristics (Wigington et al. 2013). Exploring the temporal frequency of warm and cold events within streams also helps to describe thermal regimes (Arismendi et al. 2013), as does studying spatial structure in these regimes (Imholt et al. 2013b).

Aside from naturally cool tributaries, another source of cold-water input is large reservoirs. In fact, studies of historical temperature trends (Null et al. 2013) have found that water below large dams has not necessarily followed air temperature trends (unlike water above dams). Thus, managed releases of water can have a dramatic impact on thermal regime, in addition to altering the expected stream-flow responses to warming mentioned above (Hatcher and Jones 2013).

Riparian Cover—The primary mechanism of stream warming is solar radiation, which is greatly reduced by shading. Thus, a key alternative route to cooler water is to provide riparian cover, which is effective at cooling at small spatial scales (Imholt et al. 2013a; Ryan et al. 2013).

Generally stream temperature is strongly correlated with air temperature and stream flow, but a thoughtful analysis of this relationship in the Pacific Northwest was conducted by (Mayer 2012). The relationship between stream and air temperature is non-linear, with smaller increases in stream temperature at higher air temperatures. Stream temperatures often increase with urbanization, as shown in the Green-Duwamish River near Seattle, which Tan and Cherkauer (2013) attributed to modification of riparian structures and vegetation.

Projections: Ocean Conditions

A major emphasis in the 2013 literature was toward investigations of ocean acidification and hypoxia. A survey of subject-matter experts from the IPCC Working Group found consensus regarding the physical chemistry and direct impacts of ocean acidification on calcifying organisms and primary producers. However, the transfer of these impacts up the food web was more controversial (Gattuso et al. 2013). A simulation of ocean processes by Yool et al. (2013) projected a global decrease in ocean productivity of 6.3% by the 2090s, although it projected a 59% increase in primary production in the Arctic.

A major concern is the co-variation of hypoxia and high $p\text{CO}_2$ levels. Yool et al. (2013) found that the volume of suboxic zone ($<20 \text{ mmol O}_2\text{m}^{-3}$) increased by 12.5% globally. Coastal hypoxic zones ($<70 \mu\text{M}$, equivalent to 20-30 % air saturation) are especially vulnerable to increasing $p\text{CO}_2$ because of nonlinear carbon dynamics (Melzner et al. 2013). Upwelling regions, such as the California Current, are at particular risk. However, the combined ecological impacts of low O_2 and high $p\text{CO}_2$ are not well studied.

Similar results were apparent from a comparison of seven Earth Systems Models by Cocco et al. (2013). These models projected an increase in sea surface temperature of 2-3°C and decreases in pH and total ocean dissolved oxygen of 2-4%. Levels of dissolved oxygen in the upper mesopelagic layer (100-600 m depth) showed more complex responses, including increases and decreases, because of the sensitivity of DO levels to circulation, production, remineralization, and temperature change (Cocco et al. 2013).

Focusing specifically on the California Current, Hauri et al. (2013) found that aragonite undersaturation events along the shelf have quadrupled in number and lengthened in duration, and that this trend will continue. Without sufficient aragonite, it is very difficult for calcifying organisms to build shells. Within about 20 years, the seafloor will be undersaturated most of the time; when CO_2 levels reach 500 ppm, aragonite undersaturation will become basically permanent. Within 25 years, the saturation horizon in the central California Current will shoal into the upper 75 m.

Retrospective Analyses: the California Current

Most Pacific salmon achieve the vast majority of their growth in the ocean, and survival through this life stage is a major driver of variation in abundance for most populations. Thus, understanding the factors that determine marine growth and survival, and projecting how climate change will influence these factors, is a paramount priority.

Much recent work has focused on large-scale atmospheric processes such as the North Pacific High and North Pacific Gyre Oscillation (NPGO), and how they correlate with localized levels of upwelling and productivity at the lower trophic levels. It is important to keep in mind that nonlinearities in ecological systems can produce apparent state-transitions in marine ecosystems in response to random fluctuations in the atmosphere (Di Lorenzo and Ohman 2013).

Upwelling

Upwelling plays a crucial role in generating productivity of the California Current. Schroeder et al. (2013) found a relationship between upwelling and an index of the North Pacific High in winter, which they described as a “pre-conditioning” of the ocean that affects prey availability in spring—during the crucial early marine life stages of salmon. Understanding upwelling itself is a major challenge because it varies not just in mean values, but also in intensity, as well as in the timing of shifts between upwelling and downwelling seasons.

Using a new index that integrates these components, Bylhouwer et al. (2013) analyzed correlations between signals of the PDO and El Niño and upwelling in the California Current. They found that positive/warm phases of both large-scale processes were associated with a later onset of upwelling and a weaker and shorter upwelling season. In the southern California Current Ecosystem, Garcia-Reyes et al. (2013b) found that winter and spring winds and sea surface temperatures (and upwelling) strongly influenced success at higher trophic levels. Examples were Chinook salmon growth rates based on otolith microstructure, lay dates and reproductive success of multiple bird species, and sardine and rockfish recruitment and growth.

Hypoxia and pH

Upwelling brings to the surface deep ocean water that has not been exposed to air for extended periods and is generally diminished in oxygen. Peterson et al. (2013) found a link between the NPGO and oxygen levels in source waters upwelled in the California Current. They found that hypoxic water was more prevalent where the continental shelf is wider, covering up to 62% in some years. Dissolved oxygen and pH have been declining since 1980 in the California Undercurrent, while temperature and salinity have been increasing. Equatorial waters appear to be extending further up the coast. Also, in 2012, more acidic waters were upwelled along the coast than in 1980 (Meinvielle and Johnson 2013). Acidity also affects the aragonite saturation state, which has declined in surface water on the Oregon shelf from 1-4.7 in pre-industrial times to 0.66-3.9 in 2007-2011 (Harris et al. 2013).

Ecosystem Responses

Trends in chlorophyll levels vary across the California Current, but have been generally positive near shore over the 13 years from 1997 to 2010 (Thomas et al. 2013). Chlorophyll levels were highly correlated with the NPGO off Washington and Vancouver Island. Although I do not thoroughly review oceanographic modeling of the drivers of productivity at lower trophic levels, one that describes the influence of the PDO and NPGO on the California Current is worth mentioning (Franks et al. 2013). Other models describe dynamics for California, British Columbia, and Alaska (Coyle et al. 2013; Decima et al. 2013; Li et al. 2013).

Many fish respond to ocean/atmospheric forcing factors, including flatfish in both condition and distribution (Keller et al. 2013) and sardine and anchovy in population cycling (Lindegren et al. 2013); these responses are similar to those observed in birds (Hatch 2013). In an analysis of world fisheries catches, Cheung et al. (2013) developed a new index of the thermal preferences of the catch to determine whether there is evidence in catch data that southern species are moving northward. They found that in fact, the mean thermal preference of catch in 52 large marine ecosystems, excluding the tropics, increased 0.23°C per decade from 1970 to 2006.

Large-scale atmospheric drivers tend to cycle at longer time scales, alternating between positive and negative phases. Following these phases, several authors discussed corresponding “regime shifts” in ecological (Hatch 2013) and social-ecological systems (Perry and Masson 2013). Hatch (2013) suggested 2008 marks another regime shift in Alaska. Perry and Masson (2013) used the driver–pressure–state–impact–response framework (used in the Integrated Ecosystem Assessment) to develop a multivariate index of regime shifts for the Strait of Georgia. Their index included a wide variety of factors, such as physical conditions, hatchery releases, and fishing effort, as well as drivers and pressures from human populations and biological indices at all trophic levels, including catch, to describe the state and impacts (Perry and Masson 2013). They identified 6 variables that acted as leading indicators of regime shift.

Although somewhat peripheral to our main topic, we also note physical analyses of the impact of Japan's Tōhoku earthquake and tsunami in 2011 on flows in the Columbia River and how the timing of the impact depended on tide height (Tolkova 2013). Increasing wave height is also shown to be a more dominant driver of coastal flooding and erosion than sea-level rise (Ruggiero 2013). Estuarine habitat is likely to change with sea level rise, and some detailed habitat mapping helps to clarify where habitat might be gained and lost, which is crucial to long-term planning of habitat availability (Flitcroft et al. 2013).

Climate Impacts on Salmon

The literature on climate impacts on salmon fall into two categories. First, retrospective analyses strive to identify the role of environmental factors in salmon biology and distribution. This background information is essential for the second category, projections affecting salmon, wherein retrospective knowledge is used to predict salmon responses to climate change in the coming decades.

Because policy decisions depend most on projected responses to future climate, I begin with a summary of work in this category. Within this body of literature, I first address *freshwater* habitat suitability and population modeling, and then focus on implications of *ocean acidification* for marine life stages. Finally, I note the potential for *range expansion* into habitats that are currently too cold or inaccessible, but might become suitable under a changing climate.

Projections Affecting Pacific Salmon

Freshwater Life Stages

A number of studies have generated quantitative and qualitative projections specific to the populations included in this Biological Opinion. Among these, the **steelhead** vulnerability assessment of Wade et al. (2013) stands out for the following qualities:

- Broad scope covering all steelhead populations in the Pacific Northwest
- Life-stage specific approach, wherein all freshwater life stages are modeled with individual tolerance criteria and spatial and temporal exposures
- Comprehensive stress index, which incorporates duration, intensity, and extremes of environmental exposure
- Population-specific vulnerability index that accounts for current population status
- Inclusion of other habitat stressors such as land use and human population density

For this study, Wade et al. (2013) produced detailed stream-flow and temperature projections. They found that historical water temperature already approaches lethal limits for adult steelhead in the Upper Snake, Rogue, Chehalis and Middle Columbia Rivers. Thus, even minor increases in thermal exposure put some of these populations above lethal limits. In future scenarios, they project the greatest temperature increases in the Upper Columbia, Lower Snake, Lower Columbia, and Upper Willamette Basins. Populations in these locations also face high habitat stress, and hence high total vulnerability scores (see Figure 6 in Wade et al. 2013). This analysis will be very useful for conservation planning.

A second analysis of steelhead focused on life history diversity in the Methow River. This analysis compared climate change with the effects of changes in temperature and food availability (Benjamin et al. 2013). Rising temperature increased growth rates, leading to smaller and younger maturation or smoltification. However, food web changes had the ability to either mediate or exacerbate the effects of temperature.

For all west coast populations of steelhead and Chinook salmon, Beer and Anderson (2013) performed quantitative projections of spawn day, egg development, and juvenile growth under climate change scenarios. They predicted that Chinook salmon would spawn later in the year, but that steelhead spawn timing would not change. Because of counteracting impacts of increased temperature on growth, their projections showed that mid-summer weights of both species stayed the same across most of the range but increased at some high elevation and cooler sites.

Another comprehensive but qualitative analysis of full life-cycle exposure to climate change addressed Oregon Coast **coho** salmon (Wainwright and Weitkamp 2013). These authors addressed the direction and magnitude of population response to climate trends in each life stage and our certainty in that response. They found a preponderance of negative or strongly negative effects with relatively high certainty compared with neutral or positive effects, leading to a projection of population decline in most populations. A somewhat similar although simpler deduction was applied to all nine species of salmonids in the Nooksack River, Washington, where potential loss of snow and glacier melt is projected to be the primary driver of decline (Grah and Beaulieu 2013).

A model of juvenile survival for Chinook salmon in the Lemhi River compared the effects of water diversion and climate change under various management and climate scenarios (Walters et al. 2013). They found that the effects of these factors compounded: diversion alone lowered juvenile survival 42-58%, but diversion with climate change depressed survival an additional 11-39%.

Numerous additional quantitative analyses and novel approaches have been applied to a variety of trout species (Al-Chokhachy et al. 2013; Blair et al. 2013; Filipe et al. 2013; Hedger et al. 2013; Roberts et al. 2013). However, because these are not focal species for this Biological Opinion, I list only the most interesting ones: a probabilistic accounting of uncertainty for bull trout projections in the Interior Columbia River Basin (Wenger et al. 2013); a comprehensive ecological, evolutionary, and genetic model of Atlantic salmon (Piou and Prevost 2013); and a study of how carrying capacity changes with temperature in brown trout (Ayllon et al. 2013).

Of particular interest might be the release by Katz et al. (2013) of a quantitative analysis of conservation status that incorporated risk of climate change for all native salmonids in California. They found that climate change and hatchery propagation were the most pressing extinction threats, with climate change having the largest negative effect and acting on all California populations.

On a more positive, albeit limited note, Boughton and Pike (2013) showed that upstream migration in one particular steelhead population might not be very sensitive to climate warming, but that the frequency of storms could limit migration opportunity.

In summary, projections of freshwater climate impacts are consistent with those from previous analyses: a few cold-water locations showed positive responses to climate change in certain life stages, but the vast majority of impacts are negative. These negative impacts extended across salmon species, throughout the various freshwater life stages, and geographically across the West Coast. Furthermore, many populations already most impacted from other threats are also the most vulnerable to climate change.

Watershed Vulnerability Assessment

The U.S. Forest Service conducted a set of pilot vulnerability assessments of American watersheds, including two where species in this Biological Opinion reside (Umatilla and Sawtooth Basins) and summarized the general lessons learned from this process (Furniss et al. 2013). They projected a substantial loss in bull trout habitat, due to increases in winter peak flows and loss of connectivity between habitats due to high summer temperatures and reduced base-flows. Populations in 2 of the 14 subbasins assessed were considered to be at high population persistence risk by the 2040s, and in the Sawtooth Basin, 3 populations faced such risk levels by the 2080s. In the Umatilla, they estimated that about 34% of suitable bull trout habitat would be lost.

Although prospects in the Pacific Northwest are rather discouraging, we note that world-wide, salmon have successfully established new populations outside their historical range both through introduction and natural exploration (Nielsen et al. 2013). Some barriers to migration might continue to separate populations, such as the barrier of northern Quebec between North American and European Atlantic salmon. But recolonization after natural disturbances is generally swift (Milner et al. 2013).

Ocean Life Stages

An analysis of cumulative and interacting effects of tidal power development and climate change on ESA-listed species in Puget Sound, Washington (Busch et al. 2013a) found that salmon showed interactive effects from these two stressors. Although some species showed little direct impacts from climate change (e.g., steelhead), the combined effects of changing foodweb and tidal power produced very high risk to these populations.

Migration Pathways—Climate change will affect many aspects of marine life, including growth, survival, and behavior. Marine migrations are currently little understood. In a review of the impacts of climate change on marine migratory species, Anderson et al. (2013) described the relevant physical changes and current knowledge about fidelity to foraging and breeding habitats and migration corridors and bioclimate envelop models of current distributions, and phenology. They then developed an individual-based model for a generalized response to climate change based on phenology-mediated growth, survival, and reproduction. Using this model, they projected population growth, extinction risk, and adaptation mechanisms.

Anderson et al. (2013) concluded that the size of the bioclimate envelop is very important for population fate, and more specialized species are at greater risk. Genetic adaptation might be too slow to prevent phenological mismatch with prey, and rescue by phenotypic plasticity depends on whether the cue for the behavioral response tracks climate change, i.e., whether the existing reaction norm will successfully track future bioclimate envelops.

However, it is not clear to what extent individual species traits will be important in determining responses to climate change. A comparison of observed shifts in ranges across marine species with local climate changes found that variation in local climate explained more than species traits (Pinsky et al. 2013). Increasing variability in certain atmospheric indices, such as the NPGO, also seems to be correlated with increasing influence on a number of ecosystem components from krill to seabirds (Sydeman et al. 2013) in recent decades. But the extent to which these patterns will continue is unknown.

Ocean Acidification—In 2013, extensive work focused on ocean acidification and interactions with hypoxia. Generally these publications show substantial resilience to direct effects of ocean acidification at higher trophic levels, especially for fish important for fisheries such as walleye pollock (Hurst et al. 2013) and cod (Frommel et al. 2013; Maneja et al. 2013a; Maneja et al. 2013b). However, hypoxia effects at lower trophic levels are highly idiosyncratic, which makes projecting cumulative food-web responses very challenging.

An elegant demonstration of these complexities can be found in the scenarios compared by Busch et al. (2013b) using a food web model of Puget Sound. Using the *Ecopath with Ecosim* model, they examined varying numbers of functional groups that were negatively affected by ocean acidification, from one to all heterotrophic calcifying groups. Scenarios either increased or decreased fisheries yield, because impacts at different levels of the food chain sometimes cancelled each other out. Ultimately, most impacts on fisheries stemmed from direct rather than indirect effects. Thus, modeled impacts on salmon were relatively small, with less than a 5% change in yield in all scenarios except one, in which ocean acidification affected only macrozooplankton.

Our understanding of sensitivity to ocean acidification is growing quickly. A meta-analysis of 228 studies reported that 100 new species have been studied recently (Kroeker et al. 2013). In general, heavily calcified organisms, including calcified algae, corals, mollusks, and the larval stages of echinoderms, are the most negatively impacted, whereas crustaceans, fish, fleshy algae, seagrasses, and diatoms are less affected or even benefit from acidification. The diversity of individual species and life-stage sensitivities indicates that evolution of tolerance to ocean acidification is possible and perhaps likely in some species (Kelly and Hofmann 2013; Kelly et al. 2013).

Effects of ocean acidification on fish often involve olfactory ability, in some cases impairing behavior (Leduc et al. 2013; Lonnstedt et al. 2013) and in other cases improving hearing (Bignami et al. 2013). These results bear relevance to otolith studies in which bone growth is used as an indicator of body size. Ocean acidification might interact with toxicants, both in terms of the carbon balance and fish responses (Nikinmaa 2013) and might also affect virus-host interactions, though current studies mostly involve phytoplankton (e.g., Carreira et al. 2013).

Retrospective Analyses: Environmental Influences on Salmon

Migration Behavior and Survival

Temperature-Related Migration Blockage—Most Pacific salmon reproduce only once in their lifetime, and historically, survival during the upstream migration has been high. Reducing anthropogenic hindrances during this stage is crucial for recovery. Thermal barriers to migration have probably always characterized migrations for some stocks (e.g., Okanogan sockeye and Klamath River Chinook). However, modern structures and water withdrawals that cause temperatures to shoot near or past lethal limits may create serious thermal barriers for many more stocks, and addressing this problem is a high priority for salmon managers.

Several papers in 2013 documented this problem, and in some cases, the failure of transportation to mitigate the problem. In the Columbia River, temperature gradients over 4°C within fish ladders at dams were associated with fallbacks and passage delays during adult migrations (Caudill et al. 2013). In Butte Creek, California, transportation of fish that had stopped migrating did not result in successful spawning (Mosser et al. 2013).

Changes in Migration Behavior—Extensive work with Atlantic salmon continues to show high sensitivity to environmental conditions in both juvenile behavior (Heggenes et al. 2013; Roy et al. 2013) and smolt stages (Handeland et al. 2013; Lacroix 2013; Lefevre et al. 2013). Marine migratory behavior is affected by smolt timing and marine water temperature. In one case, late smolt arrival coincided with a ring of warm marine water around the Bay of Fundy. This resulted in prolonged residency in the bay, where high predation apparently caused a near failure of cohort survival (Lacroix 2013).

Although not necessarily related to environmental conditions, a useful study of spring/summer Chinook salmon in the Columbia River Basin showed that within a population, the *order* of migration timing is age-structured (Bracis and Anderson 2013). They showed that within a population, the oldest fish migrate first and the youngest last. This analysis could help understand constraints on adult distribution and ability to stay within productive areas of the ocean in the year of adult return under future conditions.

Enhanced Vulnerability to Fisheries—Temperature interacts with other stressors. Of particular concern is the stress from fisheries during the upstream migration. A review across species found widespread evidence that mortality after catch and release is elevated at higher temperatures, even when those temperatures are within the normal tolerance range (Gale et al. 2013). Consistent with this general review, a specific study on Atlantic salmon documented a negative interaction between temperature and stress from catch-release handling (Richard et al. 2013). However, pink and chum salmon seem to be more resilient to handling stress on the spawning grounds than other species ([Raby et al. 2013](#)).

Growth and Sensitivity to Environmental Conditions

Most Pacific salmon have variable life histories that depend largely on growth opportunity. Recent studies have related residency in steelhead (Berejikian et al. 2013) and unusual yearling life history in fall Chinook salmon (Hegg et al. 2013) to water temperature and flow. In these relationships, the mechanistic driver was thought to be related to lipid, as has been shown for Atlantic salmon (Jonsson et al. 2013). Temperature may affect lipid reserves, which dropped after exposure to high thermal stress in steelhead (Kammerer and Heppell 2013a) and redband trout (Kammerer and Heppell 2013b), as indicated by production of heat shock protein. At higher temperatures, steelhead grow less and produce more heat shock protein (Kammerer and Heppell 2013a).

An analysis of Willamette Chinook salmon (Johnson and Friesen 2013) found no change in mean age at maturity, despite changes in environmental conditions over 17 years. However, these researchers did detect a relationship between adult body size and the Pacific Decadal Oscillation. Because growth rates have different consequences for age at return for males vs. females, relative sizes of fish on the spawning grounds might shift in a warmer climate. In a recent study on Chinook salmon, Mizzau et al. (2013) found that at 15°C compared with 10°C, sexual-size dimorphism was biased toward males in juveniles, whereas it was biased toward females in mature adults. The head start in male growth apparently caused earlier maturation, which led to reproduction with larger, older females.

An interesting paper related multi-species fish responses to a severity index representing flow extremes in Ontario (Jones and Petreman 2013). They found that across species, low-flow events depressed young-of-the-year growth while high-flow events increased growth; likewise, abundance was depressed by low-flow events but augmented by high-flow events.

Habitat Preference

Much behavior is mediated by thermal conditions in combination with other habitat factors, and I briefly visit a few of the studies relevant to salmonids. In general, this literature is consistent with our previous understanding of salmon behavior and optimal growth conditions. For example, steelhead in California minimize activity under warmer conditions and avoid pools over 30°C (Sloat and Osterback 2013). One interesting study demonstrated a correlation between boldness and stress, such as that induced by hypoxia or temperature (Frost et al. 2013). This suggests indirect mechanisms that alter the impact of stress on growth rate. An overview of winter behavior outlines some potentially relevant insights for detailed behavior models (Weber et al. 2013).

Evolutionary Response to Thermal Environments: Migration Timing

Migration timing is strongly related to environmental covariates, but these responses can be plastic (i.e., immediate behavioral responses to the environment) or genetic (i.e., determined by selection in previous generations). Kovach et al. (2013b) show how a suite of juvenile and adult stages in five salmon species have changed with climate in Auke Creek, Alaska. Evolutionary responses in migration phenology in pink salmon were recently linked to natural selection (Kovach et al. 2012), but further study of this population has shown they did not lose genetic variation despite the rapid shift in gene frequencies (Kovach et al. 2013a).

A second study on this same population trend found that early and late-migrating phenotypes have essentially come to different solutions in the survival trade-off between the freshwater vs. marine life stages (Gharrett et al. 2013). Gharrett et al. (2013) argued that embryos from early migrating adults had lower freshwater survival but high early marine survival: these embryos face harsh winter conditions and the effects of ongoing spawning, but they arrived earlier in the ocean under better feeding conditions. Late-migrating adults, on the other hand, produce offspring with better early growth in freshwater but poorer marine survival. In salmon, this type of divergent selection with alternate solutions to a common problem (maximizing lifetime fitness) gives rise to much phenotypic and genetic diversity.

Local Adaptation in Egg Size and Survival, Redd Depth, and Heat Shock Proteins

Many aspects of thermal tolerance and preference have a genetic basis and are local adaptations to specific habitats and life histories. However, these traits are also extremely sensitive to acclimation, timing, and maternal conditions, which are very difficult to control for in population comparisons, but which might explain some of the patterns described here. Nonetheless, egg-size/temperature relationships differ among populations in the direction expected from local adaptation (Braun et al. 2013).

Populations of Fraser River sockeye salmon historically exposed to warmer incubation regimes produced larger eggs than expected from a single egg-size/temperature relationship for all populations; this might reflect compensation for the warmer environment through local adaptation. Fraser River sockeye also may have evolved thermal reaction norms to match river conditions during the migration season (Whitney et al. 2013). Another study of Fraser River sockeye found that aerobic scope and cardiac performance was consistent with local adaptation across populations with migrations of varying timing and difficulty (Eliason et al. 2013).

Whitney et al. (2013) also found that populations that experience higher egg incubation temperatures have right-shifted thermal reaction norms. However, Chen et al. (2013) showed patterns among Fraser River sockeye populations that indicated upper temperature tolerance in eggs varied with age at measurement. These results suggest that temperature tolerance at a single point in time might not be a robust test of local adaptation. This study also found differences in heart rates across populations, and concluded they had evidence for thermal adaptation (Chen et al. 2013). Another purported adaptation to incubation conditions involved female redd depth in brown trout (Riedl and Peter 2013), where variation along an elevation gradient in Switzerland was thought to reflect adaptation to scour risk.

Expression of heat shock proteins is consistent with individual population exposure to high temperatures in redband trout, but there is an interesting trade-off between the benefit of expressing these proteins in response to short-term vs. long-term exposure. In the short term, elevation heat shock proteins are beneficial. However, chronic production of these proteins has negative consequences, so over evolutionary time, selection works to reduce their expression (Narum et al. 2013). It is important to keep in mind that similar phenotypic responses to temperature and other stressors might reflect very different physiological processes (Wellband and Heath 2013a, b).

Thermal preferences are not always genetically determined. A study of ecotype by population growth and thermal preference in lake trout found that acclimation explained more variation than population growth, indicating a plastic response to early growth conditions (McDermid et al. 2013).

Many adaptations to climate have a genetic basis. However, these adaptations evolve relatively quickly, as shown by the high relatedness within basins among populations of different life history types, compared with between-basin divergence (Moran et al. 2013). Population genetics presents powerful tools for deciphering local adaptation, and great advances are being made in identifying genes subject to natural selection (Vincent et al. 2013). For example, differentiation at three circadian-clock genes was associated with differences in run-timing of spring vs. fall Chinook in Feather River, California (O'Malley et al. 2013).

Interacting Stressors: Hypoxia, Contaminants, and Disease

Methods of Analyses

A popular conceptual model for integrating the impact of multiple stressors is the theory of oxygen and capacity limited thermal tolerance (so-called OCLTT). This theory relates thermal exposure to aerobic scope, which in turn affects the performance measures typically used to indicate fitness. In 2013, this theory came under fire (Clark et al. 2013). However, the criticisms of this approach were less applicable to upstream-migrating salmon than to salmon in other contexts, and upstream migration is the primary context in which we have referred to OCLTT in these reports (see also the general defense by Farrell 2013). The effects of hypoxia generally exacerbate temperature stress (e.g., in brook char, Ellis et al. 2013), but tolerance of the two traits can be correlated. For example, enhanced tolerance of hypoxia was observed in strain of genetically selected, fast-growing rainbow trout compared to a slow-growing strain (Roze et al. 2013).

Anttila et al. presented two studies (2013a, 2013b) reviewing the evidence for a correlation between thermal tolerance and hypoxia tolerance, and found a positive correlation between these traits. They concluded that their findings supported the OCLTT theory. However, Hasnain et al. (2013) presented a broader review of traits related to thermal adaptation. These included metrics of growth (optimal growth temperature, final temperature preferendum), survival (upper incipient lethal temperature, critical thermal maximum), and reproduction (optimum spawning temperature, optimum egg development temperature). Growth, survival, and reproduction metrics were evaluated across 173 North American freshwater fish species, and results showed that all of these traits were highly correlated, with a strong phylogenetic component.

An emerging new technique is metabolomics, in which low molecular mass metabolites within the cell, tissue, or biofluid of an organism are analyzed in response to an external stressor (Lankadurai et al. 2013). This technique might lead to growth in the study of interactions among stressors. Dolomatov et al. (2013) summarize much of the physiology of temperature regulation.

Contaminants

Contaminants are a persistent problem in Northwest watersheds, as elsewhere. This threat may grow more acute as contaminants interact with factors that change with climate, such as flow, salinity, or pH. Attempts to attribute fish decline to effects of contaminants is often difficult, as shown in a case study of Fraser River sockeye salmon (Ross et al. 2013). The complexity of such interactions was reviewed by Hooper et al. (2013) and Moe et al. (2013), with the latter presenting a framework for solving the problem. For example, many climate models predict an increase in severe storm events in the Pacific Northwest. Extreme flows are associated with such events, and these flows have both direct and indirect effects.

Extreme flows carry most of the toxic sediment that arrives in an estuary from contaminated areas within a steep coastal basin in San Lorenzo, California (Conaway et al. 2013). The impact of contaminant pulses, such as those carrying polycyclic aromatic hydrocarbons, can increase at higher temperature (Brinkmann et al. 2013). Despite concern that the toxicity of insecticides in estuaries might intensify under increasing salinity, one study showed little effect (Riar et al. 2013). Aluminum is more toxic in more acidic water, and a study of migrating Atlantic salmon smolts found that at low exposures, the toxic effect of aluminum was delayed at times until the fish entered marine water (Thorstad et al. 2013).

Fish Pathogens

Some **diseases** are affected by flow and temperature regimes, either through pathogen growth rates, vector dynamics, or virulence/resistance by the fish. *Ceratomyxa shasta*, a parasite common from the Columbia to Klamath Rivers, is sensitive to temperature at all stages of transmission. Ongoing work examines relationships between transmission of this parasite and water velocity and temperature (Ray and Bartholomew 2013). The parasite-host relationship involves co-evolution, as shown for the evolution of oligochete resistance to the myxozoan parasite that causes whirling disease in the Colorado River (Nehring et al. 2013). **Proliferative kidney disease** is also more difficult for brown trout to completely expel under warmer conditions (Schmidt-Posthaus et al. 2013).

Invasive Species

A major concern for Columbia River Basin salmon is the threat of invasion by warm-adapted species that compete with or prey upon native salmon. **American shad** has come to dominate the anadromous fish migration in the lower Columbia River. The incursion of shad upstream past McNary Dam is correlated with higher water temperatures and lower levels of flow. The conditions projected with climate change (warmer summer temperature and lower summer flows) are consistent with further penetration of the upper Columbia River by American shad (Hinrichsen et al. 2013). **Brook trout** has also invaded much of the Columbia Basin. Studies in both the Canadian Rockies (Warnock and Rasmussen 2013) and in Vermont (Butryn et al. 2013), found that brook trout more readily invaded warmer streams. **Brown trout** are not a recognized threat at this point in the Columbia River Basin, but numerous studies have documented their habitat preferences and invasion behavior (see especially Labonne et al. 2013), and they are probably selectively preferred under warmer conditions.

Marine Survival and Behavior

Numerous papers analyzed the relationships between early marine conditions and adult returns for Columbia River salmon. Daly et al. (2013) found that larval fish biomass in the winter prior to smolt arrival was a good predictor of salmon survival. In a separate study, juvenile rockfish survival (a favored prey species) was correlated with sea level anomalies (Ralston et al. 2013). Miller et al. (2013) found that fish condition in September (but not June) and Columbia River plume volume explained most of the variation in adult returns. Burke et al. (2013b) found that a large suite of variables was necessary to explain adult returns. Sharma et al. (2013) related the spatial scale of ocean covariation to adult returns and found that a spatial scale of 350-450 km best represented the correlation structures. These relationships point to large-scale driving factors in the Pacific Ocean that synchronize responses from many populations.

In their study of geographic patterns, rather than survival, Burke et al. (2013a) explored decision rules that can explain marine distributions and found that geographic rather than environmental factors apparently controlled migration. These results suggest that fish might hazard highly unsuitable conditions to reach their goal. Hypoxia, in particular, is increasing along the Oregon coast, challenging the tolerance of many invertebrates, although some were resistant (Eerkes-Medrano et al. 2013).

One report published in 2013 for a stock outside the Columbia Basin was noteworthy: a modeling effort by Dorner et al. (2013) found that detection of oceanographic drivers using a Ricker function on catch data can be extremely difficult. They concluded that it is unlikely that modeling efforts at present can accurately represent such marine drivers or manage them for climatic effects.

Climate is clearly important in driving survival during both the freshwater and marine life stages of Pacific salmon, and co-variations in survival are observed over large spatial scales (Sharma et al. 2013). Nevertheless, climate over the past 500 years did not synchronize population dynamics across 20 populations of sockeye salmon in Alaska (Rogers et al. 2013).

Climate Change and Endangered Species

A series of papers in a special issue of *Conservation Biology* considers how climate change affects ESA decisions. The Special Issue addresses a range of issues from climate science to biology to policy focus. Starting with the climate science, Snover et al. (2013a) offer guidance for choosing climate change scenarios and clarification of irreducible uncertainty. One piece of advice from this paper is that climate scientists, biologists and policy makers should work together early in the process for the best outcome. Although not in the special issue, a separate paper finds a successful approach taken by NOAA's Regional Integrated Sciences and Assessments (RISAs) program in disseminating information and promoting scientist/client interaction and application of the information (Kirchhoff 2013).

The Special Issue in *Conservation Biology* also addresses more conceptual biological issues, such as clarification of the breadth of the conceptual model needed to encompass the full range of climate impacts (not just lethal maximum temperatures) and the imperative of considering long term (100 year) climate projections in setting goals for proactive actions and necessary levels of population protection (McClure et al. 2013). Although not part of this special issue, another paper fills out many of these steps in a framework document that includes a case study on salmon in the Pacific Northwest (Wilsey et al. 2013).

Other papers in the Special Issue address the policy decision making process, including an overview of ESA processes (Seney et al. 2013) and explication of a decision focused approach (Gregory et al. 2013), similar to the adaptation turning point approach mentioned above.

Our literature search was designed to identify cutting-edge experimental and analytical science relevant to understanding the impacts of climate change on Pacific salmon. As such, it does not cover most policy documents or practical approaches to decision-making, which are typically not published in peer-review scientific journals. Nonetheless the smattering of papers from this literature may be useful to mention.

A crucial question for reintroduction or restoration programs is whether climate change will make a given habitat unsuitable, regardless of habitat restoration actions. This question is addressed in a case study of prospects for reintroduction of Atlantic salmon to the Rhine River, where (Bolscher et al. 2013) propose a five-step process to determine adaptation turning points. These steps are

- 1) Describe the system of interest and scope of the project
- 2) Identify potential key impacts of climate change,
- 3) Identify the socio-political objectives of concern
- 4) Determine adaptation turning points, such as when critical thermal maxima are likely to be exceeded, and

5) Develop alternate adaptation strategies, i.e., actions to postpone or avoid turning points.

Obstacles to applying these frameworks often involve institutional and operational issues, including competing demands for a shared resource, and effective communication between climate information and water managers. A study of hotspots of water quality vulnerability in the Columbia River Basin lays out some areas of concern when human interests are considered alongside biological interests in an integrated water supply, demand, quality assessment (Chang et al. 2013).

Options for responding to ocean acidification are especially sparse. To address this deficiency, Bille et al. (2013) review four categories of management responses: preventing ocean acidification; strengthening ecosystem resilience; adapting human activities; and repairing damages.

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Glossary

A1B, A2, B1	Carbon emission scenarios from AR4
AR4	4 th IPCC Assessment Report
AR5	5 th IPCC Assessment Report
CMIP3	Coupled Model Intercomparison Project Phase 3
CMIP5	Coupled Model Intercomparison Project Phase 5
ENSO	El Niño-Southern Oscillation
GCM	Global Climate Model
IPCC	Intergovernmental Panel on Climate Change
NPGO	North Pacific Gyre Oscillation
PDO	Pacific Decadal Oscillation
RCM	Regional climate model
RCP	Representative concentration pathways (Emissions scenarios for AR5)
VIC	Variable infiltration capacity model