Endangered Species Act
Federal Columbia River Power System
2011 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. Section 3 includes a list of projects implemented in 2011 along with their associated RPA subactions.

Contents

Tables

Figures

Hydropower Implementation Reports, RPA Actions 4–33

This document reports on actions taken during calendar year 2011. The Hydropower RPA actions are intended to be implemented over the term of the National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries) 2010 FCRPS Supplemental Biological Opinion[1] (BiOp). Although many of these actions were under way or being implemented during 2011, 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 because this is more meaningful.

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

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 and water quality to improve juvenile and adult fish survival consistent with Hydropower Strategy 1 of the BiOp as described in the 2011 Water Management Plan[2] (WMP) (BPA et al., 2010a). The WMP describes the Action Agencies' annual plan for implementing specific operations identified in the BiOp. The WMP was developed in the fall of 2010 with full regional coordination.

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 USFWS 2000 and 2006 BiOps.

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 in date order from October 2010 (the start of the 2011 water year) through December 2011. Real-time operations follow RPA action 4 specifications as adjusted in-season with the help of the inter-agency Technical Management Team (TMT), and oversight group consisting of regional biologists and hydrologists. Since it was a very high water year, flows and spill during the salmon migrations period were relatively high, as was total dissolved gas related to involuntary spill. Further discussion of these operations is included in the minutes of the TMT "2011 Year End Review Session" (TMT 2011).

Dworshak Dam

From October 2010 until January 11, 2011, Dworshak Dam released near minimum flows, approximately 1,600 to 1,700 cubic feet per second (cfs), except for some minor unit testing. Dworshak Reservoir began January 2011 at elevation 1527 feet, well under flood control elevations. Beginning on January 12 the project increased outflow to meet future flood-control targets. A strong, warm, precipitation event spiked inflows about mid-January to as high as a daily value of 32,000 cfs. Water forecasts and snowpack kept rising through the remainder of the winter and into the spring. The project outflows varied but reached as high as 24,900 cfs in early April, with releases designed to help meet flood-control drafts based on an April water supply forecast that was 126 percent of the average for the April–July period. Dworshak Dam was operated to meet standard flood-control criteria during the winter and spring flood-control season. By the end of April the project was drafted to elevation 1450.7 feet.

---

[2] The WMP describes specific operations defined in BiOps 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).

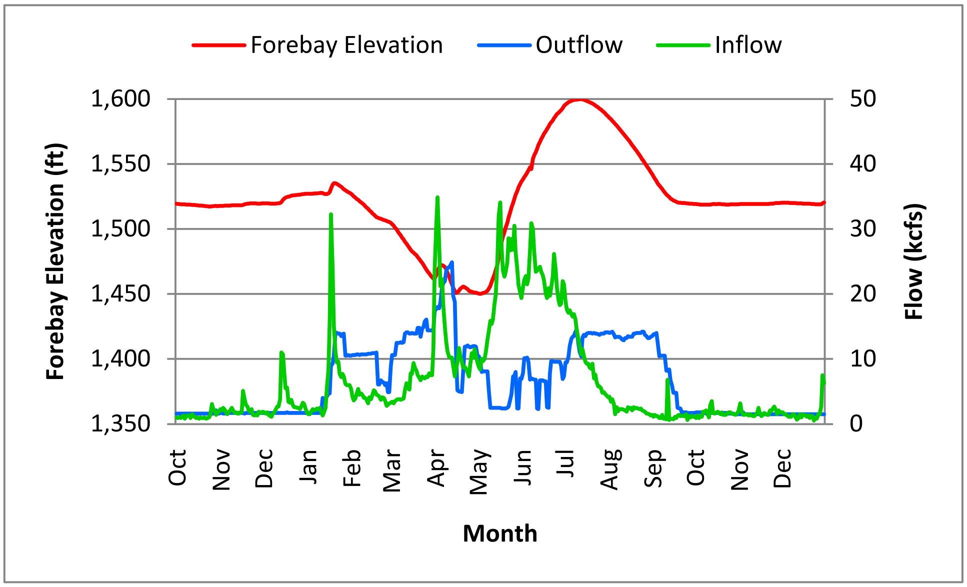


Figure 1. Dworshak Dam inflow, outflow, and forebay elevation from October 1, 2010, through December 31, 2011.

The deeper draft was partly for flood control (the May Corps forecast for April to July rose to 141% of average) and was partly a result of delayed runoff combined with flow augmentation provided during the latter part of April to help meet the early portion of the spring Lower Granite fish-flow objectives. Dworshak was operated for fill and flood control during May and filled to elevation 1534.6 feet by May 31. The project was operated for continued fill and system and local flood control during June. Daily flows varied between full powerhouse of about 10.2 thousand cubic feet per second (kcfs) to as low as 2.3 kcfs. For both May and June, some daily and weekly load shaping occurred. The peak Dworshak inflow appeared in two spikes, the first on May 16 at 34,100 cfs, and the second on June 7 at 30,900 cfs. Both events were influenced by rain on snow. In July, the project increased outflow in order to control final fill. The project filled to within one foot of full by July 6 and briefly reached elevation 1600.00 feet on July 12. For the remainder of July and August, Dworshak operated for temperature control on the lower Snake River (as measured at the Lower Granite Project tailwater) and for ESA-listed species flow augmentation. The 2008 FCRPS BiOp prescribed target is 1535.0 feet by the end of August unless limited by excessive total dissolved gas (TDG) production above the State of Idaho standard. Additionally, under an agreement with the Nez Perce Tribe (NPT), the Corps is obligated to draft 200 thousand acre feet (kaf) of storage during September, targeting an elevation of 1520.0 feet by about September 20. Due to high inflows the project released the maximum possible flow, generation plus limited spill, in order to stay below the 110 percent TDG standard, and it ended August at elevation 1541.4 feet. The 1535.0 elevation was reached on September 4, at which time the project began a stepped and prescribed ramp down to provide the 200 kaf of storage volume and to reach the 1520-foot elevation. As of September 26, the project had drafted to 1519.6 feet. These operations were coordinated through TMT.

From October to December 2011, Dworshak Dam released near minimum flows between 1,500 and 1,800 cfs. It ended December 2011 at elevation 1,520.5 feet.

Libby Dam

Libby began November 2010 at a pool elevation near 2441.6 feet. Libby was operated to reach an end-of-December flood-control elevation while accommodating regional power needs. Based on the December Libby water supply forecast of 6.3 million acre-feet (maf), the end-of-December flood-control target was set at elevation 2411 feet. The project stayed near minimum until November 8, at which time outflow increased and significant drafting began. By the end of November Libby had drafted slightly more than 10 feet, to 2431.3 feet. November inflows averaged 5.1 kcfs while outflows averaged 10.3 kcfs. Libby continued drafting during December. The project ended December at 2411.9 feet (midnight elevation). December inflows average 3.9 kcfs and outflows averaged 18.2 kcfs. The project ramped down to near minimum outflows (4.0 kcfs) by January 5, 2011, and stayed at that flow for the rest of the month.

Libby's elevation at the end of January was 2410.2 feet, 12.1 feet below the end of January flood–control target of 2422.3 feet. Supported by strong snow accumulation in the Kootenai Basin in January, the February official water supply forecast for April–August rose from 89 percent of average the previous month, to 105 percent of average (using the 1929–99 period of record). This volume set an end of February flood control draft requirement of 2,392.7 feet. The project increased outflows and operated for flood control draft, shaping for power benefits when possible, ending February slightly below the flood control rule curve at 2391.1 feet. The March official water supply forecast rose again, predicting an April-August volume of 7.1 maf, or 112 percent of average. As of March 11, the project was operating at about 16.3 kcfs outflow (four units efficient, with one of the five units forced out of service until May), targeting the end of March flood control elevation requirement of 2,364.3 feet. The project ended March at 2364.5 feet.

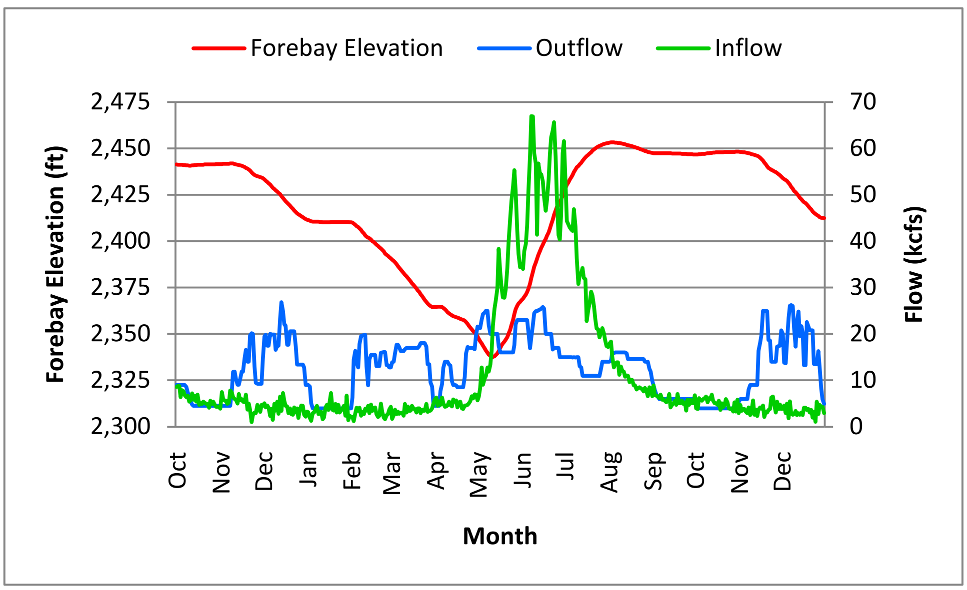


Figure 2. Libby Dam inflow, outflow, and forebay elevation from October 1, 2010, through December 31, 2011.

Due to the increasingly high amounts of snow in the basin (snow water equivalent on April 15 in the Montana portion of the Kootenai River Basin was 141 percent of average); Lake Koocanusa was drafted 9.8 feet below the project's end-of-April flood control elevation of 2359.2 feet. The Lake ended April at elevation 2349.4 feet. In early May, the project continued drafting, reaching a seasonal low elevation of 2337.6 feet on May 12. A unit that was forced out of service on March 3 remained unavailable until May 4. The project compensated for lost capacity by adding 5 kcfs of sluice gate spill from April 30 through May 9. By May 12, inflows rose above full powerhouse, and a cautious refill operation was initiated. Outflow was set well above the minimum variable outflow flood-control procedures (VARQ) flow, due to the forecast high seasonal runoff volume. Average May inflow was 27.4 kcfs, and the average May outflow was 19.8 kcfs. The lake elevation was 2367.8 feet on May 31.

The Corps' May forecast of April-August water supply reported an estimate of 8,165 kaf (128.9% of the 71-year average). This volume resulted in a Tier 5 sturgeon operation of 1,200 kaf. The volume accounting refers to outflow minus 4 kcfs of minimum flow. Snow continued to accumulate at higher elevations through May and even into June, with record amounts in some locations. Accounting of the sturgeon volume began on June 2, when temperature and fish movement criteria were met. Due to the high runoff volumes, the project was operating concurrently for flood control, sturgeon volume accounting/benefits, and refill. A primary consideration during the sturgeon operation was to operate Libby to not exceed flood stage of 1764.0 feet at Bonners Ferry, Idaho. The highest recorded stage reading at Bonner's Ferry was 1763.4 feet on June 11. Libby ended June at elevation 2425.5 feet, with average June inflows of 51.7 kcfs and average outflows of 20.8 kcfs. Peak seasonal inflows into Libby were recorded on June 9, with a daily average calculated inflow of 66.9 kcfs. The 1,200 kaf of water for sturgeon was expended on July 11, with outflows ramped down from 15 to 13 kcfs on July 12 and then from 13 to 11 kcfs on July 13, to achieve filling. The sturgeon pulse objectives, to operate Bonners Ferry as high as possible but below flood stage, were achieved without having to add spill. Furthermore, consideration was given to the high stages on Kootenay Lake in addition to Bonners Ferry stage.

The 11-kcfs outflows were held through July 26. Libby was then ramped up to 14 kcfs through the end of the month, with a July 31 elevation of 2452.8 feet. The ramp-up was in response to an incoming request from the Kootenai Tribe of Idaho to minimize flows in September and October to accommodate habitat restoration work around Bonners Ferry and to also meet the 2449-ft FCRPS BiOp target on September 30. Libby began August with a constant outflow of 14 kcfs, and then ramped up to 16 kcfs on August 4 to facilitate the implementation of a System Operational Request (SOR) discussed at the August 3 TMT meeting. The SOR was presented by the Kootenai Tribe for reduced outflows in September and October to allow for habitat improvement work below Libby Dam. This habitat work was part of the first phase of the Master Plan for the Kootenai River, as coordinated with the Kootenai Conservation and Restoration Plan and the USFWS Bull Trout BiOp. Specifically, the SOR requested a flow of 6 kcfs in September and 4 kcfs in October. TMT members supported the plan to operate Libby to reach a target elevation of 2449.0 feet before August 31, and then reduce outflows to the requested rates thereafter. Libby ramped down to 14.6 kcfs on August 15 due to a unit going out of service for maintenance. Flows were adjusted again, down to 14 kcfs on August 27 ramping down further on August 30 to 12.0 kcfs, and beginning the reduction from the 12 kcfs to 6 kcfs, following USFWS BiOp ramping rates on August 31. The peak elevation at Lake Koocanusa was reached on August 4 at 2453.4 feet. Libby ended August at elevation 2447.7 feet, reflecting a request by TMT to maintain steady outflows. The flat discharge of 6 kcfs was reached on September 5, to be held for the remainder of the month. The 6 kcfs discharge is also the minimum flow required in September for bull trout pursuant to the USFWS Bull Trout BiOp. The projected elevation at the end of September was 2446.8 feet, at which time outflows were ramped down, to 4 kcfs.

Libby ended November at elevation 2435.3 feet. The December water supply forecast came in at 93 percent of average, allowing a slight relaxation to the end of December target elevation, targeting 2412 feet (full draft according to VARQ and standard flood control is 2411 feet for December 31). In December the project drafted for flood control, shaping for power. The project actual elevation on December 31 was 2412.44 feet, and minimum outflow, 4000 cfs, was reached on December 31, 2011, at 2400 hours.

Grand Coulee Dam

In 2011, 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 for salmon during the migration season (e.g., managing reservoir elevations and drafting Banks Lake); helped support flows for chum salmon; and completed drum gate maintenance within the flood control draft. The following paragraphs detail actual operations.

Grand Coulee Dam was operated during November and December 2010 to facilitate chum spawning below Bonneville Dam, resulting in a 12.2-foot chum redd protection tailwater elevation at Bonneville Dam for the 2011 season. In 2011, the Northwest River Forecast Center (NWRFC) in Portland, Oregon, forecasted the April-August volume for The Dalles on a monthly basis beginning in January, with two forecast updates issued each month. Climate and weather experts predicted that moderate to strong La Niña ocean conditions would develop and persist during the 2010–11 winter, which typically increases the chance for below-normal temperatures and above-normal precipitation in the U.S. Pacific Northwest. However, even strong La Niña winters do not necessarily yield above-average winter precipitation, as was the case for the early part of the winter in 2010–11. For much of the fall and early winter, while precipitation was slightly above normal across the southern half of the basin, mountain snowfall initially lagged well below normal across Canada. Record low snowpack was noted in December and the first half of January in the northernmost portions of the basin. Despite being dry in the northern portion of the basin, the NWRFC forecast for The Dalles and Grand Coulee hovered near the 30-year average. By March, though, persistently heavy precipitation was finally falling in Canada, with above-average precipitation continuing basin-wide through June. In addition, temperatures remained well below average, in a few places setting new records, which allowed snow to accumulate much later than normal at unusually low elevations and delayed melt. Forecasts responded accordingly, with unprecedented increases between the March and June final forecasts. It became apparent, by early April, that the spring runoff would be above average and, by early May that it would be well above average. The January-July volume forecast increases at The Dalles between March and June were the largest ever made by NWRFC (32.0 maf), while forecasted April-August runoff increased from 97 percent of average in January to 138 percent of average by July. Table 2 shows the water supply forecasts (WSFs) for The Dalles and Grand Coulee, and the forecast based April 30 flood control elevations at Grand Coulee.

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 (% of average)	97	99	99	109	121	135	138
Grand Coulee Apr-Sep forecast (% of average)	94	102	103	107	117	126	128
Grand Coulee Apr 30 flood control elevation (feet)	1238.5	1235.1	1237.0	1220.2	N/A	N/A	N/A

During January and February 2011, Grand Coulee Dam was operated to help maintain the chum redd protection tailwater of 12.2 feet below Bonneville Dam as well as the Vernita Bar protection flows of 65 kcfs below Priest Rapids Dam. In order to perform required drum gate maintenance in 2011, Lake Roosevelt had to be drafted to at least elevation 1255 feet by March 15. A significant region-wide warming and precipitation event in January increased streamflows throughout the system and subsequently Lake Roosevelt filled to within a few feet from full. Lake Roosevelt then had to be drafted hard to achieve the drum-gate maintenance elevation by early March. Based on the March final forecast, the April 30 flood control elevation was 1237 feet: however, significant precipitation in March resulted in an increase in the forecast of 10 percent, bringing the April final forecast to 109 percent of average. This resulted in a drop in the April 30 flood control URC elevation of 17 feet, taking it to elevation 1220.2 feet. As a result of the large required draft to the April 30 flood control elevation, Lake Roosevelt was at elevation 1238.5 feet on April 10 which was about 20 feet lower than the March forecast determined April 10 elevation objective [2] of 1258.4 feet[3]. Lake Roosevelt was at elevation 1250 on April 1, so in order to achieve the April 30 flood control elevation, Lake Roosevelt had to start drafting on April 1 at a rate of at least a foot a day. Figure 3 shows inflows, outflows and reservoir operations through the water year.

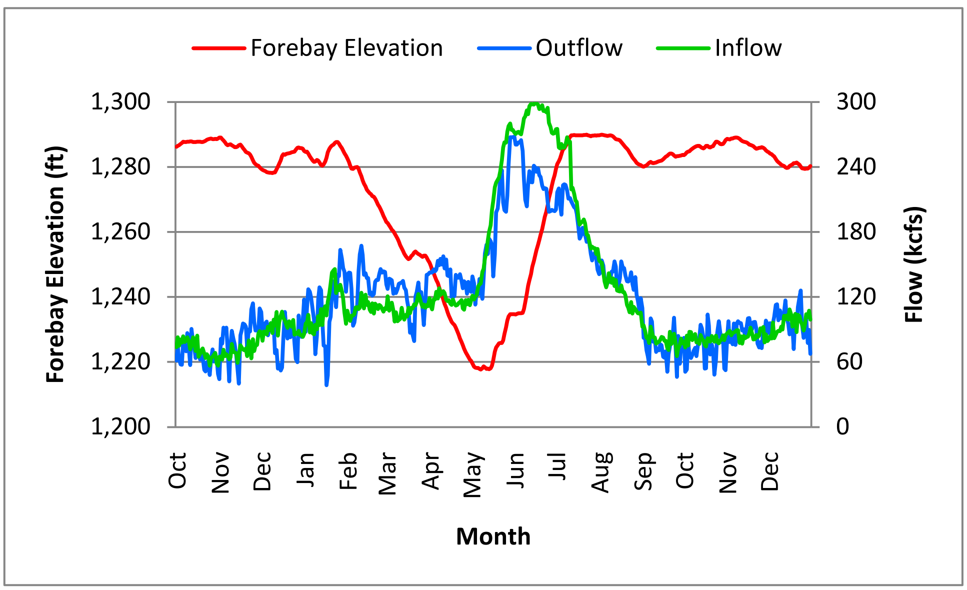


Figure 3. Grand Coulee Dam inflow, outflow, and forebay elevation from October 1, 2010, through December 31, 2011.

[3] *Reclamation computes Grand Coulee Dam's April 10 elevation objective by linear interpolation between the March 31 and April 15 forecasted flood control elevations based on the NWRFC March Final April-August WSF at The Dalles. The March forecast is chosen for the calculation of the April 10 elevation objective in order to allow enough time to react and to plan Grand Coulee operations accordingly. The April final forecast is typically not released until the 5th business day of the month, after which the Corps calculates flood control elevations. This usually means that final April 15 and April 30 flood control elevations are not released until around April 8 at the earliest. It is notable that even modest changes in The Dalles water supply forecast can produce significant changes in the forecasted flood control elevations for Grand Coulee. In order to achieve final April flood control targets, actual Grand Coulee elevations on April 10 may be slightly below or above the April 10 objective depending on draft rates and water supply conditions.*

After drafting down to the April 30 flood control elevation of 1220.2 feet, Grand Coulee had to pass inflow until around May 15, when Lake Roosevelt was allowed to start refilling. Drum gate maintenance was also completed around this time. Due to the late snowmelt and delayed runoff, the refilling of Lake Roosevelt needed to be delayed. The rate of refill was controlled by establishing flow objectives in the Lower Columbia River so as to not fill the lake too quickly. The Corps has flood control authority for the Columbia River and established the flow objectives for the Lower Columbia River to control the rate of refill of the upstream reservoirs while at the same time minimizing flooding downstream. Flood control operations and objectives were coordinated frequently (at least twice a week if not daily) between the Corps, Reclamation, and BPA. On May 16 the flow objective at Bonneville Dam was 460 kcfs but it was slowly increased as the spring runoff began in earnest and by May 25 the flow objective at Bonneville Dam was 500 kcfs.

The flow objective at Bonneville Dam remained at around 500 kcfs until about June 17. In order to help meet the flood control flow objectives at Bonneville Dam and to control the rate of refill of Lake Roosevelt, Grand Coulee needed to release a specified amount of water downstream. Grand Coulee can release water in several different ways. The preferred method is to release it through the turbines in order to generate power and to minimize TDG production. Grand Coulee can also release water through outlet tubes and over drum gates as spill. Discharges through the turbines and through the outlet tubes can occur at any Lake Roosevelt elevation, but water cannot be released over the drum gates unless Lake Roosevelt's water surface exceeds elevation 1265.5 feet. The outlet tubes generate significantly more TDG than the drum gates.

The maximum hydraulic capacity of the Grand Coulee power plant is around 280 kcfs if all 24 generators are on line. However due to preventative maintenance requirements and unscheduled forced outages, there are always some generators off line. Such was the case in 2011: on May 16, due to generator maintenance outages, the hydraulic capacity of the power plant was around 180 kcfs. The required discharge from Grand Coulee in order to meet downstream flow objectives was around 200 kcfs, so Grand Coulee had to spill around 20 kcfs. On May 23, a large generator was taken off line for required maintenance, which decreased the hydraulic capacity of the power plant to around 160 kcfs. The flow objective at Bonneville Dam was increased the same week, so the required discharge from Grand Coulee was increased, resulting in more spill. Lake Roosevelt was still well below elevation 1265.5 feet, so all spill was through the outlet tubes. Figure 4 shows Grand Coulee discharges, spill and resultant downstream TDG levels during the spring/summer of 2011.

In late May and early June, Grand Coulee was required to release a maximum of about 260 kcfs while generating about 160 kcfs resulting in maximum spill levels of just over 100 kcfs and TDG levels in excess of 140 percent. TDG levels dropped dramatically around June 23 when Lake Roosevelt filled above elevation 1265.5 feet, and Grand Coulee was able to spill over the drum gates. (See emphasis on Figure 4.) Spill continued through the drum gates until late July.

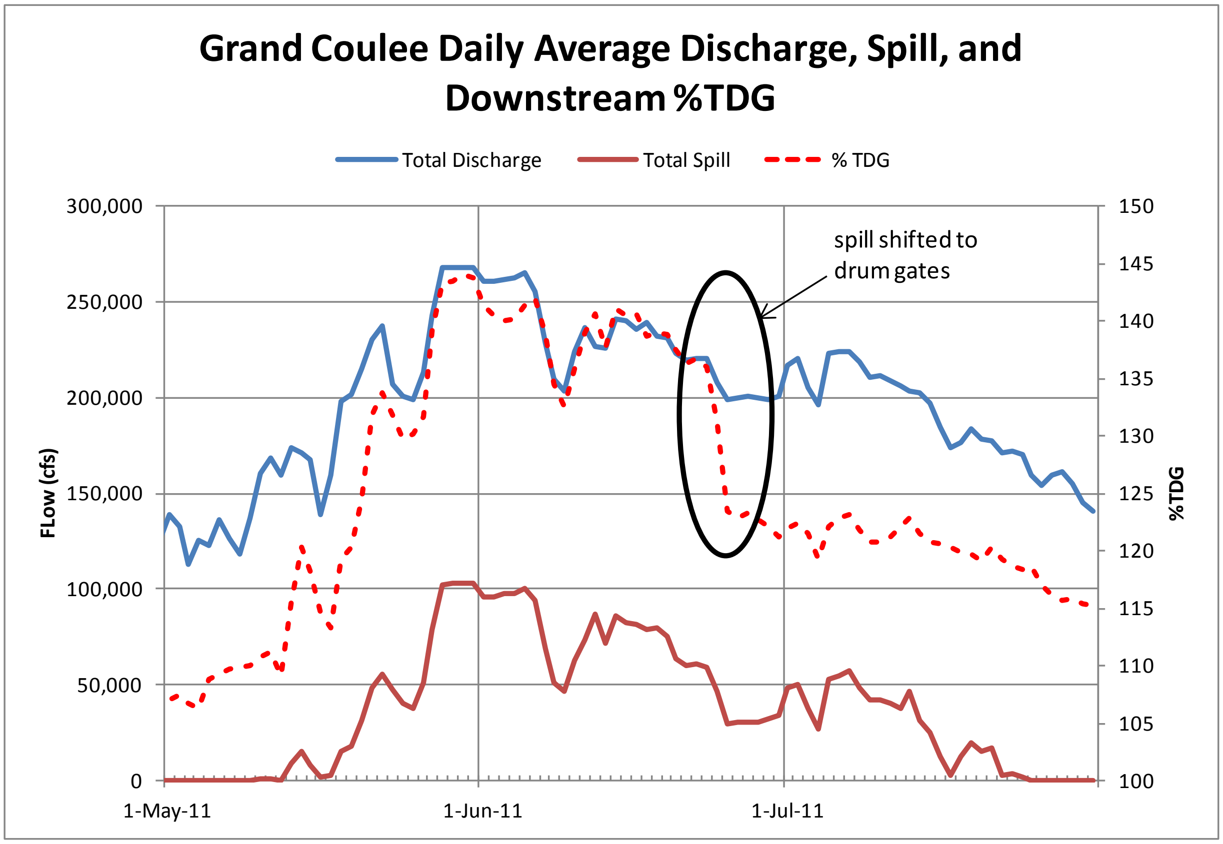


Figure 4. Grand Coulee total discharge, spill, and resultant downstream TDG, spring/summer 2011

During the spill event, several measures were taken to limit TDG as much as possible. Measures taken included:

- As much water as possible was passed though the turbines, Grand Coulee did not operate for peaking operations but loaded to turbine capacity 24 hours/day.
- Spill through the outlet tubes was configured so as to allow the lowest TDG production as possible (i.e., outlet tubes were operated in pairs with an upper tube operated in conjunction with a lower tube directly below).
- Once Grand Coulee was able to spill over the drum gates (at an elevation >1265.5 ft.) to lower TDG levels, it did so.
- Operations were in accordance with the 2011 Total Dissolved Gas Management Plan (BPA et al. 2010b).
- Due to the prolonged period of high flows, Grand Coulee did not refill until July 13 and remained near full until the end of July. Grand Coulee Dam drafted during August 2011 to support the summer flow augmentation program and reached elevation 1279.9 feet on August 31, 2011.
- Normally Banks Lake is drafted to elevation 1,565 feet (5 feet from full) by the end of August as part of the Action agencies summer flow augmentation program. Required maintenance activities in the fall and winter on the Main Canal Outlet Structure and on the Feeder Canal near North Dam required Banks Lake to be drafted down nearly 30 feet by the end of October. In order to accomplish the desired elevation, pumping was

shut off to Banks Lake during August, 2011 in order to draft Banks Lake in preparation for maintenance activities during the fall of 2011. Banks Lake reached an elevation of 1552.4 feet on August 31, 2011, 1540.5 feet on September 30, and 1537.2 feet on October 31. This resulted in higher August through October flows on the mainstem Columbia than would have occurred under normal project operations. More discussion of this maintenance activity is provided in the 2007 FCRPS Biological Assessment (FCRPS 2007) (*Appendix B, page B.1-4-8*).

Hungry Horse Dam

Hungry Horse Dam was operated through the fall of 2010 and throughout 2011 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 2010 to December 2011 are listed in Table 3. Fall 2010 minimum flows were based on the WSF for 2010. Minimum flows for 2011 were based on the WSF for January through March, with the March WSF setting the minimum flows from March to December 2011.

Table 3. Minimum Flow Requirements from October 2010 to December 2011

Period	Hungry Horse Minimum Flow (cfs)	Columbia Falls Minimum Flow (cfs)
October-December 2010	616	3,330
January 2011	900	3,500
February 2011	900	3,500
March-December 2011	900	3,500

Hungry Horse Dam operations in 2011 followed VARQ flood control procedures. In January 2011 the WSF for Hungry Horse Dam inflow from May to September was at 106 percent of average, and it continued to increase as the year progressed. The WSF was at 153 percent of average by May 2011 and at 167 percent of average by June. The actual May-to-September inflow volume into Hungry Horse was 3,213 kaf, which was 175 percent of average and the highest volume ever recorded (1929-2011), resulting in an April 30 flood-control elevation requirement of 3479.5 feet. Due to the increasing forecast and flood control requirements, Hungry Horse was drafted to elevation 3492.98 feet by April 10 [3]which was about 5 feet below the calculated elevation objective of 3497.7 feet.[4] Hungry Horse was releasing water during April in order to achieve the April 30 flood control elevation requirement and to make additional space for the forecasted spring runoff, which was continually increasing during the month of April. Releases during April started at 8.7 kcfs at the beginning of the month but increased to 10.6 kcfs on April 7. The hydraulic capacity of the powerplant during the first half of April was around 8.6 kcfs, so 2.0 kcfs of spill was required. TDG in the South Fork Flathead River below the dam increased to a high

[4] In many years, typically dry years, the previous year's summer draft for flow augmentation and year-round required minimum discharges for resident fisheries will prevent Hungry Horse from reaching the April 10 elevation objective. Reclamation computes Hungry Horse Dam's April 10 elevation objective by linear interpolation between the March 31 and April 15 forecasted flood control elevations based on the Reclamation March Final May–September Water Supply Forecast (WSF).

of 112 percent during this time period but then decreased to below 110 percent after spill was stopped on April 21. Hungry Horse was drafted to elevation 3475.3 feet by April 30, 2011, and discharges were decreased to 8 kcfs on May 3 and held at that level until June 6. Discharges were temporarily decreased on two different occasions in June for local flood control and to help reduce flows on the mainstem Flathead River. Reductions in Hungry Horse discharges for local flood control prevented the Flathead River from reaching flood stage. Inflows and discharges remained high during most of July: the average inflow was 13 kcfs, which is the highest on record for the month of July, and the average discharge was 7 kcfs. Because of the high inflows during July and in order to prevent spill, refill at Hungry Horse occurred about a month later than usual. Hungry Horse filled to elevation 3559.2 feet on August 3, 2011. Discharges were around 4.0 kcfs during August as Hungry Horse began drafting for summer flow augmentation. Changes in operations at Hungry Horse Dam followed ramping rates as prescribed in the 2000 BiOp (FWS 2000). Figure 5 shows inflows, outflows, and elevation of Hungry Horse Reservoir throughout the 2011 water year.

As the water supply forecast for 2011 was not in the lowest 20 percentile, draft for flow augmentation was limited to 10 feet. Hungry Horse Dam targeted a September 30, 2011, elevation of 3550 feet. Actual operations reached elevation 3550.3 feet on September 30, 2011 and elevation 3550.0 feet on October 2, 2011. Hungry Horse was operated to provide a stable flow during the summer flow augmentation period, with an average flow from August through September 2011 of 3.5 kcfs.

Albeni Falls Dam

The project began releasing water in late September 2010 to draft Lake Pend Oreille from full pool to elevation 2055' (all elevations as measured at the Hope gauge). Elevation 2055' was established as the winter minimum control elevation target to support kokanee spawning through interagency discussions and was recommended by TMT pursuant to SOR USFWS/IDFG - 2010-1. On November 6, the reservoir was at elevation 2055' and Idaho Fish and Game (IDFG) determined that Kokanee spawning had begun. The project operated within a half-foot band (2055.0 to 2055.5 feet) during kokanee spawning. IDFG declared kokanee spawning complete on December 17.

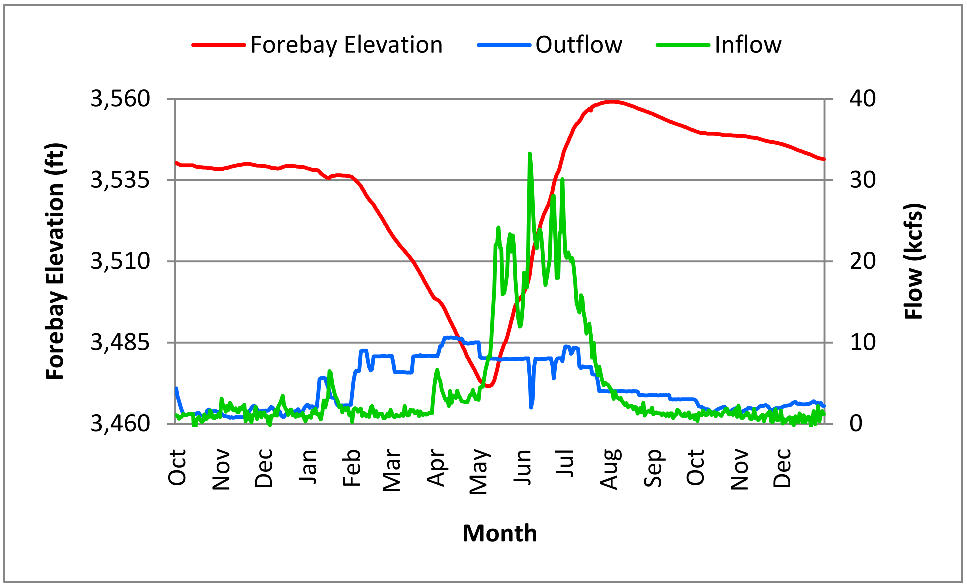


Figure 5. Hungry Horse Dam Inflow, Outflow and Forebay Elevation from October 1, 2010, through December 31, 2011.

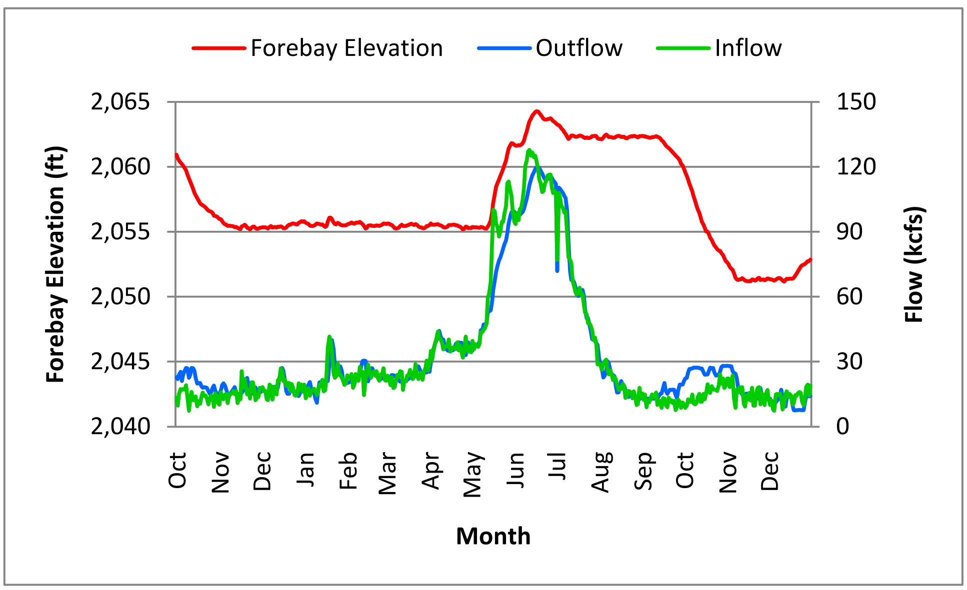


Figure 6. Albeni Falls Dam Inflow, Outflow, and Forebay Elevation from October 1, 2010, through December 31, 2011.

Between December 17 and the first part of May 2011, Albeni Falls was operated within a 1-foot band (2055 to 2056 feet). Due to a high water supply forecast (145% of average for April–August), the lake elevation was kept in the winter range as long as possible. On May 12, with releases at 53.7 kcfs, all spillway gates were lifted and the project went to freeflow. Elevation at the Hope gauge went above 2056.0 feet on May 16 and ended May at 2061.7 feet. Due to a natural channel restriction, the lake continued filling, reaching its highest elevation on July 17 — 2064.3 feet or 1.8 feet above full pool. Peak inflows were observed on June 11, with a daily average of 127.9 kcfs. Outflows exceeded 100 kcfs from June 7 through July 8, keeping the river above flood flows at Newport and at Cusick, below Newport, for that period, peaking at 120.1 kcfs on June 17. Minor flood damages were reported downstream of Albeni Falls Dam. The project went off of freeflow on July 8 and returned to its normal summer operating range, between 2062.0 and 2062.5 feet. Project outflow averaged 65 kcfs in May and 111 kcfs in June. By July 13 the project outflows were down to 66 kcfs, with rather rapid reductions as upstream reservoirs (Kerr and Hungry Horse) reduced outflow to target final fill.

For the remainder of the summer the project operated in the normal summer forebay range, with the fall draft begun during the week of September 12. The lake dropped below its summer range on September 15. For the 2011–12 season, pursuant to SOR *USFWS/IDFG-2010-1*, the TMT coordinated and requested a minimum winter lake elevation of 2051.0 ft. The target elevation was reached by November 6. The fall draft at Albeni Falls Dam, especially to a minimum control elevation of 2051, helps provide spawning flows for threatened Lower Columbia chum salmon. Annual interagency discussions in September to develop a recommended minimum control elevation include NMFS representation.

The lake was operated for kokanee spawning in a range of 2051.0–2051.5 feet, as measured at the Hope gauge from November 6 through December 16. Kokanee spawning was declared over on December 16. The minimum control elevation for kokanee spawning and incubation was set at 2051.0 feet for the 2012 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 2011 WMP included operations for these run-of-river projects. The projects were operated consistent with the WMP and the 2011 Spring Fish Operations Plan (FOP) and the 2011 Summer FOP as adopted by court order (Spring, March 24, 2011; Summer, June 14, 2011) 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. Further discussions of these operations are included in the minutes of the TMT “2011 Year End Review Session” (TMT 2011). 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, 2011. On March 23, the Action Agencies received SOR 2011-01 from the Columbia River Towboat Association, requesting a variable MOP-plus-2 operation in the Lower Granite Dam pool. The goal of the request was to provide safe navigation conditions in the Lower Granite Pool, which had been compromised due to sedimentation in the Federal Navigation Channel. In an effort to minimize any potential impacts a variable MOP–plus-2 operation could have on juvenile salmon, the Action Agencies coordinated this operation with the TMT and modified the original MOP-plus-2 operation identified in the SOR. Modifications included implementing a variable MOP-plus-2 operation that minimized the duration that Lower Granite Dam was operated outside of the MOP. The Action Agencies implemented the Lower Granite Dam variable MOP operation that was coordinated with the TMT throughout the fish passage season from April 3 to August 31, 2011.

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.

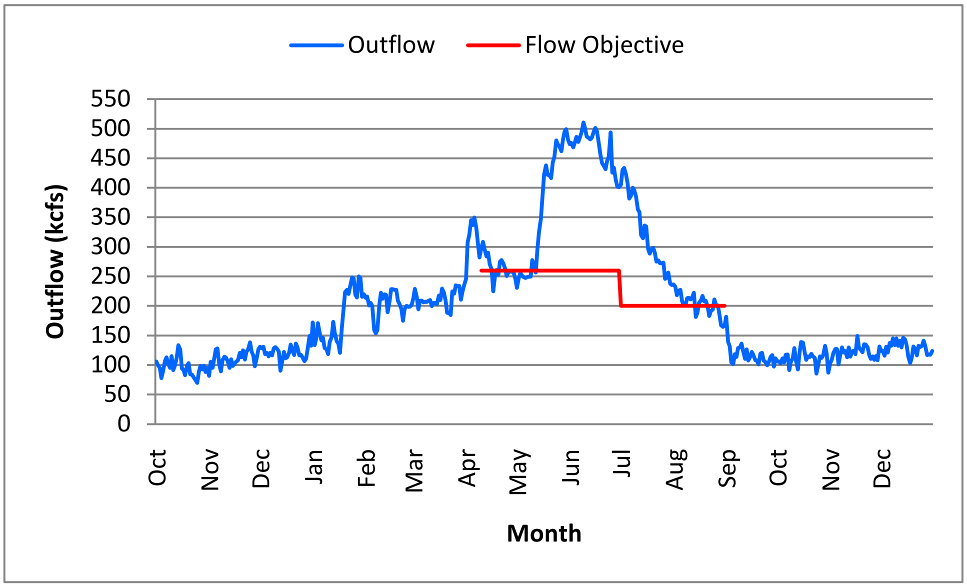


Figure 7. McNary Dam, observed outflow and flow objectives. April 11, 2011 to June 20, 2011 actual mean flow 376.1 kcfs, flow objective 260.0 kcfs. July 01, 2011 to August 31, 2011 actual mean flow 265.2 kcfs, flow objective 200.0 kcfs. The flow objectives are not achievable in all water conditions; rather they are used for pre-season planning and in-season water management to guide decision making.

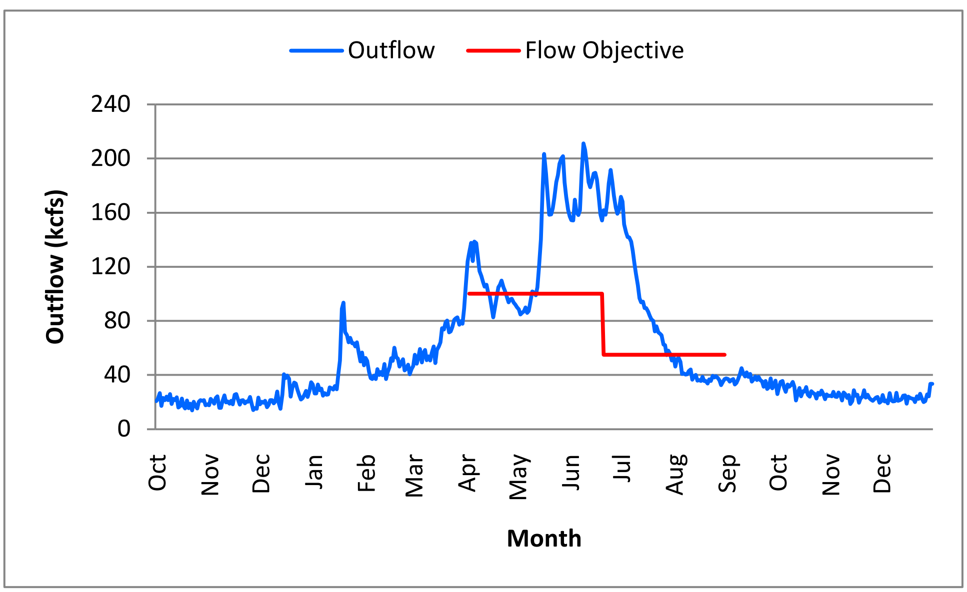


Figure 8. Lower Granite Dam, observed outflow and flow objectives. April 3, 2011 to June 30, 2011 actual mean flow 137.4 kcfs, flow

objective 100.0 kcfs. June 21, 2011 to August 31, 2011 actual mean flow 83.0 kcfs, flow objective 55.0 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.

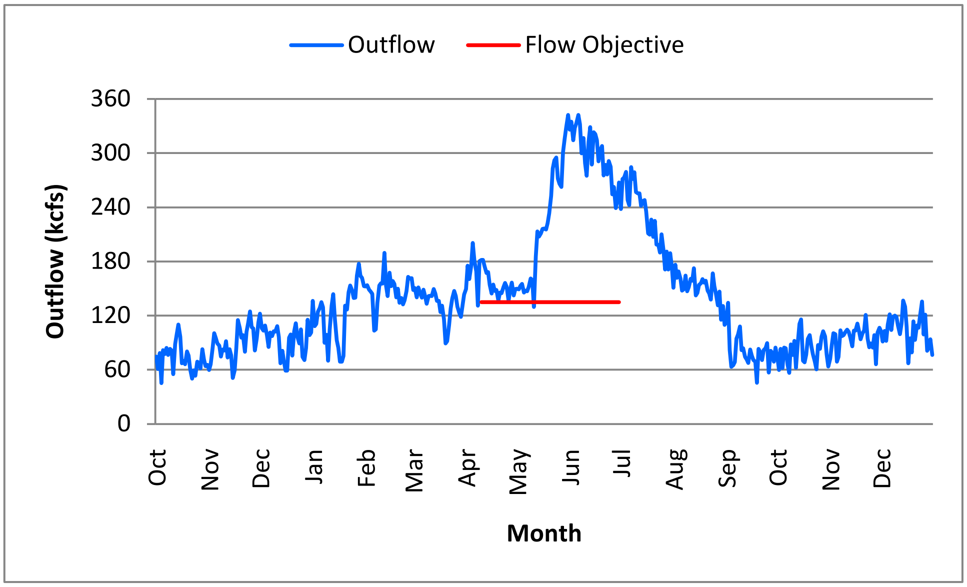


Figure 9. Priest Rapids Dam, observed outflow and flow objectives. April 10, 2011 to June 30, 2011 actual mean flow 231.2 kcfs, flow objective 135.0 kcfs. The flow objectives are not achievable in all water conditions; rather, they are used for pre-season planning and in-season water management to guide decision making.

In 2011, the Columbia River had an above-average water year according to NWRFC. The January to July volume as measured at The Dalles Dam (142.6 maf) was 133 percent of normal (107.3 maf for period rankings 1960–2012). The Snake River volume from April to July, as measured at Lower Granite (33.3 maf), was 155 percent of normal (21.6 maf for period rankings 1960–2012). The water-supply forecast had a wide range of variability between December 2010 and July 2011. December 16 to March 17 NWRFC forecasts were characterized as normal (96–104%) water supply conditions. By April, forecasts increased significantly, and this resulted in April-to-July forecasts ranging from 109 to 132 percent of normal. Stream flows at The Dalles Dam throughout the 2011 fish passage season (April through August) were 115–165 percent above average.

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 2011 operating season (October 1, 2010, through September 30, 2011) and the 2012 operating season (October 1, 2011, through September 30,2012) were developed collaboratively with the region in accordance with the NMFS 2008 Biological Opinion and NMFS 2010 Supplemental Biological Opinion (NMFS 2010 Supplemental BiOp). A draft of the WMP for the 2012 operating season was released on October 1, 2011. The final WMP was released on December 31, 2011.

Prior to 2011, the Action Agencies provided a fall/winter and spring/summer update to the WMP. The TMT decided that these biannual 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 2011 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 Action Agencies and Fish Accord partners formed the Columbia River Forecast Group (CRFG) to collaboratively implement this RPA action. The CRFG conducted six business and/or workshop meetings in 2011: January 18 (conference call), February 25, April 14, August 3, October 13 (conference call), and November 15 (annual workshop). Each meeting provided a forum to review the current runoff forecasts (or to review their performance), discuss topics of common interest, and to hear speakers on various topics related to water-supply forecasting. Meetings were attended by numerous agencies including the Natural Resources Conservation Service, NWRFC, NMFS, Columbia River Inter-Tribal Fish Commission (CRITFC), BPA, Corps, Reclamation, Northwest Power and Conservation Council (NPCC), and the Fish Passage Center (FPC).

Topics and discussion covered a wide range of interest, and included:

- Dissemination and discussion of current forecasts (winter/spring meetings), with focus on forecast discrepancies and challenges.
- Formulation of potential CRFG activities and work elements.
- Review of the Natural Resources Conservation Service's Daily Guidance forecast product.
- Summaries of snow and precipitation patterns.

- Implementation of the updated 30-year averages data set (1981-2010) and relative changes from the 1971-2000 data set.
- Future direction of NWRFC forecast products.
- Snotel network update.
- Implementation protocol for new River Forecast Center forecasts in 2012, under which official operating forecasts that set flood control will be the Ensemble Streamflow Predication (ESP) forecast closest to and prior to the 4th working day of each month.
- Review of presentations given at fall 2011 climate workshop sponsored by BC Hydro and others in British Columbia.
- Review of anomalous runoff and 2011 operations in the Upper Snake Basin.
- 2011 wrap-up and review of runoff forecasts, comparison of results, discussion of challenges and lessons learned.

Starting in October 2011, the NWRFC has eliminated the distribution of their Multiple Linear Regression Water Supply Forecasts as their "Official" forecast. The NWRFC will now be producing 3 ESP forecasts each week (or more often). The NWRFC is currently indicating that each 10 day initialization ESP forecast produced will be their "Official" water supply forecast.

The Action Agencies have coordinated with the NWRFC and determined which forecasts are likely to include the most current automatic and manually collected snow information. The 50% exceedance value for the 10 day initialized ESP forecast for The Dalles and Lower Granite released closest to and/or prior to the dates provided below will be used by the Action Agencies in place of what was previously used as the "Final" forecast for each month (e.g., a forecast is released on January 5 and 7; the January 5 forecast is used for operations). Flood Control or other computations will continue to be computed at the same intervals as before. This process for integrating the new ESP forecasts is being implemented as described for 2012 on an interim basis. The Action Agencies will be tracking the process for 2012 and will evaluate after the water year is complete to determine if any adjustments will be made.

Climate Change Study

The Action Agencies collaborated to adopt climate change and hydrology datasets for their long-term planning activities in the Columbia River Basin. This collaboration was coordinated through the River Management Joint Operating Committee (RMJOC), a subcommittee of the Joint Operating Committee that was established through a direct-funding memorandum of agreement among the three agencies. In addition to adopting these datasets, the RMJOC agencies worked together to adopt a set of methods for incorporating these data into their longer-term planning activities.

The Action Agencies selected a subset of the University of Washington's Climate Impacts Group climate-change data sets, resulting in 18 monthly future naturalized flow datasets and one historical condition. The 18 data sets included 12 Hybrid-Delta (HD) projections of future runoff of the Columbia River that reflected 30-year periods centered around the 2020s (six scenarios) and the 2040s (six additional scenarios). The HD data sets represent a change in monthly distributions of temperature and precipitation over the study region sampled from a single climate projection. In addition to the HD method, six "transient" data sets were also selected, which use time-evolving temperature and precipitation data sets beginning in 1950 evolving through 2099.

The future climate-change flow was provided for 13 locations in the Yakima subbasin, 12 in the Deschutes subbasin, and 28 in the Snake subbasin. In addition to the climate change supply, WSFs reflecting the respective climate change projections for the HD and Transient scenarios were developed for key locations across the entire Columbia River Basin. Each action agency started work to update their respective planning models as needed. Reclamation updated its planning models for the Yakima, Deschutes, and Snake Rivers to accept the new climate change supply inputs. All modeling was done on a monthly time step. Results and statistics were then generated at various locations. Reclamation generated time series of monthly flows for the Yakima River at its mouth, the Snake River at Brownlee Reservoir, and the Deschutes River above Lake Billy Chinook to be used by BPA and the Corps as input to their regional planning models. Both agencies had begun modeling the climate change projects for their own specific purposes.

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, at *https://www.salmonrecovery.gov/Files/2011 APR files/New Folder 3/Part_I_Future_Climate_and_Hydrology_Datasets_Report.pdf*;
- Part II – Reservoir Operations Assessment for Reclamation Tributary Basins, January 2011, at *https://www.salmonrecovery.gov/Files/2011 APR files/New Folder 3/Part_II_Res_Ops_Assess_for_Recl_Trib_Basins_Report.pdf*;
- Part III – Reservoir Operations Assessment: Columbia Basin Flood Control and Hydropower, May 2011, at *https://www.salmonrecovery.gov/Files/2011 APR files/New Folder 3/Part_III_Res_Ops_Assess_Col_Basin_Fld_Ctrl_Hydro_Report.pdf* ; 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, at *http://www.bpa.gov/power/pgf/ClimateChange/Final_PartIV_091611.pdf*.

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*.

Part I focused on the selection and adoption of future climate and hydrology data from the University of Washington's Climate Impacts Group, the evaluation of those data, and the development of the water-supply forecast to reflect future hydrologic and climate conditions. Climate data was incorporated into a hydrology model to produce a set of river flows. Analyses used both the Hybrid-Delta (HD) and Transient type scenarios. The HD scenarios evaluate a step-change in climate between a historical and future period. For the HD scenarios, future time periods were studied and included the 30-yr periods centered on the decades of the 2020s (2010 to 2039) and the 2040s (2030 to 2059). The Transient scenarios evaluated changes from 1950-2099 and reflect time-developing climate conditions. Eighteen climate scenarios were evaluated, plus a historical scenario for comparison. The study suggests that annual air temperatures will rise 1 to 3 degrees Fahrenheit by the 2020s, and 2 to 5 degrees by the 2040s. The average annual precipitation over all models may increase 1–2 percent. Columbia Basin precipitation and snowpack patterns would change, with more rain and less snow.

Part II focused on Reclamation's simulation models of project operations in the Yakima, Deschutes, and Snake River subbasins. Both the Yakima and Deschutes subbasins showed increased inflows in November through March and decreases in April–September. For the Yakima River subbasin, this led to an increase in storage November–March, a decrease in storage during April–September, and a decline in end-of-season storage, indicating a decline in the amount of manageable water in the subbasin. For the Deschutes River subbasin, climate change is projected to produce greater variation in water supply than has been seen historically. Reservoirs would release water earlier and be relied upon more heavily in the summer and late fall, which would create greater water supply concerns for irrigators. Because the Deschutes River subbasin is a groundwater-dominated system, other approaches need to be considered in the future to develop climate change flows. For the Upper Snake Basin, inflows into Brownlee Reservoir increase in January through April or May, and decrease in summer and fall. Drafting the reservoirs to the current flood control curves may not be sufficient to prevent reservoir fill. In the driest climate scenarios, the irrigators would have to rely more on storage water rather than natural flow. Because of the method used to downscale the climate change data, almost all of the climate change projections studied in the Snake River subbasin showed higher future flows. In subsequent studies, the potential drier future climate change projections need to be considered.

Part III focused on impacts on flood control, hydropower, and fish flows of the FCRPS due to climate change. During January through April, unregulated runoff at The Dalles Dam ranged from 108 to 150 percent of normal for the 2020s and 95–170 percent for the 2040s. Normal is based on the 2000 Level Modified Flows set for 1929–98. During June through August, runoff at The Dalles Dam for the 2020s ranged from 80 to 95 percent of normal, and that for the 2040s ranged from 65 to 95 percent of normal. The timing of the peak flow shifted from June to May. Reservoirs in the Columbia River system may need to draft earlier to capture the earlier peaks. Impacts to the timing of reservoir operations could impact spring and summer objectives such as flows for fish. Increased flows in January through April could result in higher power generation and increased spill at most dams. Increased spill may increase TDG levels, which could adversely affect fish. Modeling was accomplished using monthly time steps.

The Part IV Summary report provides a brief overview of the three technical reports and states that the next steps involve monitoring, evaluation, and additional studies that expand on this work and work of others. Present conditions will be reassessed to see if the transition towards future climate change scenario characteristics is underway. Federal agencies may explore alternative processes to achieve objectives for water supply, fisheries, power, and flood control under a new set of climate change rules. Newer climate change information will be incorporated as it becomes available, and new data and tools may be developed.

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.

On May 19 at 0714 hours, the Corps switched to a Bonneville Dam Powerhouse 1 (PH1) priority. In accordance with the FPP, Powerhouse 2 (PH2) is the priority powerhouse this time of year, but excessive debris associated with high flows clogged the vertical barrier screens (VBSs) of PH2. From May 19-21, use of the PH2 VBSs and submersible traveling screens (STSs) was suspended on turbine units 14, 15, and 16. From May 24-26, use of the remaining PH2 VBSs on turbine units 12, 13, 17, 18 was discontinued. The project re-installed screens and returned to PH2 operating priority on July 20. This operation was coordinated with the Fish Passage Operations and Maintenance Workgroup (FPOM).

On May 20 from 0700 to 1700 hours, Little Goose Dam turbine units 1-4 were out of service for emergency repair and investigation of the transformer T1 high voltage bushing. During this period, the project spilled all inflow with the exception of 5 kcfs to maintain station service. In order to complete all necessary repairs, an additional powerhouse outage was scheduled for May 24 – June 1. The powerhouse was out of service from 0600 hours on May 24 through 1500 hours on June 1 and again at 0700 hours on August 1 through 0900 hours on August 9. During this period, the project again spilled all inflow with the exception of 5 kcfs to maintain station service. After completion of this emergency maintenance, the project resumed normal operations as described in the 2011 Spring and Summer FOPs. These emergency operations were coordinated through FPOM and TMT.

From May 24 to 26, 2011, the Corps conducted an emergency closure of The Dalles Dam navigation lock due to a failed gearbox. This resulted in a temporary suspension of the juvenile salmon transportation program because barges used in the program would not have been able to pass The Dalles Dam. On May 20, 2011, the Corps coordinated an unscheduled conference call with the TMT in order to discuss the emergency situation at The Dalles Dam and implications on the juvenile transportation program. Options discussed were: (1) suspend juvenile transport during the outage, (2) continue the transportation operation and release juveniles in the forebay of The Dalles Dam, and (3) discontinue barge transport and transport via trucks exclusively. Based on TMT's recommendation, the Corps suspended transportation of juvenile salmon. On May 26, the navigation lock was repaired the Corps resumed normal juvenile transportation operations.

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.

No fish emergencies occurred in 2011.

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:

- *Providing the greatest flexibility possible for releasing water to benefit U.S. fisheries May through July.*
- *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.*
- *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 11, 2010, through July 31, 2011 (Non-Power Uses Agreement) was executed on November 30, 2010. Under this agreement, one maf of flow augmentation water was stored in Mica Reservoir from late January 2011 through early February 2011. All flow augmentation storage was released by July 31, 2011, under the Non-Power Uses Agreement. Treaty operations were coordinated during spring 2011 and fall 2011 stakeholder briefings.

A new Non-Power Uses Agreement for 2012 was executed on November 30, 2011, which provides for one maf of flow augmentation water storage under the same terms as the prior agreement.

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.

Return of non-Treaty storage under the 1990 Non-Treaty Storage Agreement (NTSA) was completed in January 2011.

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.

Before approaching BC Hydro to negotiate a new long-term NTSA, BPA has committed to the following:

- Substantial refilling of the U.S. non-Treaty storage (NTS) account
- The Dry Year Strategy Workgroup defining potential use of NTS in dry years
- Coordinating with Federal agencies, States, and Tribes under the BiOp
- Coordinating with Tribes under the Fish Accords
- Establishing the collective U.S. interests in terms of such a new NTSA

As noted under RPA Action 11, during 2011, BPA and BC Hydro refilled accounts under the 1990 NTSA. BPA held several meetings with Federal agencies, States, and Tribes to solicit input for negotiating a new long-term NTSA and to report on progress during the negotiations with BC Hydro. The feedback received was considered by BPA in discussions with BC Hydro. During these discussions, BPA and BC Hydro developed non-binding terms, which were captured in a term sheet that was released for public review in May 2011.

A short-term NTSA was negotiated in October 2010, to allow use of non-Treaty storage space through November 2011. Under this agreement, BPA and BC Hydro stored a total of 266,000 second-feet per day from mid-July through mid-August. The stored water was released to support flows for fish from mid-August through September 1st.

In September 2011, BPA and BC Hydro signed a short-term "NTS Bridge" agreement to allow use of non-Treaty storage space, as the long-term NTSA contract drafting was not yet complete. Account balances under the NTS Bridge agreement will transfer to the long-term NTSA, to be executed in 2012.

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 noted under RPA Action 11, BPA met with Federal agencies, States, and Tribes throughout 2011, to solicit ideas and information regarding terms for a new NTSA. The feedback received was considered by BPA in discussions with BC Hydro and is reflected in the contract terms. As discussions with BC Hydro proceeded, follow-up meetings were held to keep parties updated on progress.

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.*
7. *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 2011 water year was an abundant water year, with the May forecast coming in at 113 maf or 121 percent of average for the April–August period. The actual runoff volume was 127.4 maf or 137 percent of average.

The dry-year strategy technical workgroup met on December 22, 2010, and June 2, 2011. Participants included representatives from the Action Agencies, NMFS, Confederated Tribes of the Colville Reservation, and CRITFC. Discussion included the review of the previously agreed-upon study plan, review of the past hydrologic modeling done for one alternative, and review of potential NTSA releases during dry-year conditions. No significant changes to the study plan were noted except that the COMPASS survival model was not ready for evaluating survival effects between Chief Joseph and McNary Dams, and therefore the group agreed to consider a less rigorous analysis using best available information. The dry-year technical workgroup discussed whether to model additional operating alternatives but since most of the group's ideas involved Canadian projects, the group decided to defer further modeling to the negotiation with BC Hydro for NTSA water.

The dry-year strategy technical workgroup met with the Corps and BPA representatives for NTSA water negotiations in person and via conference calls on multiple dates. The group provided input and discussed ideas about non-Treaty operations that would benefit dry years. The main input from the dry-year strategy group to the non-Treaty negotiation was the desire to have more non-Treaty water released during the spring of dry years and allow refill of that water at a later time, such as the following spring, if/when flows are above average. The Corps and BPA representatives discussed NTSA water releases during dry years with BC Hydro representatives on numerous occasions, and negotiations occurred throughout 2011 with BC Hydro. Refer to RPA 13 for more detail on non-Treaty coordination.

The COMPASS modeling group made additional progress toward calibrating the mid-Columbia reach of the COMPASS model in 2011. The COMPASS model was configured in 2010 to include the mid-Columbia projects between McNary and Chief Joseph Dams, but additional passage and survival data necessary to calibrate the model was still needed.

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:

- *Real-time monitoring and reporting of TDG and temperatures measured at fixed monitoring sites,*
- *Continued development of fish passage strategies with less production of TDG, and*
- *Update the SYSTDG model to reflect modifications to spillways or spill operations,*
- *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,*
- *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*
- *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*

- *Investigate alternatives to reduce total mass loading of TDG at Bonneville Dam while maintaining juvenile survival performance, and*
- *Continued operation of the Lower Snake River projects at MOP.*

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. This plan is scheduled to be updated in 2013.

In 2011, spill at the projects was managed consistent with the 2011 Total Dissolved Gas Management Plan (BPA et al., 2010b), and real-time monitoring was operated consistent with the Dissolved Gas Monitoring Plan of Action (ACOE 2011b).

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/tmt.*

Both the John Day Dam tailwater and the Bonneville Dam tailwater fixed monitoring stations suffered damage during the high-runoff flows. During the monitor replacements at both locations, the electronics enclosure boxes were moved to higher ground, the electronics boxes were placed on new concrete foundations, and the cable conduits were replaced.

The main action implemented to further develop fish passage strategies with less production of TDG was using the Chief Joseph flow deflectors to manage systemwide TDG levels. During the high river flows, when TDG levels at Chief Joseph forebay reached 140 percent, the Corps chose to operate Chief Joseph Dam to maximize the flow deflectors' capacity to strip TDG. This approach resulted in up to a 22-percent reduction in TDG levels for the Chief Joseph spill water and up to a 12% average reduction in the Columbia River system.

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. As recommended in the 2010 statistical evaluation, model improvements included updating the TDG exchange equation for Grand Coulee, Chief Joseph, Dworshak, and McNary dams based on 2011 observed data and spill operations and improving the Camas Washougal gauge for accuracy by reinstating the wind degassing coefficients to reduce the bias in the predicted TDG pressures at this gauge. The improvement resulted in the most accurate prediction of TDG pressures at Camas Washougal gauge ever documented by the SYSTDG model.

After completion of the 2011 fish migration season, the Corps performed a statistical evaluation of the predictive errors based on observed TDG levels to quantify the uncertainty of SYSTDG estimates and to improve modeling accuracy and reliability. The results of this analysis are included as Appendix G of the 2011 Total Dissolved Gas and Water Temperature Monitoring Report (ACOE 2011a). The CE-QUAL-W2 model was used from late June through early September 2011 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.

The Corps awarded a contract to develop CE-QUAL-W2 temperature models for the Lower Columbia River from Pasco, Washington to the forebay of Bonneville Dam, including McNary, John Day and The Dalles reservoirs. The CE-QUAL-W2 temperature models for the Lower Columbia River reservoirs are expected to be completed by the end of August 2012. Reclamation has completed its three-phase hydrosurvey of Lake Roosevelt bathymetry, and has begun developing a CE-QUAL-W2 water temperature model of the Grand Coulee Reservoir.

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 in-stream flow regime not considered in the FCRPS and Upper Snake River BA/Comprehensive Analysis.

Reclamation is addressing ESA Section 7 consultations for the Yakima, Okanagan, and Tualatin Project operations. Biological assessments (BAs) have been submitted to NMFS for all these projects.

NMFS and USFWS suggested that Reclamation delay submission of its supplement to the 2000 Yakima BA until issues associated with the Yakima Basin Workgroup/ Basin Study are resolved, so that potential actions from those efforts can be incorporated into the supplement, if appropriate. The Yakima Basin Integrated Plan Workgroup will complete its study and an FEIS on the Integrated Plan in the spring of 2012. Reclamation is currently updating the BA supplement to incorporate elements of the Integrated Plan and will resume consultation with both NMFS and the USFWS in the summer of 2012.

NMFS requested a time extension to complete work on the Okanogan Project BiOp in 2010. In 2011, Reclamation and NMFS explored the potential for refining the proposed action.

The Tualatin BA was submitted to NMFS in 2009. Reclamation has completed its fish monitoring project and has provided the information to NMFS. In addition, Reclamation met with NMFS in late December 2011 to discuss fish mitigation elements of the proposed action. It is anticipated that NMFS will complete the draft BiOp during the summer of 2012.

RPA Action 17 – Chum Spawning Flows

- *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.*
- *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.*
- *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.*
- *Make adjustments to the tailwater elevation through the TMT process consistent with the size of the spawning population and water supply forecasts.*
- *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*
- *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.

- *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.*

2010–11 Operation

The 2010–11 chum operation began on October 27, 2010. The Action Agencies issued the following guidance to Bonneville Dam to protect spawning chum: (1) Effective October 27, 2010, maintain a project tailwater elevation of no lower than 9.5 feet during all hours; (2) effective November 1, 2010, maintain a project tailwater of no lower than 11.3 feet during all hours, and maintain a project tailwater of 11.3 to 11.7 feet during daylight hours (0630-1700 hours); and (3) as needed to pass excess water, increase tailwater elevation up to 18.5 feet during evening hours (1700-0600 hours).

From December 13 to 16, 2010, in coordination with TMT, the Action Agencies increased the tailwater to no lower than 12.1 feet (with a target of 12.3 feet) due to high inflows. On December 22, 2010, TMT members held a conference call to discuss the status of the chum spawning operation. The TMT discussed the impacts of a 48-hour higher tailwater elevation (due to excess precipitation in the system) on spawning chum. No redds were discovered at higher elevations in response to this operation. NMFS declared the end of chum spawning and initiation of the incubation operation on December 22, 2010. The incubation operation resulted in a tailwater elevation of 12.2 feet at all hours with no nighttime maximum tailwater elevation requirement. The chum operation ended on April 18, 2011, and the Action Agencies lifted the 12.2 feet minimum tailwater operation.

2011–12

The 2011–12 chum operation began on November 1, 2011. The Action Agencies issued the following guidance to Bonneville Dam to protect spawning chum: (1) Effective November 1, 2011, during all hours, maintain the tailwater elevation at a minimum of 11.3 feet; (2) maintain a project tailwater of 11.3 to 11.7 feet during daylight hours (0630-1700 hours), with a target elevation of 11.5 feet; and (3) as needed to pass excess water, increase tailwater elevation up to 18.5 feet during evening hours (1700–0600 hours).

On November 2, the Action Agencies increased the tailwater range to 11.3 to 12.0 feet based on discussions held during that day's TMT meeting. The increase in the daytime tailwater range was made both to achieve a higher tailwater for chum spawning and also to assist with repair work that was underway on the Bonneville Dam Bradford Island B-Branch Fish Ladder.

On November 23, the Action Agencies increased the minimum tailwater elevation to 11.7 feet during all hours. In addition the Action Agencies increased the daylight tailwater operational band to 11.7–12.5 feet. This change was made in coordination with the TMT during that day's TMT meeting, and this operation was consistent with the request to operate at a higher tailwater to increase spawning habitat for chum salmon identified in SOR 2011-05. The SOR may be found on the following website: *http://www.nwd-wc.usace.army.mil/tmt/sor/2011/*.

On December 28, the Action Agencies changed the tailwater to maintain a minimum tailwater elevation of 12.0 feet during all hours. This operation was coordinated during that day's TMT meeting and marked the end of the spawning operation and the start of the incubation/emergence operation. The Action Agencies will maintain this operation until April 10, 2012, or as otherwise coordinated through the TMT.

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

Bonneville Powerhouse II

1. *Screened bypass system modification to improve fish guidance efficiency (FGE) and reduce gatewell residence time (2008)*
2. *Shallow behavioral guidance screen installation to increase Corner Collector efficiency and reduce forebay delay (prototype 2008)*

Bonneville Dam Spillway

1. *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).*

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. Due to high flow, target spill operations were exceeded halfway through the study period, affecting estimates of precision for the dam passage survival estimates (Table 4). 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 high river flow forced postponement of the performance standards tests for subyearling Chinook salmon in 2011. Other actions are summarized below.

Table 4. Dam Passage Survival (with Standard Errors), Passage Times, and Spillway Passage Efficiency for Yearling Chinook Salmon and Juvenile Steelhead at Bonneville Dam in 2011. (Skalski et al. 2012a). Spill passage efficiency includes spillway and other surface passage route passage.

Species	Dam Passage Survival	Median Forebay Passage Time (hours)	Spill Passage Efficiency
100-kcfs Spill (April 30-May 13)			
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)			
Yearling Chinook	96.0% (1.8)	0.55	66.2%
Juvenile Steelhead	96.5% (2.1)	0.85	72.3%

Ongoing work to evaluate alternatives to address increased injury rates for fish passing through the juvenile bypass system (JBS) continued through 2011. In 2011, to minimize injury, 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 JBS.

Increased debris load, due to high flow, on the second powerhouse trash racks and within the bypass system gatewells forced removal of turbine intake screens during mid-May. Screens were replaced in July, when flow and debris loading decreased.

Due to high river flow and the resulting high spill flow, rock and other debris were washed into the Bonneville Dam stilling basin. This led to increased erosion of the spillway apron and may have affected juvenile fish survival. A survey following the spill season showed large piles of rock within the stilling basin and on the spillway apron. Work was completed over the winter to remove rock from the spillway apron and stilling basin in preparation for the 2012 juvenile salmonid outmigration.

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

In 2011, an improved avian deterrent array was constructed over the tailrace of The Dalles Dam, and the second year of performance standard testing was conducted. High river flow precluded testing for subyearling Chinook salmon. During the spring study period (late April to late May) average spill levels were 42 percent, slightly higher than the prescribed 40 percent spill. Dam passage survival for yearling Chinook salmon and juvenile steelhead either met or exceeded the performance standard requirement of 96 percent (Table 5).

Table 5. Dam Passage Survival (with Standard Errors), Passage Time, and Spill Passage Efficiency for Spring Migrants at The Dalles Dam in 2011 (Skalski et al. 2012b). Spill Passage Efficiency includes spillway and other surface passage route passage.

Species	Dam Passage Survival	Median Forebay Passage Time (hours)	Spill Passage Efficiency
Yearling Chinook	96.0% (1.0%)	0.97	83.1%
Juvenile Steelhead	99.5% (0.8%)	0.81	89.1%

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 handing stress of bypassed fish (2007)*
2. *Turbine operation optimization to improve overall dam survival (2011)*
3. *Surface flow outlet(s) construction to increase FPE, reduce forebay delay and improve direct and indirect survival (prototype 2008 with final installation by 2013), and improve tailrace egress conditions.*

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 at John Day Dam was initiated in 2011 for yearling Chinook salmon and juvenile steelhead. Operations at the dam were scheduled to alternate between 30 and 40 percent spill. However, high flow precluded the project's ability to operate at either spill level after May 15. Also due to high flows, the summer portion of testing was cancelled. Survival estimates for yearling Chinook salmon and juvenile steelhead exceeded the performance standard requirement of 96 percent survival, regardless of operation (Table 6).

Table 6. Dam Passage Survival (with Standard Errors), Passage Time, and Spill Passage Efficiency for Yearling Chinook Salmon and Juvenile Steelhead at John Day Dam in 2011 (Skalski et al. 2012c)

Species	Dam Passage Survival	Passage Time (hours) Forebay/Tailrace	Spill Passage Efficiency
30-Percent Spill			
Yearling Chinook	96.7% (1.0%)	n/a	n/a
Juvenile Steelhead	98.4% (0.9%)	n/a	n/a
40-Percent Spill			

Yearling Chinook	97.8 (1.1%)	n/a	n/a
Juvenile Steelhead	99.0 (1.0%)	n/a	n/a
Seasonwide Spill			
Yearling Chinook	96.8% (0.7%)	1.4	63.7%
Juvenile Steelhead	98.7% (0.6%)	2.9	62.9%

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:

- *Turbine operation optimization to improve survival of fish passing through turbines (2013)*
- *Improve debris management to reduce injury of bypass and turbine passed fish (2011)*
- *Relocate juvenile bypass outfall to improve egress, direct, and indirect survival on bypassed fish (2011)*
- *Surface flow outlet installation to increase FPE, reduce forebay delay, and improve direct and indirect survival (temporary structure testing in 2007 and 2008 to develop a permanent system)*

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.

Several actions were undertaken to improve the survival of fish passing the project at McNary Dam in 2010. These actions were completed as part of the McNary COP process in working toward a final project configuration for full performance standard testing. Below is a summary of the actions and work completed in 2011.

Work continued on development of the COP for McNary Dam in 2011 and 2012. A biological background section was written, and the development of baseline values for modeling began.

The frequency of vertical barrier screen cleaning was modified as follows: Inspect at least four vertical barrier screens in two different turbine units between the spring and summer migration periods. If a debris accumulation is noted, inspect other vertical barrier screens and clean debris as necessary. Inspect all vertical barrier screens at least once per year and whenever pulled for cleaning.

Efforts to develop the design of the juvenile bypass outfall relocation continued during 2011. Construction began in September 2011, with completion expected by the beginning of the juvenile migration season in April 2012.

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 FGE (2010)*
2. *Turbine operation optimization to improve survival of turbine passed fish (2011)*
3. *Spillway chute and/or deflector modification to reduce injury and improve survival of spillway passed fish through the RSW (2009)*
4. *Turbine unit 2 replacement to improve the survival of fish passing through turbines and reduce oil spill potential (2015)*

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 development of actions to improve the survival of fish passing the project at Ice Harbor Dam continued in 2011. The actions under development are part of the Ice Harbor COP process in working toward a final project configuration for full performance standard testing. Below is a summary of the actions and work completed in 2011:

BPA and the Corps agreed to support the design of test turbines optimized to improve survival and reduce juvenile fish passage injury at Ice Harbor Dam in 2010. The design of the test turbines was initiated in 2010, to incorporate both a fixed runner and an adjustable runner. The design effort continued into 2011 with the fixed-blade runner, and an in-progress meeting was held at the Corps' Engineer Research and Development Center (ERDC) in Vicksburg, MS, to test the first iteration of the runner in June 2011. Current progress is developing a second iteration, and the new design is providing promising computational fluid dynamics model results.

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

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)*
2. *Juvenile bypass system outfall relocation to improve egress, direct and indirect survival on bypassed fish (2011)*
3. *Turbine operation optimization to improve the survival of fish passing through turbines (2013)*

4. *RSW installation to improve FPE, reduce forebay delay, and improve direct and indirect survival (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.

Actions were undertaken to improve the survival of fish passing the project at Lower Monumental Dam in 2011. These actions were part of the Lower Monumental COP process in working toward a final project configuration for full performance standard testing. Below is a summary of the work completed in 2011:

Relocation of the juvenile bypass outfall and improvements to the smolt monitoring raceway structures at Lower Monumental Dam began in 2011 and were completed in early 2012. The relocated outfall will release fish in an area with higher river velocities and consistent downstream flow during all operations. This is expected to decrease predation on the bypassed fish. The improved survival of fish passing through this bypass system will be evaluated in the spring and summer of 2012.

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)*
2. *Primary bypass operations with PIT-tag detection installation to reduce handling stress of bypassed fish (2008)*
3. *Primary bypass outfall relocation to improve egress, direct and indirect survival on bypassed fish (2009)*
4. *Surface spillway weir and deflector installation to improve FPE, reduce forebay delay and improve direct and indirect survival (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.

Actions were undertaken to improve the survival of fish passing the project at Little Goose Dam in 2011. These actions were completed as part of the Little Goose COP process in working toward a final project configuration for full performance standard testing. Below is a summary of the actions and work completed in 2011.

Prior spill patterns indicated the spillway weir flow was creating eddies that resulted in observed adult Chinook salmon delay at inflows up to 100 kcfs. This operation was evaluated using the physical hydraulic model at the ERDC in Mississippi. This evaluation revealed that modifying the spill pattern to prioritize earlier spill season use of spillbay 8 would disperse the spillway-weir-powered eddy and allow adequate attraction flow vectors into the ladder entrances, thus improving fishway attraction conditions and the ladder entrance for adult salmon and steelhead. This new spill pattern was implemented in the Corps' 2011 Fish Passage Plan.

The Draft Final COP was distributed, and the Action Agencies believe the current project configuration is ready for full performance standard testing.

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

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.

Two actions were undertaken to improve the survival of fish passing the project at Lower Granite Dam in 2011. These actions were part of the Lower Granite COP process in working toward a final project configuration for full performance standard testing. Below is a summary of the actions and work completed in 2011:

- The Engineering Design Report was completed, and it recommends configuration changes to the surface bypass system, including a new fish facility to replace the existing fish facility.
- Plans and specifications were developed for two prototype overflow collection channel weirs (two prototype designs: sharp-crested and broad-crested weirs) to replace collection channel orifices for Units 5 and 6.

RPA Action 26 – Chief Joseph Dam Flow Deflectors

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

Construction of the flow deflectors was completed in 2008. Several spill tests have taken place since then, for purposes relating to dam safety, hydraulic effects, and TDG generation and spill configuration. In June 2011, there was a brief (2–3 hour) spill test to examine surging in the tailrace. A dam safety test originally intended for the same season to examine monolith uplift pressure was postponed until winter 2012 to allow for more detailed planning, which began in September 2011.

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 2011, 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).

In 2011, Bonneville Powerhouse 1 was allowed to operate outside of the 1-percent operating range to accommodate high river discharge and to mitigate TDG levels in the spillway. The lower head at Bonneville provides good fish passage survival through the powerhouse, so no adverse effects of this operation were expected or experienced.

Work continued 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. Building upon the works of Carlson et al. (2010), the Corps pursued an external tag laboratory 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 planned for FY12. (See RPA 55).

Development of a detailed biological study design for testing of the new Ice Harbor runners began late in 2011. The study design will be a working document into FY13 with a target of implementing a baseline study in 2014 prior to new runner installation. The document will detail project operations and powerhouse operating ranges to determine the safest fish passage configuration and to elucidate benefits to fish passage survival realized by the design features of the new runners. Operations considered in the study design may recommend testing outside of the 1-percent operating range.

The Turbine Survival Program also held an in-progress meeting at the ERDC in June 2011, to test the first iteration fixed-blade runner for Ice Harbor Dam designed by Voith Hydro, which was awarded a design/build contract for replacement of Units 2 and 3 at Ice Harbor. Bead strike analysis provided insight for the path forward to iteration 2, which continued into FY12.

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:

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

The following actions were taken on the Bonneville Dam adult fishways:

Large amounts of debris accumulation resulting from high river flows caused partial blockage under the diffuser gratings in the Washington Shore ladder. The system was cleaned out prior to the 2011-12 winter work period.

High flows through the spillway caused erosion and removal of rock under a section of the Bradford Island B-Branch. This section of the ladder was shut down and dewatered to prevent collapse of the ladder on 17 September. This section of the ladder remained out of service through the 2011-12 winter work period. Repairs have been completed.

Redesign work of the trash rake for the Washington Shore adult fishway began in 2011. Completion of this work is scheduled for 2013.

2. *The Dalles Dam*

- *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, with its regional partners, continues to evaluate alternatives for a backup water supply alternative.

3. *John Day Dam*

- *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 (AWS) system began in 2011.

4. *Ice Harbor Dam*

- *Repair or replace north shore fishway AWS equipment as needed so that any two of the three pumps can meet flow criteria.*

Improvements at Ice Harbor Dam were completed in 2009.

5. *Little Goose Dam*

- *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 RME Action 54).*

Spill patterns were adjusted based on the previous year's research. Then, additional analysis and physical modeling in February 2011 resulted in a new spill pattern to reduce adult passage delay. The Corps decided to design a hoist to allow closure of the spillway weir and provide a more rapid response to future passage problems. The installation of that hoist is planned for 2013.

6. *Lower Granite Dam*

- *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 AWS (2012).*
- *Adult fishway modification to improve upstream adult passage conditions impaired by temperature differentials (the need will be determined by results of further research).*

An engineering alternative study was conducted that developed three alternatives. The study also determined that a pilot study with a simple prototype structure was not feasible. Other 2011 actions include additional forebay temperature data collection, which could result in the alternative study being revisited.

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, RME 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).

Fish Passage Spill Operations

Spill operations were implemented in accordance with the 2011 Spring and Summer Fish Operations Plans (FOPs) as adopted by Court orders (Spring, March 24, 2011; Summer, June 14, 2011). The 2011 Spring and Summer FOPs can be found at *http://www.nwd-wc.usace.army.mil/tmt*. 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 2011 Total Dissolved Gas and Water Temperature Report, Appendix E at *https://www.salmonrecovery.gov/Files/2011 APR files/2011_Dis_Gas_and_Wtr_Temp_Rpt_AppE.pdf*. This report describes the Corps' Columbia River Basin spill and water quality monitoring program for 2011 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

During 2011, spring fish passage spill at the lower Columbia and lower Snake river projects was implemented consistent with the 2011 Spring FOP and the Corps' 2011 Total Dissolved Gas Management Plan at *https://www.salmonrecovery.gov/Files/2011 APR files/2011_TDG_Management_Plan_App4.pdf*. Spring fish passage spill began April 3, 2011, and continued through June 20 at the lower Snake River projects. In the lower Columbia River, spring fish passage spill began April 10, 2011, and continued through June 19 at McNary Dam, through June 30 at John Day and The Dalles Dams, and through June 20 at Bonneville Dam.

The 2011 Spring 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 spill cap, 24 hours per day
- Ice Harbor Dam: Spill alternating between (a) 30 percent of total project outflow 24 hours per day and (b) 45 kcfs during the day and up to the spill cap at night
- McNary Dam: 40 percent of total project outflow
- John Day Dam: 30 percent of total project outflow from April 10 through April 27, 2011; alternating between 30 and 40 percent of total project outflow from April 27 through July 20, 2011; and 30 percent of total project outflow from July 20 through August 31, 2011.
- 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 Court order, in-season adjustments addressing real-time conditions were implemented in coordination with regional sovereigns.

Summer Fish Passage Spill

During 2011, consistent with the Summer 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 2011 FOP called for the following spill operations during the summer:

- 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 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 21, 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. Spill 75 kcfs during the day and to the spill cap at night from July 21 through August 31, 2011.

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

2011 River Conditions and TDG Monitoring

During the 2011 fish passage spill season, system flows were high due to the large runoff volume resulting in more spill at many of the hydro-power projects. Actual spill rates were significantly higher than estimated FOP spill levels because of the large amounts of involuntary spill associated with the high runoff. Daily average total river flows on the lower Columbia River, as measured at Bonneville Dam, from April 1 through August 31, ranged from 160 kcfs to 507 kcfs, averaging 335 kcfs. Daily average flow remained high from May

13 through July 29, resulting in involuntary spill at Bonneville of almost 200 kcfs for close to three months in addition to spill for fish passage of approximately 100 kcfs. Flows began to recede in late July and continued a steady recession until the end of August, when flows reached 160 kcfs.

On the lower Snake River, as measured at Ice Harbor Dam, daily average total river flow from April 1 through August 31, ranged from 32 kcfs to 216 kcfs averaging 114 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 39 kcfs to 277 kcfs, averaging 176 kcfs. Flows began to drop in late July and continued a steady recession until the end of August, when flows reached 39 kcfs.

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 792 instances (excluding 342 gauge days[5] when flows exceed 7Q10 criteria[6]) where TDG exceeded State standards as modified by waivers or criteria adjustment. These included 103 instances from voluntary spill and 689 instances from involuntary spill. This information with additional detail is provided in the 2011 Dissolved Gas and Water Temperature Monitoring Report at: *https://www.salmonrecovery.gov/Files/2011 APR files/2011_Dis_Gas_and_Wtr_Temp_Rpt.pdf*.

Excessive TDG levels can result in gas bubble trauma (GBT). Examination of data obtained from the FPC (under "Smolt Data" at *www.fpc.org*) showed that 15,302 juvenile fish were examined for GBT at Corps dams in 2011. Of the fish examined, 382 were found to have non-severe signs of GBT, 15 exhibited severe signs. The symptoms occurred during 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 RME. 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 RME indicates a need for adaptive management (for example, if modifying these

[5] *[number of TDG gauges] x [number of days in spill season, April 3 through August 31, 2011]*

[6] *7Q10: Seven-day, consecutive low flow with a 10-year return frequency; the lowest stream flow for seven consecutive days that would be expected to occur once in 10 years.*

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.

The 2011 transportation program was conducted in accordance with NMFS ESA Permit No. 1237 and the Juvenile Fish Transportation Program criteria in the 2011 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 May 1, 2011, at Lower Granite Dam, May 5, 2011, at Little Goose Dam, and May 8, 2011, 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. High river flows and unsafe conditions precluded the barge transport of fish at Lower Granite and Lower Monumental Dams from May 16 through 18. High river flows also precluded the barge transport of fish at Lower Monumental Dam on June 10. All three Snake River sites suspended the transportation of fish by barge from May 23 through 28 due to emergency navigation lock repairs at The Dalles Dam. During these suspensions, fish were bypassed at the affected facilities since fish may not be held more than 48 hours. Otherwise, transport operations at the Snake River facilities continued through October 1 at Lower Monumental Dam, through October 31 at Little Goose Dam and through November 1 at Lower Granite Dam. Fish at McNary Dam were bypassed from March 27 through July 20, 2011, and transported from July 21 to September 30, 2011. Before transport began, sampling operations occurred every other day beginning April 13, 2011, to support research and BPA-sponsored smolt monitoring activities, as well as to assess bypass system conditions.

Juvenile fish barged during 2011 were released at varying locations below Bonneville Dam as required in the permit. The ending date for the barging season in 2011 was August 15 for Snake River facilities and August 16 for McNary Dam. At Snake River facilities, trucks carried juvenile fish from August 16 through the end of the transport season. At McNary Dam, collected fish were trucked every-other-day from August 3 through August 15, prior to the end of barge operations. During this period, fish were transported by barge at McNary Dam on even numbered days and trucked on odd numbered days. The last barge departure at this location took place on August 16. Beginning August 17, every-other day truck operations began concurrently with Snake River projects. From September 2 to 9, McNary Dam trucked fish daily to reduce the impact of debris entering the fish facility. Heavy debris loads forced the bypassing of fish and the suspension of trucking operations at McNary Dam from September 9 to 17, 2011. Routine every-other-day trucking operations resumed in this site on September 18 and concluded for the season on September 30. All trucked fish were released into the Bonneville Juvenile Monitoring Facility outfall flume. No early season (April) trucking took place in 2011.

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 6,310,606 juvenile fish were collected at Lower Granite Dam, with 2,429,798 of these fish bypassed to the river and 3,874,873 transported. At Little Goose Dam, 3,384,386 juvenile salmon and steelhead were collected in 2011. Of these, 347,521 were bypassed to the river, and 3,030,558 were transported. At Lower Monumental Dam, 1,582,909 juvenile salmon and steelhead were collected in 2011. Of these, 207,024 fish were bypassed, and 1,371,215 were transported. At McNary Dam in

2011, 3,994,343 juvenile salmon and steelhead were collected, 2,424,768 of the fish collected were bypassed to the river, and 1,473,211 juvenile fish were transported.

Table 7. Estimated Proportion of Non-Tagged Spring/Summer Chinook and Steelhead Smolts Transported in the Columbia and Snake Rivers in 2011

Species	Percent Transported in 2011
Snake River Spring Chinook—Wild	35.2%
Snake River Spring Chinook—Hatchery	40.7%
Snake River Spring Steelhead—Wild	36.1%
Snake River Spring Steelhead—Hatchery	37.8%

A total of 15,222,244 juvenile salmon and steelhead were collected at all transport program locations in 2011, with 9,749,857 fish transported (64%) and 5,409,111 bypassed (36%). Of the fish transported, 9,308,289 were transported by barge (95%) and 441,568 were trucked (5%).

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.

- Evaluating the responses of Snake and Columbia Basin fall Chinook salmon to dam passage strategies and experiences – The Corps continues to implement specific components of the regionally developed consensus proposal for evaluating transportation of fall Chinook salmon. Approximately 596,000 juvenile fall Chinook salmon (natural, surrogate, and production groups) were tagged in 2011 as part of this study. The study, "Post-Release Performance of Natural and Hatchery Subyearling Fall Chinook Salmon in the Snake and Clearwater Rivers," continued for 2011, and the 2010 report was completed. This study continues to document passage indices of subyearling fall Chinook salmon and make comparisons between natural fish and production and surrogate fish. Consistent with the 2005, 2006, 2008, and 2009 findings, post-release attributes measured on 2010 releases were more similar between natural and surrogate subyearlings than between natural and production subyearlings.
- Fall Chinook salmon scale pattern analysis – Scales from returning adults in 2007–11 are being collected and analyzed to determine age at ocean entry for different groups of fall Chinook that were passive integrated transponder (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 2011 – 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 smolt-to-adult return ratios (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. Initial analyses in 2011 suggested that water temperature was a consistent variable in explaining seasonal variation of SARs. Other environmental variables examined were significant in some years, but not others, suggesting they would not be useful in a real-time model for determining when it is best to transport fish.
- Sockeye transportation pilot study – Juvenile sockeye salmon from Idaho were PIT tagged and used for an evaluation of the efficacy of a transportation study on sockeye salmon. A total of 61,922 sockeye were PIT tagged and released in 2011: 51,936 were reared at the Sawtooth hatchery, and 9,986 were reared at the Oxbow hatchery. Survival probability from the release points to Lower Granite Dam was 71 percent for both the Sawtooth- and Oxbow-reared fish. Survival probability from Lower Granite to McNary was 58 and 56 percent for the Sawtooth- and Oxbow-reared fish, respectively. Adult returns from 2009 releases were analyzed, and the survival rates for transported fish versus in-river migrating fish (T:M ratios) were 1.05 (95% confidence interval (CI) = 0.96–1.14) and 1.47 (95% CI = 1.15–1.79) for Sawtooth- and Oxbow-reared fish, respectively.
- Steelhead Straying – The Corps developed (1) a compendium on steelhead stray rates and (2) a model to estimate total numbers of strays in the Columbia Basin based on collection proportions, hatchery releases, transport proportions, and variable stray rates. These products would be used to inform managers on effects of reducing stray rates for certain groups of fish (e.g., barged fish or hatchery reared fish). A study to evaluate straying by identifying imprinting-associated markers in steelhead continued in 2011. This study is an initial step in addressing observations of elevated straying rates in transported steelhead. 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.

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% 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, AWS 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 2011 FPP was released in October 2010. The final FPP (ACOE 2011c) was released in March 2011. 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,*
- *Research as necessary to accomplish the elements of this plan.*

The BPA and the Corps completed the 2011 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 2011 version of the KMP built upon the framework of previous plans, but also identified future direction for 2012 through 2018. The 2011 KMP reviews the goals of the plan and summarizes continuing kelt migration studies performed during 2011, including kelt reconditioning efforts. The 2011 KMP discussed research efforts that would continue in 2012, including a continued focus on kelt-specific operations at Bonneville and Lower Granite Dams. Kelts transported from Lower Granite and Prosser Dams have shown little to no increase in return rates compared to fish left in the river; therefore research efforts, for the time being, will be directed at evaluating strategies other than transport.

Lower Granite Dam collection and handling facilities have also been improved and expanded in order to better aid research; additionally, a greater number of kelts have been PIT tagged in order to better compare control groups and strategies. Long-term reconditioning efforts have been developed and implemented at Dworshak National Fish Hatchery (NFH) focusing on B-run hatchery kelts, and this program is expected to be expanded in 2012 and 2013.

The BPA continued to fund CRITFC to prepare a master plan for kelt, which will address reconditioning Snake River kelts and will focus on kelt collection and reconditioning at various locations, designed to hold fish over so they can spawn in a subsequent year.

Habitat Implementation Reports, RPA Actions 34–38

Table 8. 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 2007–09 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 (2006–07, 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.

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 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. Projects are being completed that 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 projects are reported in annual progress reports. Cumulative habitat quality and survival estimates are reported in the 2013 and 2016 comprehensive evaluations.

RPA Action 35 includes specifications for three-year implementation cycles between 2010 and 2018. The first cycle of additional habitat projects identified for implementation was included in the FCRPS BiOp 2010–13 Implementation Plan (FCRPS 2010a). The second cycle of additional habitat projects will be identified in the 2014–18 Implementation Plan that will be published in December 2013; the second cycle was expanded based on the Court Order. As specified in the RPA action, these project lists identify location, treatment of limiting factor, targeted population or populations, appropriate reporting metrics, and estimated biological benefits.

In Section 1 of this report, Figures 10 and 12–15 summarize results from habitat actions completed between 2005 and 2011 that improved water quantity and quality, in-stream habitat complexity, riparian condition, access, and entrainment to benefit salmon and steelhead. Metrics for actions completed in 2011 are summarized by population in Table 9 below. Detailed information on the 2011 progress of individual projects and actions is presented in Section 3, Attachment 2. Table 1 in that attachment summarizes metrics at the population level for tributary habitat measures implemented with funding from BPA or with technical assistance from Reclamation in 2011 and summarizes limiting factors identified and planned metrics where applicable. BPA uses Pisces, a contract management system, to track and record planned and actual work accomplishments. Details for BPA projects can be found in Pisces via the links provided 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 projects with Reclamation involvement are available in Section 3, Attachments 2 and 3. In some cases, Reclamation projects complement BPA projects (both agencies participate in the same project), 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 4; the reports can be accessed at: *http://www.usbr.gov/pn/programs/fcrps/thp/index.html*.

Table 9. Metrics Completed by BPA and Reclamation in 2011, Summarized by Population. Priority populations in bold.

ESU / DPS	Major Population Group	Population	Water Quantity		Entrainment	Passage		Channel Complexity		Water Quality Riparian Protection and Enhancement			
			Acre-feet protected	CFS protected	# of screens addressed	# of barriers addressed	Stream miles w/ improved access	Instream miles improved	Instream acres treated	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						0.14		1.69	1.15		7.00
		Polatch River				1						7.27	
		Upper South Fork Clearwater				1					8.00		98.00
	Grande Ronde/ Imnaha	**Catherine Creek**	190.2	0.75				4.30		2.00	15.70		
		Grande Ronde River upper mainstem				2		11.60			15.70	15.50	106.00
		Imnaha River mainstem											
		Lostine River	1,188.0	15				0.25					
	Lower Snake	Asotin Creek											
		Tucannon River						0.53			0.90	211.60	16.00
	Middle Fork Salmon River	Big Creek				1	2.50						
		Camas Creek											
		Marsh Creek											
	South Fork Salmon River	East Fork South Fork Salmon River								0.50		10.00	
		Little Salmon River									0.20		0.20
		Secesh River									6.00		
		South Fork Salmon River mainstem				3	10.72						0.15
	Upper Salmon River	East Fork Salmon River			3	1	1.00						
		Lemhi River	5,645.4	34.13	8	5	14.82	1.10		3.07		48.57	27.66
		Pahsimeroi River				7	12.38			8.09	1.70	14.60	4.85
		Panther Creek								2.63		96.00	
		Salmon River lower mainstem below Redfish Lake	591.0	2.00	2					1.97		23.00	12.50
		Salmon River upper mainstem above Redfish Lake								0.90		1.50	
		Valley Creek											
	Wet Clearwater	Lochsa River											
		Lolo Creek									1.00		
Snake River Spring/Summer-run Chinook Salmon ESU Total			**7,614.6**	**51.9**	**13**	**21**	**41.4**	**17.9**	**0.0**	**20.9**	**50.4**	**428.0**	**272.4**
Upper Columbia River Spring-run Chinook Salmon ESU	Upper Columbia/ East Slope Cascades	**Entiat River**			5		60.00	0.16			0.63		
		Methow River	387.4	3.89	4	1	0.00	0.28		2.60	0.70		0.73
		Wenatchee River		1.20			0.30	0.08					
Upper Columbia River Spring-run Chinook Salmon ESU Total			**387.4**	**5.1**	**9**	**1**	**60.3**	**0.5**	**0.0**	**2.6**	**1.3**	**0.0**	**0.7**
Middle Columbia River Steelhead DPS	Cascades Eastern Slope Tributaries	Deschutes River - eastside	913.2	2.28		1	4.51	0.05		1.41	0.98	61.50	16.22
		Deschutes River - westside	905.4	2.61						0.87	0.50	34.40	0.50
		Fifteenmile Creek (winter run)	334.7	9.41						3.28		176.20	
		Klickitat River				2	60.00	2.40			3.11		

ESU / DPS	Major Population Group	Population	Water Quantity		Entrainment	Passage		Channel Complexity		Water Quality Riparian Protection and Enhancement			
			Acre-feet protected	CFS protected	# of screens addressed	# of barriers addressed	Stream miles w / improved access	Instream miles improved	Instream acres treated	Stream miles protected	Stream miles improved	Riparian acres protected	Riparian acres improved
		Rock Creek									0.25		
		White Salmon River											
	John Day River	John Day River lower mainstem tributaries	0.1	0.10	2	4	19.05	3.20		57.94	25.20	883.78	33.95
		John Day River upper mainstem	1,751.6	23.47	12	9	36.70	0.05		12.50	5.00	330.00	4.50
		Middle Fork John Day River			1	1	1.00	4.00			1.25		10.25
		North Fork John Day River			2	1	5.30	0.01		9.48	3.00	202.00	50.00
		South Fork John Day River			1					1.30		15.00	
	Umatilla and Walla Walla River	Touchet River								1.25		86.00	
		Umatilla River	586.0	7.57				0.07			1.96	62.40	78.15
		Walla Walla River	1,497.0	3.53									
		Willow Creek			1								
	Yakima River Group	Naches River			1			1.00			1.00		5.00
		Satus Creek	8,062.0										
		Toppenish			1								40.00
		Yakima River upper mainstem	2,957.5	11.01	3	4	33.00	3.20			1.21		21.23
Middle Columbia River Steelhead DPS Total			**17,007.5**	**60.0**	**24**	**22**	**159.6**	**14.0**	**0.0**	**88.0**	**43.5**	**1,851.3**	**259.8**
Snake River Basin Steelhead DPS	Clearwater River	Clearwater River lower mainstem				1		0.14		1.69	1.15	7.27	7.00
		Lochsa River											
		Lolo Creek				4	5.50				1.00		
		Selway River											
		South Fork Clearwater River				1					8.00		98.00
	Grande Ronde River	Grande Ronde River lower mainstem tributaries				2							
		Grande Ronde River upper mainstem	190.2	0.75				15.90		2.00	31.40	15.50	106.00
		Joseph Creek											
		Wallowa River	1,188.0	15.00				0.25					
	Imnaha River	Imnaha River											
	Lower Snake	Asotin Creek								0.96	2.00		12.00
		Tucannon River						0.53			0.90	211.60	16.00
	Salmon River	**Big, Camas, and Loon Creek**				1	2.50						
		East Fork Salmon River	591.0	2.00	5	1	1.00			1.97		23.00	12.50
		Lemhi River	5,645.4	34.13	8	5	14.82	1.10		3.07		48.57	27.66
		Middle Fork Salmon River upper mainstem											
		Little Salmon and Rapid River									0.20		0.20
		Pahsimeroi River				7	12.38			8.09	1.70	14.60	4.85
		Panther Creek								2.63		96.00	
		Salmon River upper mainstem								0.90		1.50	
		Secesh River									6.00		
		South Fork Salmon River				3	10.72			0.50		10.00	0.15

ESU / DPS	Major Population Group	Population	Water Quantity		Entrainment	Passage		Channel Complexity		Water Quality Riparian Protection and Enhancement			
			Acre-feet protected	CFS protected	# of screens addressed	# of barriers addressed	Stream miles w / improved access	Instream miles improved	Instream acres treated	Stream miles protected	Stream miles improved	Riparian acres protected	Riparian acres improved
Snake River Basin Steelhead DPS Total			**7,614.6**	**51.9**	**13**	**25**	**46.9**	**17.9**	**0.0**	**21.8**	**52.4**	**428.0**	**284.4**
Upper Columbia River Steelhead DPS	Upper Columbia / East Slope Cascades	**Entiat River**			5		60.00	0.16			0.63		
		Methow River	387.4	3.89	4	1		0.28		2.60	0.70		0.73
		Okanogan River	699.2	120.44		8	14.60	1.80	0.25	1.50	5.70	6.00	64.62
		Wenatchee River		1.20			0.30	0.08					
		Crab Creek											120.40
Upper Columbia River Steelhead DPS Total			**1,086.6**	**125.5**	**9**	**9**	**74.9**	**2.3**	**0.25**	**4.1**	**7.0**	**6.0**	**185.8**

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 projects listed in Appendix A of the 2010–13 FCRPS BiOp Implementation Plan (FCRPS 2010a); this plan includes estimates for changes in habitat quality owing to implementation of these future habitat actions. Progress on these projects in 2011 resulted in:

- 25,709 acre-feet of water protected;
- 34 miles of stream habitat treated to enhance complexity;
- 730 acres of riparian habitat improved for better function;
- 46 fish screens installed or addressed for fish protection; and
- 281 miles of improved access to fish habitat.

Detailed 2011 habitat metrics for these projects are presented in Section 3 of this report.

The Action Agencies used results from the expert panel workshops completed in 2010 to focus efforts on specific populations in order to reach RPA 35 Table 5 commitments by 2018. For example, in 2009 Reclamation, in close coordination with local partners, initiated tributary assessments of Catherine Creek, a tributary to the Grande Ronde River in Oregon, and the Yankee Fork of the Salmon River in Idaho. These assessments were nearly completed by the end of 2011 and were used to develop plans to implement habitat improvement actions for the next few years. As refined reach assessments are completed, they are expected to help identify, prioritize, and select habitat improvement actions that will focus on the highest biological benefits. These actions can then be proposed in the next implementation cycle based on objective, scientific analyses of physical and biological characteristics in these areas. To expedite progress for populations positioned for reaching 2018 commitments, BPA initiated a programmatic approach with comprehensive project planning, implementation, and management for Upper Columbia salmon and steelhead populations through a BPA funded project with the Upper Columbia River Salmon Recovery Board. The programmatic approach will allow greater flexibility to select the best actions available for implementation each year, provide opportunity for multi-year planning to address large-effort projects, and will sustain BiOp habitat implementation through various funding and solicitation cycles. It will also ensure thorough coordination with habitat improvements implemented through other funding entities.

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 initiated a series of meetings with regional partners in the summer of 2011 to prepare for the Expert Panel workshops scheduled for spring/summer 2012. Tasks accomplished through these meetings included:

- Transitioning from the limiting factors used prior to 2012 to a standardized list of limiting factors and limiting factor definitions provided by NMFS's

Northwest Fisheries Science Center (NWFSC) in October 2011;

- Preparing lists that compare the scope and metrics of habitat improvement actions identified in 2009 for completion from 2010 to 2012 to those actually completed by the end of 2011; and
- Preparing lists of habitat improvement actions planned for completion from 2013 to 2018 (pursuant to the August 2, 2011 order from the Oregon District Court).

The Action Agencies also developed a database system to store and manage the material compiled, reviewed, and analyzed through the expert panel process. All of these tasks are expected to be finished before the 2012 Expert Panel workshops are conducted. Meetings were also held in the Upper Salmon, Clearwater, and Lower Salmon areas to explore the potential to prepare maps or graphics of available monitoring information to support the expert panel process in 2012. These meetings initiated promising interactions between research and implementation biologists that may lead to identification and development of relevant products to support future Expert Panel workshops in 2015 or beyond. In the meantime, panels will continue to rely on published scientific material to support the expert panel process in 2012.

2) *The expert panel will use methods consistent with the NWR v. NMFS Remand Collaboration Habitat Workgroup process.*

The expert panels will continue to follow the Remand Collaboration Habitat Workgroup process[7] to finalize changes in habitat limiting factors associated with the completed planned, replacement, and additional 2010–12 habitat actions and to estimate changes in limiting factors for the planned 2013–18 habitat actions at the next expert panel workshops scheduled to occur in spring/summer 2012.

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 2011 are presented in the project tables of Section 3 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.*

The expert panels will verify changes in limiting factor habitat function that result from habitat improvement projects completed from 2010 to 2012, and they will identify limiting factor changes for projects planned for completion from 2013 to

[7] 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.

2018 for each priority population during workshops scheduled for spring/summer 2012. The Action Agencies will record the final information consistent with guidance developed through the Remand Collaboration Habitat Workgroup. This information will be used in the 2013 and 2016 Comprehensive Evaluations to assess improvements to salmonid survival.

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 continue to fund and provide technical assistance for projects identified in the 2010-13 Implementation Plan (FCRPS 2010a) at an aggressive pace. The metrics reported for 2011 include additional actions and actions implemented in place of those cited in the Implementation Plan that proved infeasible in whole or in part. Local watershed groups, which generate proposals for the expert panel process, typically maintain lists of projects that can be drawn upon to replace infeasible projects. Benefits for all actions completed in the 2010–12 cycle, (including any projects carried over from 2007–09) will be evaluated in the next expert panel workshops that will occur in spring/summer 2012.

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 briefed Council staff on progress in implementing tributary habitat requirements for the FCRPS BiOp on August 31, 2011. The Action Agencies presented a tool that uses pie charts and bar graphs to plainly illustrate the most important limiting factors in areas that will provide the greatest benefits. This tool can help focus limited resources on habitat improvement actions that do the most good. The Action Agencies will continue to cooperate with the Council to identify program priorities and obtain Independent Scientific Review Panel (ISRP) review of projects as appropriate.

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.*

   Models are under development and significant information on the effectiveness of habitat projects is being accumulated. (See RPA Action 57 for 2011 progress on tributary habitat research, monitoring, and evaluation (RME *or* RM&E).) While these models and underlying data are being developed, the use of best professional judgment (expert panels) continues to be the preferred method for estimating benefits of future projects at the scale and complexity of this BiOp.

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. As part of the 2013 Comprehensive Evaluation, if new scientific or other information suggests that habitat quality improvement estimates for projects from 2010–12 were significantly in error, the Action Agencies will examine the information and review the project or projects in question and their estimated 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.*

The Action Agencies provided funding and technical assistance for projects directed to non-bolded populations in Table 5. These projects were not implemented as replacement projects, per se. However, benefits from these projects may be used should the 2013 comprehensive evaluation indicate they are necessary for the Action Agencies to achieve equivalent MPG or ESU survival benefits.

c. *For those lower Columbia populations above Bonneville Dam that have been significantly impacted by the FCRPS (CR chum, LCR coho, LCR Chinook, and LCR steelhead) the Action Agencies may provide funding and/or technical assistance for habitat improvement projects consistent with basin wide criteria for prioritizing projects, including Recovery Plan priorities.*

The Action Agencies provided funding to improve habitat for populations of Lower Columbia River coho, Columbia River chum, and Lower Columbia River Chinook and steelhead. The habitat improvements were consistent with Recovery Plan priorities.

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 2007–09 were carried forward to the 2010–13 period and the associated benefits are included in the estimates for the 2010–13 implementation cycle.

During the 2007–09 implementation period some projects proved infeasible in whole or in part. The Action Agencies will implement additional projects in 2010–13 to provide survival benefits equivalent to those of the projects that proved infeasible. These additional projects will be selected and implemented in accordance with RPA 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 2010–13 the Action Agencies are providing funding for implementation of projects as needed and appropriate to achieve the total FCRPS BiOp estuary survival benefits by 2018. Most projects implemented in the estuary are selected on an annual basis with some out year planning and scheduling as appropriate.

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 habitat quality and quantity, access for all up-river ESA listed ESUs/DPSs including interior populations of listed juvenile salmonids, and the likelihood that the project will function as designed. The ERTG incorporates new information into their process as it becomes available. To support the ERTG with this adaptive approach, the Action Agencies are developing a synthesis memorandum which summarizes the state of the science of salmon ecology and habitat restoration in tidally influenced areas of the Columbia River estuary. The synthesis memo will be complete in fall of 2012 but draft findings confirm the benefit of reconnecting tidal wetlands for both ocean and stream type life history strategies.

In 2011, the Action Agencies completed on-the-ground habitat actions for four projects in the estuary and continued planning and development of additional projects for future implementation (See Section 3, Attachment 4 for status of projects). All of the habitat projects below have been reviewed by the ERTG:

- Duncan Creek Chum Channel Restoration Phase 2. Washington Department of Fish and Wildlife (WDFW) and the Lower Columbia Fish Enhancement Group enhanced productive groundwater-fed spawning channels for Lower Columbia River Chum salmon. This restoration also provides some additional rearing habitat for other listed salmon. Spawning gravel was added to 500 feet of stream, and stream complexity and stability were increased through the use of log jams, channel excavation, and other in-stream structures.
- Fort Columbia. The Columbia River Estuary Study Taskforce restored 96 acres of tidal and floodplain wetlands by replacing a perched, impassable structure with an ungated 12-foot by 12-foot box culvert. Restoring floodplain connectivity has allowed multiple populations of listed salmon to access this area. Initial monitoring of the site demonstrates utilization of the restoration area by juvenile salmonids immediately after the restoration.
- Germany Creek Restoration, Phase 2. Columbia Land Trust placed engineered log jams along 300 feet of creek and restored (through weed control, planting, and coarse wood inputs) seven acres along 1,700 feet of creek channel. The goals of the project include increased habitat complexity, elimination of ongoing erosion and road-armoring issues, and restoration of the natural floodplain vegetation within the tidal zone. This work is the second part of an ongoing effort to restore habitat function on the lower 1.5 miles of Germany Creek.

- Grays Bay/Mill Road Restoration. The Columbia Land Trust (1) removed portions of the existing levee along the Grays River to reconnect the project site to the Grays River, (2) constructed approximately 2,300 feet of set-back levee utilizing the existing Mill Road embankment on the boundary of the conservation property to provide flood protection to adjacent properties and public infrastructure, and (3) placed wood materials from on-site sources within the created channel and in the existing wetland areas to increase habitat function and to establish native riparian and intertidal wetland plant communities.

In 2011, the Action Agencies developed the first draft of the Columbia Estuary Ecosystem Restoration Plan (CEERP) documents shown in blue on Figure 10 below. 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 and estuary (LCRE). The overall goal of the CEERP is to understand, conserve, and restore ecosystems in the LCRE.

Figure 10. CEERP Adaptive Management Process.

In 2011, the Action Agencies continued developing an expanded portfolio of high-quality projects in the estuary. They included:

- Working with all major restoration practitioners and partners to identify and evaluate all potential restoration projects for out year 2014–18 planning purposes.
- Incorporating cost per survival benefit unit metrics into their decision process. This approach has yielded a number of benefits:
  - Provides a coarse filter that weeds out less promising projects early in the process
  - Provides a quantitative, transparent and consistent approach to project selection
  - Increases the pace of project implementation by focusing project partners on higher value projects
- Continuing to have all estuary projects reviewed and scored by the Expert Regional Technical Group (ERTG).
- Expediting the Washington Estuary Memorandum of Agreement (Estuary MOA) projects with high survival benefits for juveniles from Interior Columbia ESUs/DPSs. The Corps, BPA, and the WDFW will identify and implement estuary restoration projects that provide the highest survival benefits.
- Identifying and implementing joint BPA/Corps projects (non-Estuary-MOA) that yield high survival benefits for juveniles from Interior Columbia ESUs/DPSs.

- Working with partners to identify large tracts of land on the Oregon and Washington shoreline that are suitable for implementation actions.
- Continuing to explore the potential use or development of mitigation banks for restoration activities.

The Action Agencies continue to use the Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead (NOAA Fisheries 2011) to guide restoration and protection efforts through a collaborative process. In 2011, the Action Agencies continued development of a strategic approach to identifying restoration projects in the estuary using the Columbia River Estuary Ecosystem Classification being developed by the University of Washington and the U.S. Geological Survey (USGS). The Action Agencies began applying this classification system to completed river reaches in 2010. This strategic approach provides guiding principles based on salmonid ecology to identify potential sites with the highest value to salmon and steelhead. This is a collaborative effort between the Action Agencies and other regional interests, including the Lower Columbia River Estuary Partnership (LCREP), the States of Oregon and Washington, the Cowlitz Tribe, local restoration practitioners, and experts, including the Columbia River Estuary Study Taskforce, the Columbia Land Trust, watershed councils, and conservation districts.

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 2011, the Action Agencies continued to use the ecosystem criteria developed by LCREP's Science Workgroup to help select restoration and protection projects in the Lower Columbia River and estuary. Additionally, the LCREP was instrumental in coordinating and hosting the 2014–18 outyear 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 convened 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; NMFS, NWFSC; the Department of Energy's Pacific Northwest National Laboratory; and the Skagit River System Cooperative. In 2011, the ERTG completed three key deliverables:

   - They scored a proportion of the projects to calculate ocean and stream survival benefit units;
   - They held a regional public meeting to disseminate scores, to educate project partners about how the ERTG applies scientific principles to the scoring process, and to solicit feedback from the partners on the ERTG template; and
   - They created additional guidance documents to assist project partners in filling out the ERTG template and navigating the ERTG process.

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.*

In 2011 the ERTG solicited feedback from project partners on the ERTG Project Template to streamline the scoring process. This feedback was incorporated into the template in 2012.

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.*

   As described in the 2010 APR, the ERTG previously reviewed the approach applied in the FCRPS BA. The improved version was used to estimate changes in estuary habitat and population survival during 2011. In 2011, the ERTG provided additional guidance to project partners on how to select the appropriate subactions when filling out their templates and they clarified which water levels to use when calculating floodplain subaction metrics.

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 2011 were delayed or proved infeasible. The delayed projects will be constructed in 2012–13. In 2011, the Action Agencies and project partners kicked off an outyear 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 NMFS.

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 find 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 2011, the Action Agencies actively engaged research agencies, consultants, LCREP'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 LCREP'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 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.*

   A final draft pile structure program plan was presented to NMFS in November 2008, and was reviewed in early 2009. This plan will be modified as new information becomes available.

2. *Beginning in 2008 and 2009, the Action Agencies will begin implementation. Implementation will continue through 2018.*

   In 2011, the Corps completed a study of pile structures for a structural, hydraulic, and environmental analysis of Columbia River pile dikes. The Corps also set up a product development team to evaluate options based on the report findings and identified those pile structures eligible for further work. Structures that are not necessary for navigation may be evaluated for removal to decrease predation by both birds and fish. Structures necessary for navigation may be modified to improve access to shallow-water habitat or, possibly, to increase juvenile salmon habitat complexity, as long as these efforts do not detract from the navigational functions.

Hatchery Implementation Reports, RPA Actions 39-42

Table 10. 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.

The ESA consultation process began in September 2008 for Upper Columbia hatchery programs, in March 2009 for programs in the mid-Columbia Steelhead DPS, and in May 2009 for Snake River Basin programs. NMFS began the process by sending letters to hatchery operators and interested parties, and by asking the Action Agency-funded hatchery operators in these regions to update the HGMPs for their respective hatchery programs. In July 2009, a letter from the Action Agencies to hatchery program operators described a process for working collaboratively on development of HGMPs for consultation and transmitted the criteria for funding decisions on ongoing and new hatchery programs in the Columbia Basin. Information from the reports of the USFWS Hatchery Review Team process and the Columbia Basin Hatchery Scientific Review Group process is guiding and informing the development of program-specific HGMPs.

In 2011, 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 11 through 13.

Table 11. FCRPS-Funded Hatchery Programs in the Upper Columbia Region

Program	Operator	Lead Action Agency	Basin
Leavenworth NFH spring Chinook	USFWS	USBR	Wenatchee
Entiat NFH summer Chinook program	USFWS	USBR	Entiat
Winthrop NFH Methow Composite spring Chinook	USFWS	USBR	Methow
Winthrop NFH steelhead	USFWS	USBR	Methow
Methow coho	Yakama Nation (YN)	BPA	Methow
Wenatchee coho	YN	BPA	Wenatchee

Table 12. FCRPS-Funded Hatchery Programs in the Mid-Columbia Region

Program	Operator	Lead Action Agency	Basin
Yakima Spring Chinook	YN	BPA	Yakima
Yakima Summer-Fall Chinook[1]	YN	BPA	Yakima
Yakima Coho	YN	BPA	Yakima
Touchet Endemic Steelhead	WDFW	BPA Lower Snake River Compensation Plan (LSRCP)	Walla Walla
Umatilla Spring Chinook	ODFW & Confederated Tribes of the Umatilla Indian Reservation (CTUIR)	BPA	Umatilla
Umatilla Fall Chinook[2]	ODFW & CTUIR	BPA and Corps	Umatilla
Umatilla Coho Chinook[3]	ODFW & CTUIR	BPA	Umatilla
Umatilla Summer Steelhead	ODFW & CTUIR	BPA	Umatilla

[1] Corps funds release of John Day mitigation fish (fall Chinook salmon) in the Yakima subbasin.

[2] Sub-yearling program funded by BPA, and Yearling program funded by the Corps.

[3] BPA funds the operation of the CTUIR acclimation releases in the Umatilla subbasin; and Mitchell Act funding covers the Bonneville and Cascade Hatcheries operations of the program.

Table 13. FCRPS-Funded Hatchery Programs in the Snake River Region

Program	Operator	Lead Action Agency	Basin
Lyons Ferry Summer Steelhead	WDFW	BPA (LSRCP)	Lower Snake
Snake River Stock Fall Chinook (Lyons Ferry Hatchery) 1	WDFW	BPA (LSRCP)	Lower Snake
Tucannon Summer Steelhead Endemic	WDFW	BPA (LSRCP)	Tucannon
Tucannon Summer Steelhead (Lyons Ferry)	WDFW	BPA (LSRCP)	Tucannon
NF Clearwater Summer Steelhead (B-Run-Clearwater Hatchery)	IDFG	BPA (LSRCP)	Clearwater
NF Clearwater Summer Steelhead (B-Run-Dworshak NFH)	USFWS	Corps	Clearwater
Clearwater River Basin Spring Chinook (Clearwater Hatchery)	IDFG	BPA (LSRCP)	Clearwater
S.F. Clearwater B-Run Steelhead (Clearwater Hatchery)	IDFG	BPA (LSRCP)	Clearwater
Clearwater Spring Chinook (NPT Hatchery)	NPT	BPA	Clearwater
Clearwater Fall Chinook (NPT Hatchery)	NPT	BPA	Clearwater
Cottonwood Creek Summer Steelhead (Wallowa Stock)	WDFW	BPA (LSRCP)	Grande Ronde

Program	Operator	Lead Action Agency	Basin
Grande Ronde Basin Summer Steelhead (Wallowa Hatchery)	ODFW	BPA (LSRCP)	Grande Ronde
Grande Ronde Endemic Spring Chinook Salmon Supplementation (Upper Grande Ronde River Spring/Summer Chinook Salmon Stock)	ODFW & CTUIR	BPA (LSRCP)	Grande Ronde
Grande Ronde Basin Catherine Creek Spring/Summer Chinook	ODFW & CTUIR	BPA (LSRCP)	Grande Ronde
Lostine Spring Chinook	ODFW, NPT & CTUIR	BPA (LSRCP)	Grande Ronde
Lookingglass Creek Spring Chinook	ODFW	BPA (LSRCP)	Grande Ronde
Little Sheep Creek Summer Steelhead	ODFW	BPA (LSRCP)	Imnaha
Imnaha Spring/Summer Chinook	ODFW	BPA (LSRCP)	Imnaha
Upper Salmon River B-Run Steelhead (Sawtooth- Magic Valley)	IDFG	BPA (LSRCP)	Salmon
Upper Salmon Spring Chinook (Sawtooth Hatchery)	IDFG	BPA (LSRCP)	Salmon
South Salmon Summer Chinook (McCall Fish Hatchery)	IDFG	BPA (LSRCP)	Salmon
Johnson Creek Summer Chinook (South Fork Salmon)	IDFG & NPT	BPA (LSRCP)	Salmon
Yankee Fork Summer Steelhead Streamside Incubation Supplementation	IDFG & Shoshone-Bannock Tribe SBT	BPA	Salmon
Yankee Fork Summer Steelhead Supplementation	IDFG & SBT	BPA	Salmon
Yankee Fork Chinook Supplementation	IDFG & SBT	BPA	Salmon
SF Salmon-Dollar Creek Summer Chinook (McCall FH-Eggbox)	IDFG & SBT	BPA	Salmon
E. Fork Salmon River Natural integrated Steelhead (Sawtooth)	IDFG	BPA (LSRCP)	Salmon
Little Salmon River A&B Run Steelhead (Niagara/Magic Valley)	IDFG	BPA (LSRCP)	Salmon
Upper Salmon River A-Run Steelhead (Sawtooth/ Magic Valley/Hagerman National)	IDFG	BPA (LSRCP)	Salmon
Snake River Sockeye (Eagle Fish Hatchery)	IDFG	BPA (LSRCP)	Salmon

As of December 2011, the Action Agencies had completed reviews for 43 of the 44 draft HGMPs for Action Agency-funded hatchery programs. The exception is the Nez Perce Tribal Hatchery Spring Chinook Program; a draft HGMP for this program is expected in early spring 2012. Table 14 provides an abbreviated summary for the status of the HGMP consultation process relative to RPA action 39. The remaining steps of the process to complete the consultations and permits called for under RPA Action 39 are, with limited exceptions noted in this report, with NOAA. Brief status updates on individual Action Agency-funded hatchery programs follow Table 14.

Table 14. Status of Action Agency Funded Hatchery Programs by Region, December 2011

Region	Action Agency-Funded Hatchery Programs Requiring an HGMP	Draft HGMPs Reviewed by/ Com-mented on by Action Agencies	Draft HGMPs Submitted for NOAA Review-Comment	Request for Consultation Package (HGMP-Letter) Submitted to NOAA	HGMPs Determined by NOAA as Sufficient for Consultation	Program Consultations Completed and Biological Opinion Issued
Upper Columbia	6	6	6	4	4	0
Middle Columbia	8	8	8	8	8	3[a]
Snake	30	29[b]	29[c,d]	22	11	0
TOTAL	44	43	43	34	23	3

[a] On April 20, 2011, NMFS issued the BiOp for the Umatilla River spring Chinook, fall Chinook, and Coho salmon hatchery programs, completing the ESA Section 7 consultation process for these BPA direct funded programs.

[b] A draft HGMP for the NPT Spring Chinook Program is expected for submittal in early spring 2012; this program is the sole remaining F&W program that BPA has not received a draft for review and comment.

[c] Shoshone Bannock Tribes submitted drafts of HGMP documents for the Yankee Fork Summer Steelhead Egg-Box and Supplementation, Yankee Fork Spring Chinook Supplementation, and Dollar Creek Summer Chinook Programs (Shoshone Bannock Tribes) to NOAA in June 2010; and the Tribes will finalize and submit consultation packages for these programs upon receipt of review comments from NOAA.

[d] The Corps submitted a draft HGMP for the Dworshak NFH Summer Steelhead Program to NOAA in April 2010; the Corps will finalize and submit the consultation package for that program upon receipt of review comments from NOAA.

Upper Columbia Programs

Methow Subbasin

- *Winthrop NFH Spring Chinook Program:* USFWS originally submitted the draft HGMP in July 2009. The HGMP Consultation process was delayed pending interagency resolution of two issues: (1) the integrated management and evaluation of all spring Chinook programs in the Methow subbasin; and (2) the CTUIR protest, via the *U.S. v. Oregon* dispute resolution, regarding apportionment of Winthrop NFH production between Methow and Okanogan (a program of the Confederated Tribes of the Colville Reservation) releases. In 2011, informal discussions made progress towards resolution of these issues.
- *Winthrop NFH Summer Steelhead Program:* USFWS originally submitted a draft HGMP in July 2009. The consultation process was delayed pending interagency resolution of two issues: (1) the integrated management and evaluation of all summer steelhead programs in the Methow subbasin; and (2) compatibility of program production numbers with ESA biological guidelines. In 2011, basin-wide steelhead program discussions were sparked by a series of “Value Planning” meetings hosted by Reclamation, and subsequent discussions made considerable progress in resolving these issues.
- *Methow Coho Program:* A letter of sufficiency for ESA Section 7 Consultation for this program was forwarded by NMFS on December 13, 2010. Per informal telephone conversations between NOAA and BPA, NOAA has indicated that a consultation for the Methow Coho Program can and will probably proceed separately from consultations for other Methow hatchery programs that were delayed. So far, however, NOAA has not provided a date for initiating the consultation for this program.

Entiat Subbasin

- *Entiat NFH Summer Chinook Program:* USFWS submitted the HGMP to NOAA on July 29, 2009. In a letter dated March 9, 2011, NOAA accepted the HGMP for this program as sufficient for formal ESA Section 7 Consultation, and began development of a draft BiOp. Completion of the consultation process is expected in 2012.

Wenatchee Subbasin

- *Leavenworth NFH Spring Chinook Program:* USFWS submitted the HGMP in July 2009. The consultation was delayed by Icicle Creek water issues. In 2011, the water issues were resolved and an ESA Section 7 Consultation was completed with USFWS on effects to bull trout and other USFWS jurisdiction species, thereby clarifying the proposed action for the NOAA consultation. The HGMP was revised and submitted on March 21, 2011. NOAA indicated the consultation package is sufficient for formal consultation on June 2, 2011, and a BiOp is expected in 2012.
- *Wenatchee Coho Program:* NMFS forwarded a letter of sufficiency for ESA Section 7 Consultation for this program on December 13, 2010. The consultation process for this program is on track for completion with other Wenatchee programs in 2012.

Middle Columbia Programs

Yakima Subbasin

- *Yakima Spring Chinook, Fall/Summer Chinook, and Coho Programs:* A response letter from NOAA to BPA, dated May 2, 2011, requested BPA to notify NOAA that the letter "accurately characterizes each proposed action and its effects on salmon and steelhead under the ESA." On June 20, 2011, based on responses BPA had received from WDFW and the Yakama Nation (YN), BPA responded to NOAA with a letter that concurred with NOAA's finding that the programs are HGMP sufficient. *The BiOp is completed and the permit is issued for the Yakima Summer Steelhead Reconditioning Program.*

  Continuance of the consultation process for the Yakima programs was pending the submittal of a co-manager-approved Klickitat Endemic Summer Steelhead program HGMP; this HGMP is the remaining document required by NOAA to initiate consultation ("batching of programs") for the mid-Columbia Summer Steelhead ESU (Yakima, Walla Walla, Umatilla, Deschutes, and Klickitat populations). The YN did submit a co-manager-approved HGMP for the Klickitat Summer Steelhead Programs, and it was accepted by NOAA in July 2011. *Completion of the Yakima hatchery programs is expected in late summer 2012.*

Walla Walla Subbasin

- *Walla Walla/Touchet Segregated Steelhead Program (Lyons Ferry Hatchery programs).* The ESA consultation process for this program was completed in November 2007.
- *Touchet Endemic Steelhead Program:* NOAA determined that the WDFW consultation package (Letter and Co-Managers Approved HGMP) as sufficient for ESA Section 10 Consultation on March 16, 2011; completion of the consultation process is expected in 2012.

Umatilla Subbasin

- *Umatilla Spring Chinook, Fall Chinook, Coho, and Steelhead:* On April 20, 2011, NMFS issued the BiOp for the Umatilla River spring Chinook, fall Chinook, and Coho salmon hatchery programs, completing the ESA Section 7 Consultation Process for these BPA direct funded programs. *Completion of the consultation process for Umatilla Summer Steelhead is expected in June 2012*.

Snake Programs

Lower Snake Subbasin

- *Lyons Ferry stock Summer Steelhead (Lyons Ferry) Program:* NMFS forwarded a letter of sufficiency for ESA Section 7 Consultation for this program on May 2, 2011; *completion of consultation process is expected in 2012*.
- *Lyons Ferry SRFC Hatchery-Acclimation Project Program:* NMFS initiated and is currently conducting the ESA Section 10 permitting process with program operators (WDFW, NPT, and Idaho Power Company) of the Lyons Ferry Fall Chinook Hatchery-Acclimation Project and Nez Perce Tribal Hatchery Fall Chinook (Clearwater Subbasin) programs. As mitigation for the FCRPS, BPA is funding all but the Idaho Power Company fall Chinook program.

  NOAA will request BPA to fund high-priority RM&E activities as stipulated within the terms and conditions of the ESA Section 10 Permit. BPA has communicated to NMFS that as much as $500,000 will be available for new RM&E studies under the ESA Section 10 Permit. These are the funds originally budgeted for a new SRFC relative reproductive success (RRS) study and other SRFC RM&E specified in FCRPS BiOp RPA actions 64 and 65. On February 2, 2012, NOAA sent BPA a letter confirming that the ESA Section 10 Permit RM&E will fulfill the requirements of RPA actions 64 and 65 as they relate to SRFC.
- *Tucannon Summer Steelhead Endemic Program:* NMFS forwarded a letter of sufficiency for ESA Section 10 consultation for this program on May 2, 2011; completion of the consultation process is expected in 2012.
- *Tucannon Spring Chinook Program:* NMFS forwarded a letter of sufficiency for ESA Section 10 consultation for this program on August 26, 2011; completion of the consultation process is expected in 2012.

Clearwater Subbasin

- *North Fork Clearwater Spring Chinook (Dworshak Hatchery) Program:* The Lower Snake River Compensation Plan (LSRCP, part of USFWS) submitted an ESA Section 7 consultation package (cover letter and co-manager-approved final HGMP) on December 21, 2010.
- *North Fork Clearwater Summer Steelhead (Dworshak Hatchery) Program:* Submittal of the consultation package (letter requesting ESA Section 7 consultation and co-managers approved HGMP) to NOAA is pending action by the Corps (Walla Walla District).
- *Nez Perce Hatchery Fall Chinook Program:* Refer to "Lyons Ferry SRFC Hatchery-Acclimation Project Program" in Lower Snake Subbasin section, above.
- *Nez Perce Hatchery Spring Chinook Program:* No draft HGMP for this program has been submitted. The Tribe communicated to BPA that a draft final HGMP is in the process for completion and submittal to NOAA in late spring 2012; completion of consultation process is expected in 2012.
- *Clearwater Hatchery Spring/Summer Chinook Program:* The IDFG submitted consultation package (cover letter and co-manager-approved final HGMP) requesting ESA Section 10 consultation on January 17, 2011. Initiation of the consultation process is pending acknowledgement from NOAA of the HGMP's sufficiency for consultation; completion of consultation is expected in 2012.

- *Clearwater Hatchery Summer Steelhead Program:* IDFG submitted consultation package (cover letter and co-manager-approved final HGMP) requesting ESA Section 10 consultation on January 23, 2011. Initiation of the consultation process is pending acknowledgement from NOAA of the HGMP's sufficiency for consultation; completion of consultation is expected in 2012

Grande Ronde-Imnaha Subbasin

- *Lostine Spring Chinook Program (Northeast Oregon Hatchery):* On May 27, 2011, the Bureau of Indian Affairs, on behalf of the NPT, submitted consultation package (cover letter and co-manager-approved final HGMP) requesting ESA consultation under ESA Section 10 (a)(1)(A). NMFS forwarded a letter of sufficiency for ESA Section 10 consultation for this program on August 4, 2011; completion of the consultation process is expected in 2012.
- *Grande Ronde Summer Steelhead-Wallowa Stock (Cottonwood Creek/Lyons Ferry Hatchery) Program:* NMFS forwarded a letter of sufficiency for ESA Section 10 consultation for this program on May 2, 2011; completion of the consultation process is expected in 2012.
- *Grande Ronde Basin Summer Steelhead (Wallowa Hatchery):* NMFS forwarded a letter of sufficiency for ESA Section 10 consultation for this program on August 31, 2011; completion of the consultation process is expected in 2012.
- *Catherine Creek Spring/Summer Chinook:* NMFS forwarded a letter of sufficiency for ESA Section 10 consultation for this program on August 4, 2011; completion of the consultation process is expected in 2012.
- *Imnaha Spring/Summer Chinook:* ODFW submitted a consultation package (cover letter and co-manager-approved final HGMP) to NOAA requesting application for an ESA Section 10 permit for this program on May 2, 2011. Initiation of the consultation process is pending acknowledgement from NOAA of the sufficiency of the HGMP for consultation; completion of the consultation process is expected in 2012.
- *Little Sheep Creek Summer Steelhead (Imnaha):* NMFS forwarded a letter of sufficiency for ESA Section 10 consultation for this program on August 4, 2011; completion of the consultation process is expected in 2012.
- *Upper Grande Ronde Spring Chinook:* On behalf of the CTUIR, the Bureau of Indian Affairs submitted a letter (and a co-manager-approved HGMP) to NOAA requesting application for an ESA Section 10 permit for this program on July 15, 2011. NMFS forwarded a letter of sufficiency for ESA Section 10 consultation for this program on August 26, 2011; completion of the consultation process is expected in 2012.
- *Lookingglass Creek Spring Chinook (Grande Ronde):* ODFW submitted consultation package (cover letter and co-manager-approved final HGMP) to NOAA requesting application for an ESA Section 10 permit for this program on January 23, 2012. Initiation of the consultation process is pending acknowledgement from NOAA of the sufficiency of the HGMP for consultation; completion of consultation process is expected in 2012.

Salmon Subbasin

- L*ittle Salmon Summer Steelhead (A & B):* IDFG submitted a consultation package (cover letter and co-manager-approved final HGMP) to NOAA requesting application for an ESA Section 10 permit for this program on September 13, 2011. Initiation of the consultation process is pending acknowledgement from NOAA of the sufficiency of the HGMP for consultation; completion of the consultation process is expected in 2012.

- *Johnson Creek Summer Chinook:* The Bureau of Indian Affairs, on behalf of the NPT, submitted a consultation package (cover letter and co-manager-approved final HGMP) to NOAA requesting application for an ESA Section 10 permit for this program on June 6, 2011. Initiation of the consultation process is pending acknowledgement from NOAA of the sufficiency of the HGMP for consultation; completion of the consultation process is expected in 2012.
- *East Fork Salmon Summer Steelhead:* IDFG submitted a consultation package (cover letter and co-manager-approved final HGMP) to NOAA requesting application for an ESA Section 10 permit for this program on December 21, 2011. Initiation of the consultation process is pending acknowledgement from NOAA of the sufficiency of the HGMP for consultation; completion of the consultation process is expected in 2012.
- *Upper Salmon Summer Steelhead (B-Run):* The LSRCP submitted a consultation package (cover letter and co-manager-approved final HGMP) to NOAA requesting application for an ESA Section 10 permit for this program on January 17, 2012. Initiation of the consultation process is pending acknowledgement from NOAA of the sufficiency of the HGMP for consultation; completion of the consultation process is expected in 2012.
- *Upper Salmon Summer Steelhead (A-Run):* The LSRCP submitted a consultation package (cover letter and co-manager-approved final HGMP) to NOAA requesting application for an ESA Section 10 permit for this program on January 17, 2012. Initiation of the consultation process is pending acknowledgement from NOAA of the sufficiency of the HGMP for consultation; completion of the consultation process is expected in 2012.
- *Upper Salmon Spring Chinook:* IDFG submitted a consultation package (cover letter and co-manager-approved final HGMP) to NOAA requesting application for an ESA Section 10 permit for this program on December 21, 2011. Initiation of the consultation process is pending acknowledgement from NOAA of the sufficiency of the HGMP for consultation; completion of the consultation process is expected in 2012.
- *McCall (South Fork Salmon) Summer Chinook:* IDFG submitted a consultation package (cover letter and co-manager-approved final HGMP) to NOAA requesting application for an ESA Section 10 permit for this program on December 21, 2011. Initiation of the consultation process is pending acknowledgement from NOAA of the sufficiency of the HGMP for consultation; completion of the consultation process is expected in 2012.
- *Yankee Fork Programs (Summer Steelhead Stream Side Incubation and Supplementation, and Spring Chinook Supplementation):* Submittal of a consultation package (cover letter and co-manager-approved final HGMP) to NOAA requesting application for an ESA Section 10 permit for this program is pending action by Shoshone Bannock Tribes.
- *Dollar Creek (South Fork Salmon) Summer Chinook (Egg-Box):* Submittal of a consultation package (cover letter and co-manager-approved final HGMP) to NOAA requesting application for an ESA Section 10 permit for this program is pending action by Shoshone Bannock Tribes.
- *Snake River Sockeye (Eagle Fish Hatchery):* NMFS forwarded review comments on draft HGMP to IDFG on May 18, 2010; submittal of consultation package (cover letter

and co-manager-approved final HGMP) to NOAA requesting application for an ESA Section 10 permit for this program is pending action by IDFG.

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 reprogramming of the John Day Mitigation Program has been the topic of ongoing coordination and negotiation for a number of years. The current effort, initiated in 2006, is to coordinate a regionally acceptable, detailed plan to accomplish the construction and operational modifications to the program to address a long-held objective to better provide for an in-place, in-kind mitigation concept.

   In 2011, the Corps, in conjunction with the *U.S. v. Oregon* Strategic Work Group, awarded a contract for completion of an Alternatives Study on the John Day Mitigation program. The study evaluates current mitigation production and assumptions, clarifies in-place in-kind mitigation production objectives, determines the delta between objectives and production, analyzes alternatives, and prepares preliminary designs and cost estimates for the most feasible alternatives. The draft report is currently under review with the *U.S. v. Oregon* parties.

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 LSRCP program office and WDFW, the LSRCP hatchery program operator for the Tucannon River steelhead supplementation Program. For Tucannon steelhead, WDFW developed a revised HGMP (9/22/11) to eliminate releases of Lyons Ferry Hatchery steelhead in the Tucannon River and to increase production of the endemic Tucannon River summer steelhead population. 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 brood-year 2010 production for release in 2011), which required use of the maximum production space that Lyons Ferry currently has available for the program.

   As the program expands beyond 75,000 toward the production goal of 150,000 in the future, following needed facility modifications at the Lyons Ferry and Tucannon fish hatcheries, up to two-thirds of the annual production would be marked (adipose fin-clipped) and available for harvest mitigation as part of the LSRCP mitigation program. The remaining one-third of the program would not be adipose fin-clipped and would be used primarily for conservation purposes in the Tucannon River. Production facilities, brood source, size and life history at release, and time of release would all remain the same as the current program.

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 LSRCP program office and WDFW. For Touchet steelhead, WDFW submitted a HGMP to NMFS in November 2010 to align with a NMFS request to consult on mid-Columbia 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. WDFW is in the process of conducting statewide review of steelhead hatchery programs and expects to complete a review of the Touchet program by late 2012 or early 2013. After that review, WDFW and co-managers will recommend the appropriate actions that should be taken for Touchet River steelhead.

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, that the measures are biologically and economically feasible and effective. Implementation of reforms will be prioritized and sequenced.*

   The Winthrop NFH continued to transition to local broodstock by collecting more brood from the Winthrop Basin via hatchery volunteers (adult fish that come in to the hatchery channel), 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, and 60,000 in 2011. The release goal of 100,000 fish annually is still being met during the transition, with the remainder coming from the hatchery's traditional broodstock collected from Wells Dam. Raising juvenile steelhead from local broodstock requires longer-term (two-year) rearing of juvenile steelhead, compared to a one-year rearing cycle for Wells Dam stock. Study plans were established with NMFS to evaluate the survival benefits of the local broodstock and two-year rearing strategy. Preliminary results from 2011 indicate promising survival and fitness benefits to progeny from the local broodstock.

   Efforts to manage returning Winthrop NFH-produced steelhead on the spawning grounds continued in 2011. All NFH-produced steelhead that were collected through hatchery volunteers or angling were removed. Additional tools may be required to manage a higher proportion of hatchery returns.

   In 2011, Reclamation sponsored a series of facilitated meetings, 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. Foghorn Dam at the hatchery intake had previously been suggested as a likely place to intercept returning adult steelhead but does not effectively block fish passage. A weir at Foghorn Dam had been suggested as a means to block fish there for management, but this is a difficult and controversial solution. A coordination meeting in Portland in February 2011 identified interested parties and scoped the issues. A larger, facilitated "Group Objectives And Logistics (GOAL)" meeting held in Twisp, Washington on June 14, 2011, developed a problem statement, sideboards, and criteria. Entities involved in these meetings included Reclamation, BPA, USFWS, WDFW, YN, UCSRB, Confederated Tribes of the Colville Reservation, and the Public Utilities Districts of Douglas, Grant, and Chelan Counties. Finally, a smaller focused workgroup convened October 4-6, 2011, and developed proposals to collect broodstock and effectively manage returning adults. These proposals included:

a. A suite of actions that could use existing infrastructure to collect fish such as increased angling effort, conservation fisheries, seining/netting, and release strategies in concert with increased monitoring;

b. Using temporary structures such as picket panel weirs or pound nets throughout the basin to capture returning adults;

c. Modifying Foghorn Dam to enhance capability to manage adults and collect broodstock; and

d. Implementing new structures such as permanent weirs throughout the basin to manage hatchery adult escapement and capture broodstock.

In the short term, the team recommended collaboratively developing and implementing a cooperative plan using techniques described in proposals a and b, including monitoring of the efficacy of these measures to meet adult management and broodstock collection objectives. Furthermore, project proponents recommended further evaluation of structural solutions such as proposals c and d, as longer-term structural solutions to be considered to meet objectives if necessary (Reclamation 2012).

Further progress was made in 2011 on hatchery upgrades. A project to remove and replace outdated structures and install new holding and rearing ponds for sorting and spawning adult fish was considered by the technical evaluation team and bids were solicited in 2010. A contract was awarded on January 19, 2011, for this effort, and construction was underway throughout 2011. The new holding pond is part of the package of actions needed to transitions to local broodstock. An additional recommendation was for Winthrop NFH to reduce spring Chinook salmon production, thereby increasing steelhead capability. In 2011, 1,516 surplus hatchery spring Chinook salmon were removed from the natural spawning population and donated to the Yakima, Colville, and Spokane Tribes.

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.

BPA continued to fund BPA Project No. 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. The progeny are raised in carefully managed hatcheries and released into their natural habitats using multiple release strategies, including smolt, fry, and parr releases; eyed-egg incubation boxes; and adult releases for volitional spawning. The Stanley Basin Technical Oversight Committee continues to provide guidance on the program. Since 1999, 4,311 adults from the program have returned to Redfish Lake in Idaho. In 2011, 1,118 adult sockeye salmon returned to Redfish Lake or the Sawtooth Hatchery weir on the upper Salmon River. This is one of the largest recorded annual returns since 1956.

1. *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 No. 2000-019-00 (Tucannon River Spring Chinook Captive Brood), a one-generation safety-net program, was completed as planned in 2010. BPA continues to fund a supplementation hatchery program for Tucannon River spring/summer Chinook salmon through the LSRCP Direct Funding Agreement.

2. *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 No. 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.

3. *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 this safety-net program through BPA Project No. 1996-043-00 Johnson Creek Artificial Propagation Enhancement Project.

4. *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).*

   BPA continued to fund this experimental captive rearing program through BPA Project No. 2007-403-00 Idaho Snake River Spring Chinook Captive Propagation.

5. *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.*

   It is not feasible to implement this action at this time because of a lack of adequate B-run steelhead population viability data. Once sufficient data are available (as determined by NOAA Fisheries) through the enhanced Snake River B-run steelhead population productivity and abundance monitoring called for in RPA Action 50.5, the Action Agencies will begin to work with NOAA Fisheries to develop the type of "trigger" described above. We estimate it may be several years before adequate data are available from the enhanced monitoring effort.

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.*

   When constructed and fully operational, Chief Joseph Hatchery (BPA Project No. 2003-023-00) is expected to serve as the artificial production facility needed for this reintroduction program. This production will initially be contingent on the availability of within-ESU spring Chinook broodstock from the Methow River Basin. Following final approval from the NPCC, major construction work began in February 2010. The hatchery is now expected to be completed in February 2013.

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 2011, BPA funded the YN to begin constructing a steelhead kelt reconditioning facility at Winthrop NFH.

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 through BPA Project No. 2007-212-00 (Locally Adapted Okanogan Steelhead Broodstock).

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 No. 2007-401-00 (Kelt Reconditioning/Reproductive Success).

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.*

   BPA continued to fund operation and maintenance for this action through the LSRCP Direct Funding Agreement.

6. *For Snake River Spring/Summer Chinook Salmon: For the Lostine and Imnaha rivers, contingent on a NOAA 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.

As of December 2011, HGMPs for the Lostine and Imnaha River supplementation programs had been submitted to NOAA for ESA consultation. When consultation is completed by NMFS, BPA will plan for construction of the Northeast Oregon Hatchery Lostine and Imnaha spring/summer Chinook propagation facilities when capital funds are available. It is possible that NMFS may complete ESA consultation for this program during the RPA Action 39 ESA consultation process for the Snake River Basin in 2012.

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.*

The Springfield Hatchery property near Pocatello, Idaho, was acquired in 2010 as the site for construction of a new Snake River sockeye hatchery to help meet this BiOp action. Construction of the Springfield Sockeye Hatchery is expected to begin in 2012 and be completed in 2013. The construction and the operation and maintenance of the new hatchery will be funded under BPA Project No. 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 highly successful pilot project in 2010 to evaluate feasibility of ground transport from the Lower Granite 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 NMFS and the fishery co-managers, in coordination with the Action Agencies, decide to implement this option. No further action will be taken unless warranted.

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.*

To create implementation efficiencies, the BPA-funded project implementing this action (BPA Project No. 2001-053-00, Reintroduction of Chum Salmon into Duncan Creek), was merged into BPA Project No. 2008-710-00 (Development of an Integrated Strategy for Chum Salmon Restoration in the Tributaries Below Bonneville Dam).

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.*

In 2011, BPA continued funding BPA Project No. 2008-710-00 (Development of an Integrated Strategy for Chum salmon Restoration in the Tributaries below Bonneville Dam) to implement this action and the action to reintroduce chum salmon in Duncan Creek.

Predation Management Implementation Reports, RPA Actions 43–49

Table 15. 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 Results of periodic program evaluations (including updates on age restructuring and compensatory responses)
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	Annual progress reports will describe actions taken if warranted.
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.

Since 1990, BPA has funded the NPMP to reduce the numbers of larger pikeminnow and improve survival of juvenile salmon. In 2004, after BPA increased the reward for the catch of this predator, the number of pikeminnow removed increased by 25 percent compared to prior years. The increased reward was made permanent in 2005 to sustain the higher catches. This resulted in the highest harvest rate of pikeminnow observed since the program began. The pikeminnow program has removed nearly 3.65 million northern pikeminnow from the Columbia River since 1990. Evaluation indicates that, as a result of the program, pikeminnow predation on juvenile salmon has declined 38 percent, saving 3 to 5 million juvenile salmon annually that would otherwise have been eaten by this predator.

The 2008 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. In 2011, researchers continued to maintain higher tagging effort, however due to high flows early in the season tagging rates saw a slight decline from the previous year. Nevertheless, 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) in Hankin and Richards (2000).

Also in 2011, the exploitation rate on northern pikeminnow was 15.6 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 155,312 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 2011 catch of 3,964 from the forebays and tailraces of The Dalles and John Day Dams. This represents a 14-percent increase in catch from 2010.

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 2011, the Action Agencies continued to fund two studies to address the prioritized non-native fish predation issues resulting from a series of workshops in 2009. The first study objective was to evaluate the physiological condition of smallmouth bass, walleye and channel catfish as they head into the over-wintering time-period. In addition, a dam angling study was initiated in 2011 to evaluate forebay and tailrace catch of smallmouth bass per unit of effort.

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. NMFS 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.

Implementation of the Caspian Tern Management Plan for the Columbia River Estuary continued in 2011. As a result of the available alternative nesting habitat in 2011 (see Table 16 below) the acreage available for nesting at East Sand Island was reduced to 2 acres, Construction of a new nesting island at Malheur Wildlife Refuge began in late 2011.

Table 16. Status of Artificial Caspian Tern Nesting Islands for the 2011 Breeding Season. Productivity measured as offspring per nest.

Location	Size (acres)	Completion Date	Social Attraction	Watered	Breeding Attempts	Productivity
Fern Ridge Reservoir (OR)	1	Feb 08	Yes	Yes	0	0

Crump Lake (OR)	1	Mar 08	No	Yes	35	0.43
East Link Unit, Summer Lake Wildlife Area (OR)	0.5	Dec 08	Yes	Yes	2	0
Dutchy Lake, Summer Lake Wildlife Area (OR)	0.5	Feb 09	Yes	Yes	0	0
Sump 1B, Tule Lake NWR (CA)	2	Aug 09	Yes	Yes	34	0.03
Gold Dike Unit, Summer Lake Wildlife Area (OR)	0.5	Sep 09	No	No	-	-
Orems Unit, Lower Klamath NWR (CA)	1	Sep 09	Yes	Yes*	0	0
Sheepy Lake, Lower Klamath NWR, (CA)	0.8	Feb 10	Yes	Yes	188	0.11

*For some, but not all, of 2011 breeding season.

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.

In 2011, the Action Agencies continued to evaluate potential management techniques for reducing losses of juvenile salmonids due to double-crested cormorant predation in the Columbia River estuary. This year's pilot program used two techniques to discourage nesting on East Sand Island. The first technique, human disturbance, was used on a discrete portion of the breeding colony area. The second technique was the placement of a privacy fence to separate 15 percent of the nesting area. Birds dissuaded from this area did not leave the island but moved to nest at other locations on East Sand Island. The effectiveness of exclusion from a larger percentage of potential nesting area is planned for 2012. This information will be utilized in developing the cormorant management plan.

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 RME) for Corps-owned lands and associated shallow water habitat.

In 2011, the Action Agencies, USFWS, and NMFS continued development of an Inland Avian Predation Management Plan for Corps-owned lands and associated shallow water habitat upriver of Bonneville Dam. Multiple individual projects, as cited below and further discussed in RPA 68, were completed in 2011 to support development of the management plan including the continued monitoring of the impacts of avian predators on juvenile salmonids on the Columbia Plateau, development of a 'synthesis report' summarizing pertinent RM&E efforts between 2004–09, and completion of a 'benefits analysis' assessing potential benefits to anadromous juvenile salmonids from potential reductions in avian predation on the Columbia Plateau. Based on the results of these projects, the Corps and Reclamation have agreed to expand the scope of the plan to include Reclamation owned lands, specifically at Goose Island in Potholes Reservoir (near Othello, WA), where a Caspian tern colony appears to be preying heavily on Upper Columbia River steelhead. As a note, while early drafts of the Inland Avian Predation Management Plan had originally included "dam-component" actions, regional discussions concluded that improvements to the Corps' avian deterrent program will continue to be addressed through FPOM, that they will be included in the FPP per RPA 48, and that they will not be included within this habitat-based management plan.

A full draft of the Inland Avian Predation Management Plan is planned to be available for regional review in late 2012.

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.

Other avian deterrent actions, such as longer-term hazing and wire arrays, were implemented in consultation with FPOM and in accordance with the FPP (ACOE 2011c), as called for in RPA Action 48.

In 2011, the Corps' Fish Field Unit (FFU) conducted a final year of monitoring at John Day and The Dalles Dams to assess whether the new wire array structures are providing adequate protection to outmigrating juvenile salmonids. FFU's objectives were to: (1) Determine species composition and numbers of piscivorous birds; (2) Estimate fish consumption and attack location of gulls; (3) Determine the effectiveness of intense boat hazing and avian deterrent line arrays at John Day and The Dalles Dams. Unlike previous years, no lethal take was permitted for gut analysis purposes in 2011 and therefore total fish consumption numbers are reported instead of salmonid consumption numbers. Preliminary results indicated that a combination of hazing from boats and improved avian line arrays appeared successful in dissuading avian predators from both projects in 2010 and 2011. At John Day Dam, preliminary estimates indicate about 6,000 fish were consumed in 2011 by avian predators, a reduction from the 38,000 fish consumed in 2010. At The Dalles Dam, preliminary estimates indicate about 16,000 fish were consumed in 2011 by avian predators, a reduction from 86,000 fish consumed in 2010. At both dams, gulls continue to be the primary predators and while gull attacks were widely scattered, predation was typically focused immediately downstream of avian lines on the spillway side of the river. While deterrent efforts were similar in both years, FFU attributes the decreases in fish consumption to natural variation in the number of foraging gulls, not level of hazing deterrent effort. Regardless, the management objective of reducing predation through improvements to the respective avian deterrent programs was achieved in both years.

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 2011, the Corps implemented and evaluated a variety of sea lion deterrents, from physical barriers to non-lethal harassment (Stansell et al. 2011). Sea lion exclusion devices (SLEDs) were installed at Bonneville Dam's 12 primary fishway entrances to prevent sea lions from entering the fishways. SLEDs were installed on January 19, 2011 at powerhouse one and "B" branch entrances. They were not installed at the Powerhouse 2 and Cascades Island entrances until February 22, 2011, as the fishway was out of service for maintenance until that time. The SLEDs feature 15.38-inch (39.05-centimeter) gaps that are designed to allow fish passage. The SLEDs were removed on July 5, 2011. Floating orifice gates were also equipped with SLED-like barriers. Acoustic deterrent devices, which emit a 205-decibel sound in the 15-kilohertz range, had been used since 2006; however, they proved ineffective and were removed before the 2011 season.

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 in March 2011 and was conducted daily through the end of May 2011. Harassment involved a combination of acoustic, visual, and tactile non-lethal deterrents, including above-water pyrotechnics (cracker shells, screamer shells, or rockets), rubber bullets, rubber buckshot, and beanbags.

In part supported by BPA, CRITFC conducted boat-based harassment along with ODFW and WDFW from March 2011 through May 2011. Boats operated from the Bonneville Dam tailrace at river mile 146 downstream to navigation marker 85 (river mile 139). 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 crews from ODFW, WDFW, and CRITFC on all sea lion harassment activities at Bonneville Dam to ensure safety and increase the effectiveness of harassment efforts.

RME Implementation Reports, RPA Actions 50–73

The following section provides information on the RME actions implemented by the Action Agencies in 2011. In many cases, Action Agency projects identify actions that were funded and initiated prior to the completion of the 2008 BiOp, or were initiated as part of a previous BiOp. This section of the report highlights examples of how projects contracted in 2011 fulfilled the RPAs, while Section 3 provides the full list of projects.

Table 17. 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.

RPA Action No.	Action	Annual Progress Report
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).
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.

RPA Action No.	Action	Annual Progress Report
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)

A comprehensive list of all actions implemented by the Action Agencies for RPAs 50 and 51 is included in Section 3.

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).*

   In 2011, three BPA projects continued to implement maintain and improve the Pit TAG Information System (PTAGIS) in BPA Project 1990-080-00 (Columbia Basin Pit-Tag Information) by the Pacific States Marine Fisheries Commission. In addition to the Columbia Basin Pit-Tag Information Project, the Integrated Status and Effectiveness Monitoring Project (ISEMP) No. 2003-017-00 supported the expansion of PTAGIS from management of hydrosystem arrays to track tributary PIT Tag detection systems by joining the steering committee and PTAGIS technical workgroups. Enhancements to the PTAGIS system include an updated user input and output interface found at *http://www.ptagis.org/* (Figure 11). Completions of several major updates to the PTAGIS system are expected to be completed in 2012.

   In 2011 additional work by the Data Access in Real Time Project (1996-019-00) and ISEMP 2003-0017-00 further developed tools to deconstruct the PTAGIS system raw detection data of adults and juveniles to rapidly assess individual fish at the population scale. See Results under RPA 50.5 for further information.

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

In 2011, the Corps implemented its adult fish count program as described in the Fish Passage Plan (ACOE 2011c). Results are available in the 2011 Annual Fish Passage Report: Columbia and Snake Rivers (ACOE 2011d).

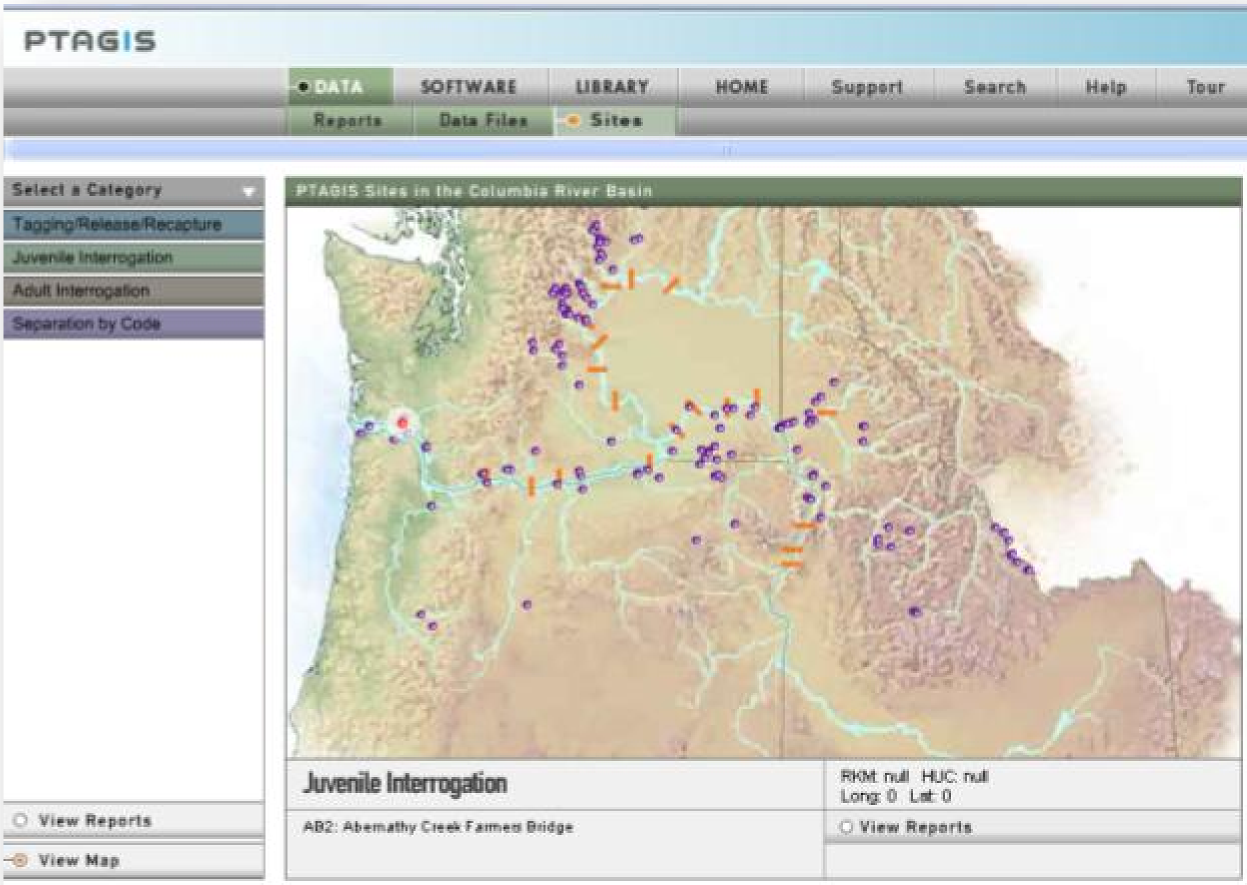


Figure 11. Example screenshot of the new PTAGIS Map system of Juvenile Interrogation Sites at *http://www.ptagis.org/*.

BPA continued implementation of Project No. 2005-002 in 2011 to support of this RPA subaction. For example, adult return data from yearling steelhead and Chinook tagged under BPA Project No. 1993-029-00 (Survival through Snake and Columbia River reservoirs) will be analyzed over the next three years in combination with outmigration survival data from wild and hatchery populations.

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

BPA continued implementation of nine smolt monitoring projects to address the needs of this RPA subaction. For example, BPA Project No. 1987-127-00 (Smolt Monitoring by Non-Federal Entities) collected species, condition, and external mark detail from all sampled fish, condition and length data from a subsample of the smolts, and all incidental species caught in the samples.

Under BPA project number 1993-029-00 (Survival through Snake and Columbia River reservoirs), NOAA PIT tagged 22,010 hatchery steelhead, 17,999 wild steelhead, and 16,023 wild yearling Chinook at Lower Granite dam in order to estimate reach survival and travel time through reach segments of the FCRPS hydrosystem. The use of PIT-tagged juveniles from additional projects above Lower Granite improved sample size and population specific survival data at the mainstem dams. Travel time through the hydropower system during 2011 was among the fastest of all years of the study for both yearling Chinook salmon and steelhead. During 2011, flows and spill at Snake River dams were at relatively high levels. For Snake River yearling Chinook salmon, estimated survival through the entire hydropower system in 2011 (from the head of Lower Granite Pool to Bonneville tailrace) was 0.483, below the average for the last 13 years. Juvenile steelhead survival was 0.592, higher than the 13-year average, but lower than 2009 and 2010 estimates. Survival rates of yearling smolts from hatcheries to Lower Granite dam suggest that substantial mortality occurs upstream from the Snake and Clearwater River confluence. The study estimated that 87 percent of the overall yearling Chinook outmigration run size in 2011 was of hatchery origin. They were unable to estimate the hatchery proportion for steelhead. Proportions of transported fish (wild and hatchery combined) in 2011 were among the lowest estimated since 1995, averaging 39 percent for yearling Chinook and 37 percent for steelhead.

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.)*

In 2011, seven BPA projects continued to be implemented for RPA 50.4. Results for BPA projects are reported in their Annual Progress Reports or technical reports in the BPA project tracking system, PISCES, which can be reviewed through the Taurus reporting system at *www.cbfish.org.* Example results for some of these projects follow.

For BPA Project No. 1998-016-00, Escapement and Productivity of Spring Chinook and Steelhead, ODFW sampled 48 random, spatially-balanced sites throughout the John Day River Basin during the spring and early summer of 2011 to estimate summer steelhead escapement and the proportion of hatchery-raised fish. They observed 53 steelhead redds while surveying 96 kilometers (km) of stream (2 km/site), approximately 2.2 percent of an estimated 4,322 km of steelhead spawning and rearing habitat that is within the total 15,455 km of stream habitat available to fish within the John Day River Basin. The expansion of this small sample using the average redds/km density and a spawner to redd expansion factor resulted in an estimated steelhead spawner escapement in 2011 of 11,334 spawners. This 2011 estimate is the highest since ODFW implemented the Environmental Monitoring and Assessment Program sampling protocol in 2004. (See Figure 12.) Hatchery composition of adult steelhead was estimated at 4.2 percent, the lowest proportion since the new sampling design began.

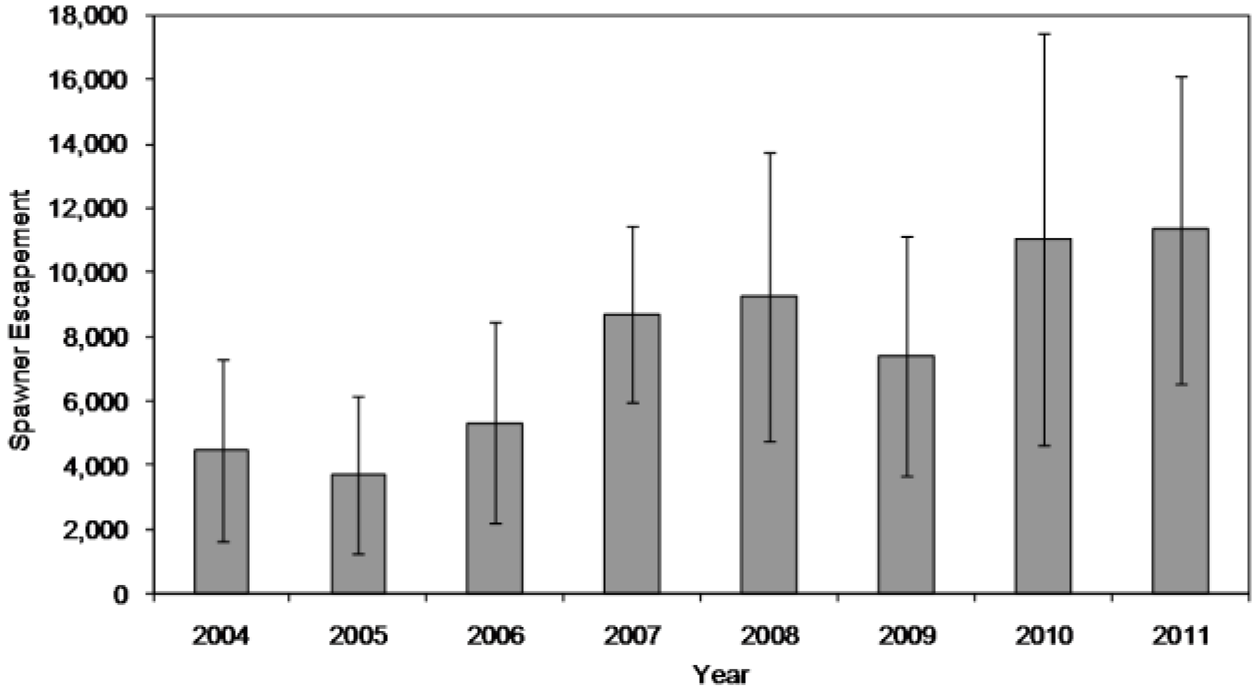


Figure 12. Annual adult steelhead spawner escapement estimates for the John Day River Basin from 2004 to 2011. Error bars indicate 95-percent confidence intervals.

Some key lessons learned from this project included:

- The coefficient of variation for the steelhead escapement estimate continues to be larger than the NMFS guidelines of 15 percent (Crawford and Rumsey 2011). The current high variance level in these escapement estimates compromise evaluations of restoration efforts and management decisions. A large increase in sampling or alternative monitoring approach may be needed to achieve the needed precision levels.
- Over the 8 years of ODFW's Environmental Monitoring and Assessment Program, the intensity of stream discharge is negatively correlated with redds density observations. At some point, increased flow volume can completely preclude redd detection.
- The annual fish per redd constant, developed at the Deer Creek weir in the Grande Ronde River Basin, was the highest ever used to estimate escapement. The use of an out of basin (Deer Creek weir in the Grande Ronde River) spawner per redd expansion factor raises concerns about the accuracy of the escapement estimates. There appears to be no relationship between uncorrected redd densities and Columbia River dam counts which emphasizes the necessity of having a weir where a fish-per-redd estimate specific to the John Day and a given water year can be generated to correct for variable survey conditions.
- Despite a high escapement estimate, ODFW observed spawning at only seven of the 17 sites they survey annually, suggesting that with increased escapement levels steelhead spawning range is not increasing and that steelhead spawning habitat in the basin is not fully understood.

BPA Project No. 1991-073-00, Idaho Natural Production Monitoring and Evaluation

Project (INPMEP), is a project that monitors trends in abundance, productivity, spatial structure, and diversity at the independent population, and MPG scales for spring/summer Chinook salmon and steelhead trout in the Salmon, Clearwater, and minor middle Snake tributaries in the Idaho portion of Hells Canyon. The project also assesses abundance, productivity, and diversity for the Snake River spring/summer Chinook ESU based on samples obtained at Lower Granite Dam (LGR). At LGR, INPMEP continues to sample adult Chinook with NMFS (Project 2005-002-00) and will expand efforts in coordination with the Smolt Monitoring Project at LGR (1987-127-00) to obtain juvenile samples. Analysis of genetic samples has been transferred to the Genetic Stock Identification (GSI) Project (2010-026-00). INPMEP will collaborate with the GSI Project to break aggregate abundance estimates and age composition into MPGs, and in some cases, independent populations. Over time, productivity will be assessed. In 2012, the project continues to gather length, sex, and age data from wild Chinook salmon on the spawning grounds across Idaho, and evaluate biases in these data. The run reconstruction analyses conducted in the past will be updated as well. The INPMEP Project is working with NMFS, NPT, and the Shoshone-Bannock Tribe to provide a one stop coordinated effort for reporting abundance data at the independent population level. This effort will provide status and trend monitoring information annually and inform NOAAs ESA status assessments in the future.

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.)*

Eleven projects were continued in 2011 to assess B-run steelhead abundance and productivity. One project, BPA Project No. 2010-038-00 (Lolo Creek Permanent Weir Construction) has been delayed until 2013 because of continued evaluation of the potential environmental impacts of the new weir design. This is a requirement under the National Wild and Scenic Rivers System, which was created by Congress in 1968 (Public Law 90-542; 16 U.S.C. 1271 et seq.) to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations.

Some of the work currently conducted to address this RPA includes collecting and PIT tagging wild steelhead collected at Lower Granite Dam to assess the efficacy of using GSI and PIT tags to estimate the population characteristics of naturally produced steelhead upstream from Lower Granite Dam (BPA Project No. 2005-002-00). As a result of this work, ISEMP's PIT tag analysis results posted in RPA 50.4 provided population return assessments for many B-run steelhead populations. BPA Project No. 2010-026-00 (Chinook and Steelhead Genotyping for Genetic Stock Identification at Lower Granite Dam) supports the PIT tagging work by (1) evaluating single nucleotide polymorphism (SNP) panels for high-throughput genotyping of steelhead in the Snake/Columbia River Basins, (2) developing initial SNP baselines to describe genetic variation and using them as a reference in GSI methods for steelhead in the Snake River Basin, and (3) implementing GSI to estimate the stock composition of steelhead passing Lower Granite Dam. In addition, BPA Project No. 2010-031-00 (Snake River Chinook and Steelhead Parental Based Tagging) is evaluating parentage based tagging (PBT), which has the capability to assess steelhead life history and trait heritability. So far, this project has sampled and inventoried nearly 100 percent of hatchery broodstock for steelhead (~16,000 total individuals) from spawn years 2008, 2009, and 2010. Using the PBT SNPs identified for steelhead, researchers have genotyped nearly 100 percent of the sampled steelhead broodstock from spawn years 2008 and 2009. Results indicate that annual sampling, inventorying, and genotyping of all steelhead broodstock in Idaho is feasible and that the SNP set identified for PBT is sufficient for accurate assignment of offspring to brood year, hatchery stock, and even individual parents. This will help support B-run steelhead pedigree analysis, which supports the 2011 population assessments and also provides a baseline for potential future assessments with genetics data.

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. (Initiate in FY 2008, develop proposed modification in FY 2009, and implement modifications in FY 2010.)*

Fifty BPA projects were implemented that supported fish population status monitoring based on strategies developed through the Anadromous Salmonid Monitoring Strategy (ASMS). Regional fish population monitoring standards and protocol documentation tools were advanced through BPA Project No. 2004-002-00 (Pacific Northwest Aquatic Monitoring Partnership [PNAMP]). This project facilitated further management of the Protocol Library resulting in the creation of the www.monitoringmethods.org web tool to track and support the documentation of protocols and designs and the standardization of methods and associated metrics and indicators, which was used in the RME Artificial Production Categorical Review (ISRP 2010). Additional work will continue to refine standard methods for data collection and analysis for population abundance of juvenile out-migrants and adult spawners. Project 2008-724-00 was closed and the scope of work was transferred to 2011-015-00 for the final year of BPA funding of PIT tag purchases for sockeye monitoring. Note: Additional information from sponsor reports has been provided if reports were completed after completion of the 2010 Annual Progress Report (FCRPS 2011).

For the BPA Status-Trend Project No. 1991-028-00 (PIT-Tagging Wild Chinook) wild spring-summer Chinook parr have been tagged in 10-16 streams in the Snake River Basin in Idaho and Oregon for over two decades. In July and August 2009, for example, 15,347 wild Chinook salmon parr were PIT tagged and released. When the surviving smolts are detected at remote interrogation sites, traps, and dams, the resulting data are used for both trend information on the stocks tagged, hydrosystem reach survival, and upstream survival from Bonneville Dam to Lower Granite. Installation of flat plate detectors in Valley Creek and Big Creek have allowed researchers to estimate within-subbasin survival rates, and have yielded information on temporal patterns in emigration from the subbasins of origin. These instream detectors are operated under the ISEMP Project.

BPA Project No. 1997-030-00 (Chinook Salmon Adult Abundance Monitoring) involved the collection of adult Chinook salmon escapement and productivity information for long-term monitoring of the natural-origin salmon population in the Secesh River since 2004. This is the first project in the Columbia Basin in which dual frequency identification sonar (DIDSON) was evaluated and then used to determine total adult escapement. DIDSON is a newer class of identification sonar that allows near video quality images for identification of objects underwater. Underwater optical cameras were also used for species identification and to validate DIDSON target counts. The 10-year geometric mean natural-origin spawner abundance was 698 salmon. Natural-origin spawning escapement ranged from 103 to 1,326 adults from 1998-2010. Adults-per-redd estimates (total escapement) ranged from 1.7 to 3.7 (66 to 705 redds). Arrival timing of adults ranged from a minimum of June 26 (10% of adults) to maximum of August 16 (90% of adults) from 2004 to 2010.

BPA Project No. 1999-020-00 (Analyze Persistence and Dynamics in Chinook Redds) monitors wild Chinook salmon distribution, abundance, and trends by mapping the annual distribution of Chinook salmon redds across the entire Middle Fork Salmon River Basin, and it assesses spatial and temporal patterns in extinction and colonization dynamics of wild Chinook salmon. For the past 16 years, researchers have annually mapped and geo-referenced the distribution of Chinook salmon redds in about 800 km of stream channel, including both tributaries and the mainstem of the Middle Fork Salmon River. Redds were counted by foot and helicopter surveys during the first week of September from 1995 through 2010. Basin-wide total redd counts over this period averaged 711 redds (range 20 to 2,271). In low escapement years, redds occurred sporadically through much of the used spawning reaches, while in years with larger escapements, spawning has been more widespread. During this time, the population grew at a rate of 5.3 recruits per spawner. Connectivity between spawning areas was the strongest predictor of redd distribution, but connectivity interacted with habitat size. The results demonstrate that the size and connectivity of existing habitat networks should be maintained whenever possible.

Under the Okanogan Basin Monitoring and Evaluation Program (BPA Project No. 2003-022-00), the Colville Tribes continued for their seventh consecutive year to monitor habitat and viable salmonid population (VSP) conditions of Upper Columbia River summer steelhead in the Okanogan River Basin. Highlights included annual summer steelhead adult population estimates using a combination of traps, underwater video counting stations, and redd surveys. Steelhead spawning occurs throughout the mainstem Okanogan River (primarily downstream from Zosel Dam and in the lower Similkameen River) and in tributaries to the Okanogan River. Researchers have found that variation in the distribution of steelhead redds in tributaries is largely driven by (1) discharge and elevation of the Okanogan River, (2) discharge of the tributary streams, (3) timing of runoff that alters the shape of the hydrograph, and (4) stocking location of hatchery smolts. In addition, they have documented that the percentage of wild summer steelhead returning to Omak Creek has increased from an average of less than 10 percent wild steelhead adults to over 80 percent wild returning adults. These results coincide with favorable and stable juvenile rearing conditions during the previous several years and habitat improvement actions implemented by the Tribes. In 2011 and 2012, PIT tag arrays were installed at the downstream extent of most tributaries throughout the Okanogan River Basin. Returning adults will be implanted with PIT tags at mid-Columbia public utilities district facilities. Once the Okanogan Basin-wide PIT tag arrays are in place, interrogation of PIT tagged adult steelhead will allow further examination of age, sex, and origin within each sub-watershed. PIT tag interrogations will also help to validate redd survey observations.

Under BPA Project No. 1998-007-02 (Grande Ronde Supplementation Operations and Maintenance (O&M) and Monitoring and Evaluation (M&E) on Lostine River) a new hydraulic weir was installed in 2010 that will enable steelhead escapement monitoring into the Lostine River and provide representative broodstock collections and escapement monitoring of spring Chinook salmon. In 2010, a total of 558 adult Chinook, including jacks, were captured during the season. The composition of the run included 107 natural origin fish, 448 hatchery supplementation fish, and two adults that were of unknown origin. No “stray” hatchery fish from other hatchery programs were trapped in 2010. Of the fish captured, 43 natural and 98 hatchery supplementation adults were retained for broodstock, 141 adult Chinook were passed above the weir to spawn naturally, and 272 hatchery adult Chinook were transported back down the Wallowa River to increase sport and tribal fishery opportunities.

BPA Project No. 2002-053-00 (Asotin Creek Salmon Population Assessment) monitors the abundance, productivity, survival rates, and temporal and spatial distribution of summer steelhead in Asotin Creek. Adult steelhead entering Asotin and George Creeks to spawn were enumerated using a floating, resistance board weir. In 2011 (the seventh season of adult trapping in Asotin Creek), 959 unique wild adult steelhead were captured, resulting in a population estimate of 1,128 adults. Juvenile steelhead emigrants in Asotin Creek were estimated using a rotary screw (smolt) trap. The spring 2011 emigrant steelhead population was estimated to be 34,997 (95% CI = 32,127–38,564) and an additional 5,869 (95% CI= 4,208-7,192) juvenile steelhead were estimated to outmigrate during the fall 2011 trapping period. This project has generated seven years of adult steelhead data (2005–2011) and eight years of juvenile steelhead data (2004–2011). These data continue to describe a persistent wild steelhead population that is variably affected by adult hatchery strays, but remains substantial (relative to the size of its subbasin) when compared to other steelhead populations in the Columbia Basin.

BPA Project No. 2010-035-00 (Abundance, Productivity, and Life History of Fifteenmile Creek Steelhead) evaluated the population and life history characteristics of Fifteenmile Creek steelhead. Researchers deployed a rotary screw trap to capture, tag, and enumerate outmigrating juvenile steelhead, and also a weir to capture and enumerate returning adult steelhead. In addition, spawning ground surveys were conducted in accordance with methods established since 2003. Researchers found that steelhead from the Fifteenmile Creek watershed exhibit life-history characteristics most similar to summer run-type steelhead, whereby fish return to freshwater as adults in July and August and spawn in the following spring. This was determined by observing PIT tag detections at Bonneville Dam of returning adults that were tagged as smolts in Fifteenmile Creek since 2006. Adults entered Fifteenmile Creek in February or March as flows allowed. Spawner abundance was estimated between 240 (mark recapture) and 985 (redd count expansion) individuals for 2011, and smolt abundance was estimated to be about 25,800 for 2011.

Results from BPA Project No. 1997-015-01 (Imnaha River Smolt Monitoring Study), which evaluated the survival, biological characteristics, and migration performance of natural and hatchery spring/summer Chinook and steelhead from the Imnaha subbasin showed:

- Survival of PIT tagged natural Chinook salmon from the Imnaha trap to Lower Granite ranged from 53 to 88 percent, and natural steelhead from 79 to 92 percent for migration years 1994 through 2008.
- Survival from the trap to McNary Dam ranged from 53 to 79 percent and 18 to 72 percent respectively.
- The median date of arrival of natural Chinook smolts at Lower Granite was from May 5 through May 13 (May 18 for natural steelhead) in 2008.

BPA Project No. 2003-017-00 (ISEMP) directly supports identifying fish status and trend. With the recent advances in instream PIT array construction and analytical techniques, ISEMP is estimating "fish-in" numbers with known statistical properties (i.e., associated estimates of uncertainty). In addition, by using the existing trapping facilities at Lower Granite Dam, ISEMP tags a known representative fraction of adult spring/summer Chinook salmon and steelhead and collects biological information (age, sex, genetics, etc.) on all fish sampled. Subsequent detection of these adults as they pass instream PIT tag arrays enables an estimate of total escapement above that point with accompanying estimates of uncertainty for the purpose of decomposing the run-at-large into population and/or tributary specific escapement estimates. Escapement estimates generated this way are reported in Tables 18 and 19. These escapement results continue to validate the proof of concept of the recommended approach of monitoring the populations.

Table 18. Escapement Estimates and 95-Percent Confidence Intervals for Steelhead Generated by ISEMP Adult Tagging and PIT Tag Array Interrogation

Independent estimates are generated by weirs and provided to validate escapement estimates generated by PIT tag arrays. (Table copied from ISEMP 2011, pg. 12.)

Tributary	2009–2010			2010–2011		
	Estimate	95% CI	Independent Estimate	Estimate	95% CI	Independent Estimate
Potlatch River	784	621–992		739	443–1,541	
Fish Creek (Lochsa River weir)	246	129–434	205			
Asotin Creek	1,687	1,407–1963	1,500	973	778–1,224	1,128
Rapid River (weir)	136	72–235	150			
South Fork Salmon River	1,795	1,527–2,081		2,980	2,654–3,361	
Secesh River	298	169–558		433	250–738	
Big Creek	753	431–1914		745	562–960	
Lemhi River	630	455–928		503	346–736	
Valley Creek	237	155–411		270	190–382	
Upper Salmon (Sawtooth weir)	138	76–226		79	36–147	98
Lapwai Creek				455	262–1340	
Joseph Creek (Grande Ronde River)				1,663	1,420–1,921	
Cow Creek (Imnaha River)				161	94–250	
Imnaha River				3,516	3,167–3,897	

Table 19. Escapement Estimates and 95-Percent Confidence Intervals for Spring/Summer Chinook Salmon Generated by ISEMP Adult Tagging and Pit Tag Array Interrogation

Independent estimates are generated by weirs and provided to validate escapement estimates generated by PIT tag arrays. (Table copied from ISEMP 2011, page 12.)

Tributary	2009–2010			2010–2011		
	Estimate	95% CI	Independent Estimate	Estimate	95% CI	Independent Estimate
South Fork Salmon River	7,005	6,655–7,355		4,749	4,326–5,201	
Secesh River	1,308	1,165–1,451		779	745–791	
Big Creek	285	150–411		449	290–689	
Lemhi River	262	243–281		337	230–470	
Valley Creek	235	191–281		460	380–560	
EF South Fork Salmon River	1,026	2,731–4,169	1,032			
Imnaha River				2,421	2,124–2,716	

ISEMP also generates “fish out” estimates and developed a protocol that allows the estimation of juvenile abundance, growth, and survival in the habitats most often targeted for restoration actions. Within the Salmon subbasin, juvenile abundance estimates were initiated in 2009 and were confined to the South Fork Salmon River subbasins (Figures 13 and 14), which are targeted for status and trend evaluation.

Adaptive Management of the FCRPS BiOp 2010–13 Implementation Plan (FCRPS 2010a) was required for the Lower Mainstem Grande Ronde RM&E recommendation for RPA 50.6. The ISEMP Project sponsors determined the proposed action to install a PIT tag interrogation system in the Lower Grande Ronde Mainstem to assess the population within preferred PIT tag detection efficiency standards was not feasible.

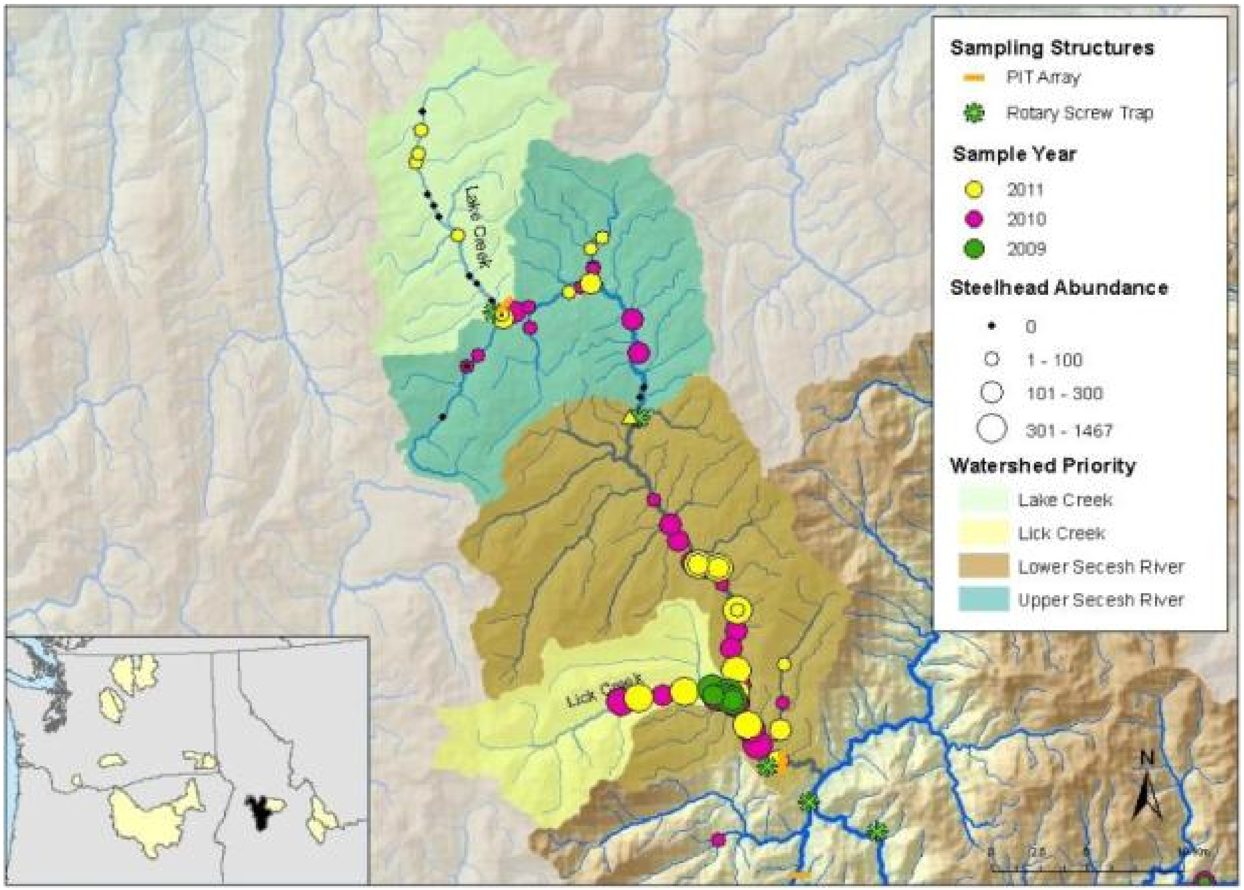


Figure 13. Location of juvenile sampling infrastructure and distribution and abundance of juvenile steelhead obtained via remote juvenile surveys in the Secesh River. (Figure copied from ISEMP 2011, page 13.)

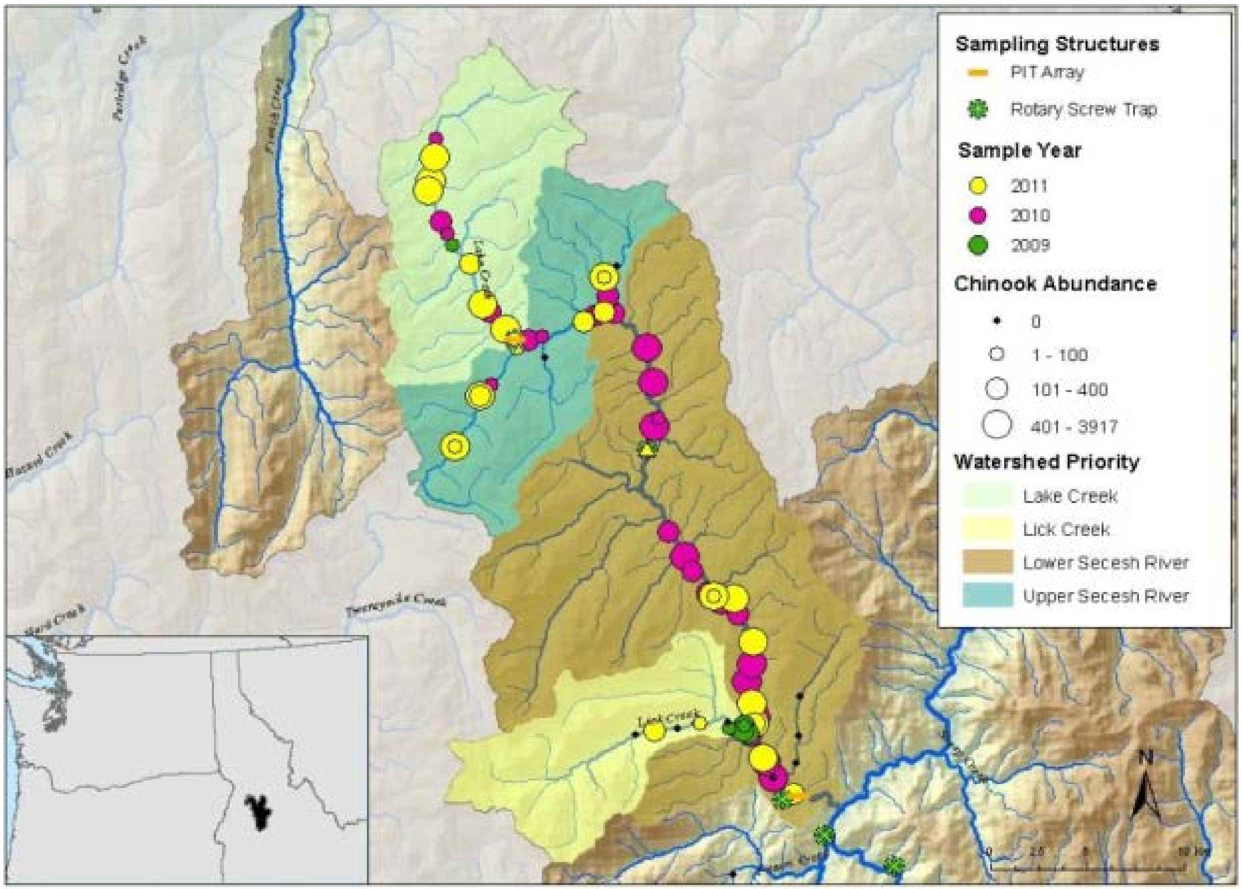


Figure 14. Location of juvenile sampling infrastructure and distribution and abundance of juvenile spring/summer Chinook salmon obtained via remote juvenile surveys in the Secesh River. (Figure copied from ISEMP 2011, page 13.)

An alternative approach was proposed and accepted by the Action Agencies/ NOAA RPA recommendation work group as well as the State and tribal implementing organizations. Specifically additional arrays are planned to be installed and integrated into a network of additional arrays in 2012 in the Upper Grande Ronde and Wallowa Rivers to provide estimates of population escapement to the MPG based on tagging at Lower Granite Dam.

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).*

Eighteen BPA projects were continued to support the workgroup recommendation that 100 percent of all hatchery fish should be marked to meet VSP, hatchery, and habitat action effectiveness evaluation needs identified under several RPAs and regional recovery plans.

In addition, BPA implemented a policy to support the Implementation Plan action "Where 100 percent of the hatchery fish cannot be marked with an adipose fin clip, alternative external or internal marks and marking rates will be used to assess VSP and habitat and hatchery effectiveness called for under the BiOp and Columbia Basin Recovery Plans."

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 to NMFS to facilitate population viability assessments. In 2011, the BPA participated and supported the Coordinated Assessments Project working with fishery management co-managers and NMFS to develop data exchange templates to facilitate assessments for VSP indicators such as adult spawner abundance, spawner to adult ratios, and recruit per spawner relationships for ESA listed populations. BPA has also developed guidelines and templates for RM&E reporting to facilitate more consistent and timely reporting of monitoring results. BPA has also 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)*

   Three projects were continued to fully support the annual synthesis of fish population metrics through Regional Data Repositories. These were BPA Projects 1988-108-04 (StreamNet — Coordinated Information System [CIS]/ Northwest Environmental Database [NED]), 1989-062-01 (Annual Work Plan for Columbia Basin Fish and Wildlife Authority [CBFWA]), and 2004-002-00 (PNAMP) . Under these projects, States and Tribes participating in the Coordinated Assessment task continued to develop data exchange templates for critical VSP information for the NOAA Salmon Population Summary database. BPA developed reporting requirements for sponsors to provide timely annual technical reports, meeting basic technical structure guidelines.

   Eleven RPA associations were discontinued because it was determined that electronic data transfers established through coordinated assessments would be used, in lieu of annual project reports, to provide population metrics to the SPS data repository for NOAA analysis.

   BPA Project 2008-505-00 (StreamNet Library) has been closed, and the information it had provided is now delivered through the Tribal Data Network Project (2008-507-00).

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 continued to support ongoing collaboration to develop a regional strategy for fish population status and trend monitoring in 2011 through the ISRP review and revisions of the ASMS. As part of the data management component of this strategy, BPA participated and supported the ongoing Coordinated Assessment Forum and data sharing strategy. In addition, BPA supported the ongoing PNAMP coordination process through funding of BPA Project No. 2004-002-00 (PNAMP Coordination) and provided staff support to the PNAMP steering committee and the fish population workgroup.

3. *Provide cost-shared funding support and staff participation in regional coordination forums such as the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) 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 continued to provide funding and staff support to PNAMP (BPA Project No. 2004-002-00). This project supports coordination of PNAMP efforts to integrate resource monitoring programs of State, Federal, tribal, local, and private organizations in the Pacific Northwest. This project also facilitates the transfer of information within PNAMP and across relevant organizations to establish and maintain strong relationships between scientists and management, and to promote and facilitate communication between organizations and disciplines. In 2011, BPA ended its support for facilitation of the NED Network forum to advance coordinated data management strategies, and this support and associated work were transferred to PNAMP.

RME Strategy 2 (RPA Actions 52–55)

A comprehensive list of all actions implemented by the Action Agencies for RPAs 52 through 55 is included in Section 3.

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.*

   At Bonneville Dam, the 700 ft long behavioral guidance structure was removed from the B2 forebay prior to the 2011 juvenile salmon migration; turbine intake extensions at B2 were not installed; and Turbine Unit 11 at the B2 was out of service all year. During high flows in late spring, peak spill at Bonneville reached 60 percent of total river flow.

   Studies to evaluate compliance with the Juvenile Salmon Dam Passage Performance Standards were conducted at John Day, The Dalles, and Bonneville Dams in 2011. These studies made use of the experimental design and virtual/paired release survival model developed and independently reviewed in 2009. At all three dams the summer portion of the study was postponed until 2012 due to high flows. At John Day, a first year of compliance testing was conducted at both 30 percent and 40 percent spill for yearling Chinook salmon and juvenile steelhead. A second year of testing was completed at The Dalles Dam operating under a target spill level of 40 percent. At Bonneville Dam, a first year of testing at a 24-hour spill rate of 100 kcfs was conducted. Beginning in mid-May, high flows precluded operation to target spill levels at both John Day and Bonneville. Spill at The Dalles Dam also increased above the 40-percent target spill level after mid-May however the average during the entire spring study period was 42 percent. Survival rates from compliance tests at Bonneville, The Dalles and John Day for yearling Chinook and steelhead are reported under RPAs 18-20 in Tables 4-6.

   No dam survival or passage efficiency telemetry studies were performed in 2011 at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, or McNary 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.*

Eight projects were continued that addressed this RPA subaction. Smolts tagged in 2011 were used to estimate survival through the FCRPS (Lower Granite through Bonneville Dams), continuing a juvenile system-survival monitoring program started in 1994. NMFS conducts the analysis under BPA Project No. 1993-029-00 (Survival Estimate for Passage through Snake and Columbia River Dams and Reservoirs) using fish that were PIT-tagged under BPA Project No. 1987-127-00 (Smolt Monitoring Program). The percentage of fish transported from Snake River dams in 2011 was the second lowest fraction since estimates started in 1995 – 37 percent of steelhead, and 39 percent of yearling Chinook juveniles. The Comparative Survival Study (No.1996-020-00) concluded that as in-river survival has increased in recent years, transport to in-river survival ratios have declined for both Chinook and steelhead. Both NOAA and the Comparative Survival Study report a benefit to steelhead from transportation under most conditions even though the benefit may be reduced from some previous years. The benefit to Chinook salmon from transportation appears to be more variable in both the magnitude and duration.

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

Three projects were continued to fulfill this subaction. For example, BPA Project No. 1990-080-00 (PTAGIS) provides data on returning adults of known origin. In addition, NMFS biologists analyzed and reported on upstream passage survival for 2011. BPA Project No. 2008-908-00 (FCRPS Passage of Adult Salmon) analyzes rates of adult survival, fish ladder fallback, harvest, migration speed and straying rates among populations from different regions of the Snake and Upper Columbia River.

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 system survival performance is evaluated for five stocks using a 5-year rolling average of annual system survival estimates. Snake River Chinook and sockeye are used as surrogates for Snake River sockeye and mid-Columbia steelhead. In 2011, the 5-year rolling averages (2007-11) for Snake River fall Chinook and upper Columbia River steelhead surpassed the performance standard, while the 5-year rolling averages for the Snake River spring/summer Chinook salmon ESU, the Snake River steelhead DPS, and the upper Columbia River spring Chinook ESU were below adult performance standards (Figure 15).

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.

Two projects were continued to fully address this effort in 2010: BPA Project Nos. 2008-724-00 (PIT-tag SR Sockeye-UC Sp Chinook) and 1987-127-00 (Smolt Monitoring by Non-Federal Entities). These populations would be incorporated into the annual system smolt and adult survival monitoring. Efforts being undertaken by public utility districts may supplement the Federal effort.

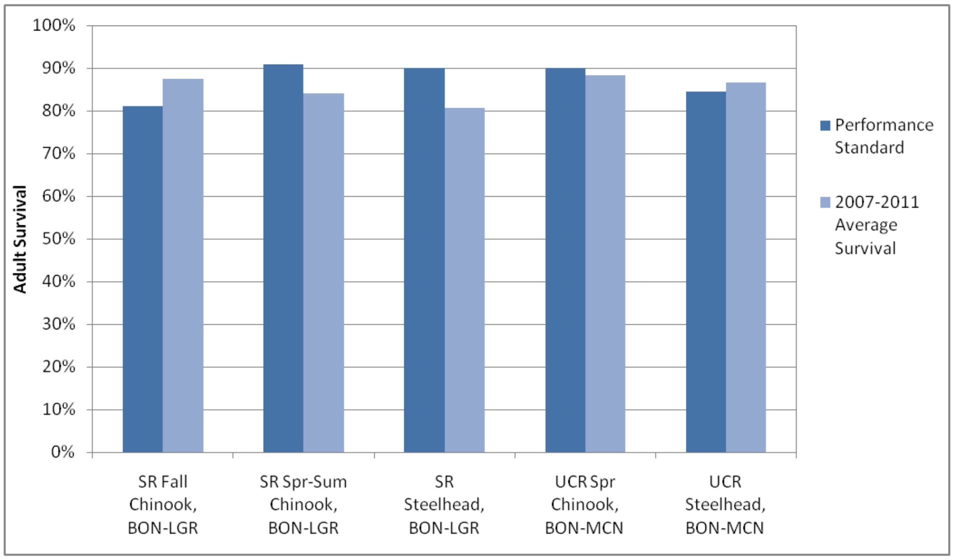


Figure 15. 2008 FCRPS BiOp adult survival standard and five-year rolling average survival of adults that migrated in-river as juveniles, based on pit-tag conversion rates of Snake River (SR) and Upper Columbia River (UCR) ESUs. (BON = Bonneville, MCN = McNary, LGR = Lower Granite.)

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.*

   Two projects were continued to fully address this effort in 2010: BPA Project Nos. 2008-724-00 (PIT-tag SR Sockeye-UC Sp Chinook) and 1987-127-00 (Smolt Monitoring by Non-Federal Entities). These populations would be incorporated into the annual system smolt and adult survival monitoring. Efforts being undertaken by public utility districts may supplement the Federal effort.

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.*

   Three projects were continued to address this subaction. Under the scope of BPA Project 2010-076-00, supplemental tags were added to the Corps' research funded under the AFEP in which juvenile sockeye salmon from Idaho were PIT tagged and used for an evaluation of barging effects on sockeye salmon. A total of 62,270 sockeye were PIT tagged and released in 2011; 51,672 from Sawtooth hatchery, 623 from Burley Creek hatchery and 9,975 from Oxbow hatchery. Survival probability from their release points to Lower Granite Dam among three hatchery groups (0.73-0.78) was higher in 2011 than in the previous 16 years of monitoring, suggesting that high flows with cooler temperatures during late spring were beneficial for survival in this subregion.

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.)*

A draft of a regional PIT Tag Monitoring Plan was developed, including input from the Action Agencies, NMFS, other Federal agencies, State, and tribal agencies. This goal of the plan was to meet the needs of the 2008 FCRPS Biological Opinion, regional Habitat Conservation Plans, and the Fish Accords agreement by improving coordination among user groups and minimizing the effects of tagging on salmon populations. Following working group sessions in the region in the summer and fall of 2011, comments on the drafted plan were received from advisory agencies in preparation of a revised PIT plan document in 2012.

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 UCR steelhead and spring Chinook salmon compared to SR 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.*

The Colville Confederated Tribe completed a draft Phase 1 analysis containing nine alternative hypotheses of potential explanations for the observed differential conversion rates between Upper Columbia and Snake River salmon. This document is under regional review.

8. *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, 2011.
- At Lower Granite, 24-hour counts were conducted from June 15 through September 30, 2011, rather than through August 31, 2011.

All changes were fully coordinated during development of the FPP and through the FPOM workgroup process. Results are available in the 2011 Annual Fish Passage Report (ACOE 2011d).

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.*

Five BPA projects addressed this subaction in 2011. For example, BPA Project No. 1994-030-00 (FPC) calculated passage indices at all collector dams, as well as population estimates at Lower Granite Dam. The smolt index, daily collection counts, and transported fractions were archived on a public, online database.

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

   Ten BPA projects were continued in 2011 to fully address this subaction. Data provided by this program were analyzed by FPC under BPA Project No. 1994-033-00 and by NMFS and a host of other regional fish management agencies. Three projects used methods of GSI to identify the population of origin or parentage of Chinook and steelhead smolts entering the Snake River. For example, BPA Project 2010-026-00 (Chinook and steelhead genotyping at LGR) used panels of SNPs to develop multiyear baseline frequency distributions for different regional populations. They were able to estimate tributaries of origin for adult steelhead and Chinook returning to Lower Granite in 2011, and used Coded Wire Tag identities to estimate the rate of correct assignment with GSI.

   Under BPA Project 1991-028-00 (Pit tagging wild Chinook), 15,347 parr were PIT tagged in 16 Idaho streams. Parr-to-smolt survival at Lower Granite Dam for summer-tagged fish ranged from 5.0 percent at Valley Creek to 25.5 percent at Big Creek, and survival rates by length, and detection timing were recorded at the base of each stream, and at LGR.

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

   Four BPA projects were continued to fully address this subaction. As in RPA Action 53.2, the Smolt Monitoring Program monitored and documented fish condition in 2011. The reduction in handling was the only potential problem identified that may be addressed in future operations.

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

   In 2011, the Corps again implemented its adult fish count program as detailed in the FPP. Results are available in the 2011 Annual Fish Passage Report: Columbia and Snake Rivers (ACOE 2011d).

   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 NMFS 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 28 above.

   Under BPA Project #1993-029-00 (Adult survival through the FCRPS), several hypotheses were examined to explain why Upper Columbia River stocks of spring Chinook and steelhead have lower survival rates than Snake River stocks, after detection at Bonneville ladder. No single hypothesis could conclusively explain the pattern and it was not possible get accurate harvest data for adults by population of origin. The study detected contrasts in survival rates of adults by age and size class: fish returning after only 1 year at sea showed significantly higher survival than older adults from Bonneville to McNary Dam. Straying rates of steelhead (7.0% UCR, 6.8% SR) were higher than those of Chinook (below 2.5% for all ESUs), but rates were similar by basin. Snake River steelhead also required an average of 10 days more than Upper Columbia populations for migration between Bonneville and McNary.

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.*

The Bonneville Corner Collector was opened for steelhead Kelt passage on March 14, 2011 (normal spill operations began on April 10, 2011). This provided 23 additional days of downstream passage for steelhead kelts.

A study to compare the direct injury and survival of adult steelhead passing through Bonneville Dam's First Powerhouse ice and trash sluiceway and the Second Powerhouse corner collector was conducted in 2011 to determine if the sluiceway would be a safe downstream passage alternative. Direct survival was 100 percent and 99 percent for adult steelhead released into the sluiceway and the corner collector, respectively (Normandeau Assoc. 2011). The injury rate for study fish did not exceed 1 percent for either passage route. Additional evaluations that look at longer term migration success related to passage route are planned for 2012.

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.*

Spillways at John Day, The Dalles, and Bonneville Dams were evaluated in 2011 as part of the Juvenile Salmon Dam Passage Performance Standard compliance studies. Spillway survival estimates, derived using the Virtual-Paired Release model, for yearling Chinook salmon and steelhead are provided below with standard errors (Ploskey et al. 2012).

Table 20. Spillway passage percentage and survival estimates (with standard errors) for yearling Chinook salmon and steelhead.

Location	Yearling Chinook		Steelhead	
	Passage	Survival	Passage	Survival
John Day	39.9%	97 .4% (0.8%)	30.5%	99.0% (0.7%)
The Dalles	65.8%	96.1% (0.8%)	75.4%	100.0% (0.8%)
Bonneville	56.6%	95.7% (2.1%)	54.4%	95.7% (2.1%)

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

A final report summarizing spillway and bypass survival metrics for yearling and sub-yearling Chinook and steelhead from 2006–09 at McNary Dam was submitted to the Corps in December 2011.

Juvenile bypass systems at John Day and Bonneville Dams were evaluated in 2011 as part of the Juvenile Salmon Dam Passage Performance Standard compliance studies. Juvenile bypass system survival estimates, derived using the Virtual-Paired Release model, for yearling Chinook salmon and steelhead are provided below with standard errors (Ploskey 2012).

Table 21. Juvenile bypass system passage percentage and survival estimates with standard errors for yearling Chinook salmon and steelhead.

Location	Yearling Chinook		Steelhead	
	Passage	Survival	Passage	Survival
John Day	24.8%	99.3% (0.8%)	33.2%	100.3% (0.6%)
Bonneville Powerhouse 2	4.5%	98.2% (2.4%)	1.8%	94.0% (3.3%)

A project to relocate the juvenile bypass outfall and to improve the smolt monitoring raceway and release structures at both Lower Monumental and McNary Dams was begun in 2011 and completed in early 2012. The relocated outfall will release fish in an area with higher river velocities and consistent downstream flow during all operations. This is expected to decrease predation on the bypassed fish. During the spring and summer of 2012, in concert with performance standard testing, a post-construction review will evaluate the new outfalls at Lower Monumental and McNary Dams, changes made to the smolt monitoring facility to improve juvenile salmonid passage, and the improved survival of fish passing through the bypass system.

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

Surface passage structures at John Day, The Dalles, and Bonneville Dams were evaluated in 2011 as part of the Juvenile Salmon Dam Passage Performance Standard compliance studies. Surface passage route survival estimates, derived using the Virtual-Paired Release model, for yearling Chinook salmon and steelhead are provided below with standard errors (Ploskey et al. 2012).

Table 22. Surface passage route percentage and survival estimates with standard errors for yearling Chinook salmon and steelhead.

Location	Yearling Chinook		Steelhead	
	Passage	Survival	Passage	Survival
John Day – Surface Weir	23.8%	95.8% (1.1%)	32.3%	98.9% (0.7%)
The Dalles – Ice & Trash Sluiceway	17.3%	99.1% (7.8%)	13.8%	101.0% (0.9%)
Bonneville – Powerhouse 2 Corner Collector	3.0%	99.4% (2.1%)	9.6%	99.4% (3.3%)
Bonneville – Powerhouse 1 Ice & Trash Sluiceway	6.6%	96.9% (2.4%)	8.2%	95.4% (2.8%)

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

Turbine operations at John Day, The Dalles, and Bonneville Dams were evaluated in 2011 as part of the Juvenile Salmon Dam Passage Performance Standard compliance studies. Surface passage route survival estimates, derived using the Virtual-Paired Release model, for yearling Chinook salmon and steelhead are provided below with standard errors (Ploskey et al. 2012).

Table 23. Turbine passage route percentage and survival estimates (with standard errors) for yearling Chinook salmon and steelhead.

Location	Yearling Chinook		Steelhead	
	Passage	Survival	Passage	Survival

John Day	11.5%	91.0% (1.9%)	4.0%	79.7% (4.2%)
The Dalles	16.9%	93.0% (1.2%)	10.9%	91.9% (1.7%)
Bonneville – Powerhouse 2	8.2%	94.7% (2.3%)	2.9%	91.9% (3.3%)
Bonneville – Powerhouse 1	21.1%	96.8% (2.1%)	23.1%	93.6% (2.6%)

The Turbine Survival Program has continued to develop a biological index test through computational fluid dynamics modeling and physical modeling at the ERDC.

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

Three Corps AFEP projects (at John Day, The Dalles, and Bonneville Dams) conducted passage and survival studies which estimated forebay residence times and survival rates in the forebay. 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. 2012a, 2012b, 2012c) for yearling Chinook salmon and steelhead are provided below.

Table 24. Season-wide estimates of dam passage survival for yearling Chinook and steelhead.

Species	John Day		The Dalles		Bonneville	
	Survival	Residence Time	Survival	Residence Time	Survival	Residence Time
Yearling Chinook	96.8%	1.4 h	96.0%	0.97 h	96.0%	0.55 h
Steelhead	98.7%	2.9 h	99.5%	0.81 h	96.5%	0.85 h

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

In 2011, the Action Agencies continued to make progress on monitoring and evaluating the effectiveness of the juvenile fish transportation program; this effort included six BPA projects. Information resulting from the 2011 RME will enable further progress in identifying the benefits of transportation and supporting adaptive management actions. Significant 2011 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 2011. More precise temporal transportation data should help clarify effects of transportation and relationships to environmental variables. Initial analyses in 2011 suggested that water temperature was a consistent variable in explaining seasonal variation of SARs. Other environmental variables examined were significant in some years, but not others suggesting they would not be useful in a real time model for determining when it is best to transport fish. Overall, T:M ratios (ratio of SARs of transported to in-river migrating fish) reported by NOAA 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. Transport is beneficial to hatchery Chinook salmon and hatchery and wild steelhead starting April 15 in most years. 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 becomes even more beneficial later in the season.

Summer Migrants: In 2011, 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 2011, intensive RME efforts were directed toward Snake River fall Chinook. These efforts provide information to evaluate early life history and migration behavior, the performance of hatchery fish as surrogates for wild fish, the benefits of late season transportation and the performance of production fish groups compared to wild and surrogate fish. Over the last several years surrogate fish have consistently performed more similarly to wild fish than to hatchery fish. Preliminary results suggest that transport does not provide a clear benefit for Snake River summer migrants (T:B ratio 0.66, $p = 0.094$), but does benefit Clearwater River surrogates (T:B ratio 1.62, $p = 0.016$). Similar to spring migrants, the differences in transport effects may be related to seasonal migration timing. Clearwater surrogates tend to migrate later in the year than Snake River surrogates.

Researchers continue to refine and evaluate methods for analyzing fall Chinook data and are on track to produce methods for analysis report in June 2012 for review by ISAB.

Sockeye transport: In an effort to better estimate in-river survivals and SARs, a pilot study was continued in 2011 to examine the relative survival of sockeye subject to transport, bypass, and spill. For this study, sockeye salmon smolts were PIT tagged at Sawtooth Hatchery in Idaho (n=51,936) and Oxbow Hatchery in Oregon (n=9,986). PIT tagged sockeye salmon were released into Redfish Lake Creek and into the upper Salmon River. Approximately 70 percent of the PIT-tag smolts were to be diverted for transportation via barges, and 30 percent returned to the river; with the goal of achieving a 1:1 ratio of transported to in-river migration. 2012 will be the final year of tagging for this pilot study. A final report will be available upon completion of all adult returns in fall 2014. See RPA 52.5 for additional results related to sockeye transport.

Steelhead Straying: The Corps initiated a study in 2011 to develop a white paper on steelhead stray rates and to develop a model to estimate total numbers of strays in the Columbia Basin based on collection proportions, hatchery releases, transport proportions, and variable stray rates. The study's purpose is to inform managers on effects of reducing stray rates for certain groups of fish (e.g., barged fish or hatchery reared fish). A study to evaluate straying by identifying imprinting associated markers in steelhead continued in 2011. This study is an initial step in addressing observations of elevated straying rates in transported steelhead. 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.

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

See RPAs 66 through 70 for detailed information on activities addressing this subaction.

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

   See RPAs 48, and 66 through 70 for detailed information on activities addressing this subaction.

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

   New passage technologies have been and will continue to be prototyped, tested, and ultimately deployed as part of the AFEP and the Columbia River Fish Mitigation Project.

   A Juvenile Salmon Acoustic Telemetry System transmitter downsize project was initiated in 2011 to allow new applications of study objectives and size ranges of fish that could be tagged, with decreased adverse tag effects. A new design will be completed in early 2013.

   Advanced video image processing by a Corps contractor, enabled the Corps and Fish Managers to monitor lamprey passage (and possible salmon passage) at the raised picketed lead section of the counting stations of McNary and Ice Harbor Dams to provide an alternative route of passage for migrating adult Pacific Lamprey in 2011. Advances in the video processing capabilities now allow video footage to be processed up to 50 times faster than it could be processed by human annotators. The addition of PIT tag detectors to the adult passage system at Lower Monumental Dam was considered, but did not receive sufficient Regional support. Previous concerns for high adult fallback rates at Lower Monumental were likely related to the occasional passage delay seen at Little Goose Dam. (The latter is discussed under RPA 29, above.)

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

    The spill pattern at Little Goose Dam was evaluated at the Corps' physical hydraulic model at the ERDC 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 surface-weir-powered eddy that may have been a cause of adult passage delay. This change was implemented in the FPP for 2011.

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

    See RPA 52.3 for 2011 adult system survival results.

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

    In 2011, picketed leads near the count stations at Bonneville Dam were raised approximately 1 to 1½ inches to allow lamprey easier access to alternative passage systems in the AWS channels. Sockeye salmon began to be observed in these dead end channels, primarily at Bradford Island exit, requiring salvage of these fish and lowering of the leads. It was discovered that due to the irregularity of the ladder floor there were openings large enough to allow sockeye to slip under the leads. The Corps is working through the Fish Facility Design Review Workgroup (FFDRWG) to determine to what height the leads can be lifted that will assist lamprey passage but not allow sockeye into the AWS.

Video cameras were used to monitor the raised picketed lead sections at the counting stations of McNary and Ice Harbor Dams for the purpose of providing an additional lamprey passage alternative to the count window slot. There were no salmon passage events or attempted passage noted at the monitored locations in 2011; however lamprey did utilize passage under the raised picketed leads.

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–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 provided large enough benefits (0.9% of a 6% target for Snake River steelhead) to justify operating this route early and to keep this surface route open later, March 1 to 15 December (Tackley and Clugston 2011)

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).*

In the winter of 2010–11, the Corps funded a study to enumerate and determine the vertical and horizontal distribution of adult steelhead as they passed through the powerhouse at McNary Dam. Downstream passage of adults through turbines is of greatest concern during winter months when other passage routes are typically unavailable and fish guidance screens are not in place to limit turbine passage. Study results have implications for winter operations as well as the operation or location of surface bypass improvements that may be implemented if warranted at the McNary project.

Adult passage was monitored at 8 of 14 operating turbine intake A-slots from December 17, 2010 through April 13, 2011. Two of the units that were not monitored were out of service for the duration of the study. Fixed-aspect hydroacoustics were used to estimate the number of fish entering each turbine intake unit. The hydroacoustic transducers detected 68 targets with characteristics consistent with steelhead. The 68 targets were expanded to account for spatial and temporal sample coverage. During the entire sample period, the researchers estimated that 946 steelhead passed through the powerhouse with 95-percent confidence bounds extending from 750 to 1,142 individuals. If a similar rate of passage is assumed through unmonitored intakes the estimate of total power house passage would be 50 percent higher at 1419 individual steelhead. The horizontal distribution was skewed toward the outer turbine units (i.e., units 3, 4, 11, and 13). The distribution could look different if all units were operating. What would not change is the relatively low passage numbers near the center of the powerhouse where sample coverage was complete. (Ham et al., 2012)

A DIDSON device was used to monitor the region just upstream of the trash rack at units 5C and 6A in order to verify the presence of adult steelhead and other similar-sized individuals of other species. The researchers used DIDSON cameras to sample during the first 15 minutes of every hour from December 17 through January 20. From January 20 through April 15 the cameras sampled for 20 minutes at the top of every hour. The bulk of steelhead observed with the DIDSON camera were moving and behaving in ways that were not suggestive of turbine passage. The steelhead were observed milling around and slowly swimming just upstream of the intake and trash rack with much less movement across the powerhouse than shad. It was not possible to determine with certainty whether a particular steelhead or other fish passed downstream of the trash racks because a fish could exit the volume sampled by the DIDSON in more than one direction. During much of the latter portion of the study, atypically-high river flows resulted in forced spill, which created an unexpected and unmonitored passage route through the dam. As a result, turbine passage estimates in the present study are likely less than would occur in a typical year without spill.

This research will be continued in the winter of 2011–12 to gather baseline turbine passage estimates for overwintering steelhead. Study results will be presented to the Studies Review Workgroup (SRWG) and the FFDRWG to determine the magnitude of fallback at McNary in the winter months and to potentially develop alternative routes to safely pass overwintering steelhead downstream.

See RPA Actions 53.5 and 54.13 above for additional information.

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.)*

   Multiple projects (including nine BPA projects) were continued to fully address this subaction. 2011 was the 8th year of NOAA's latent mortality study which compares survival rates between a set of tagged yearling Chinook released at Lower Granite Dam, another set trucked and released below Ice Harbor, and a control group trucked and released at Lower Granite. The second cohort of returning adults was available for analysis of smolt-to-adult ratios. In contrast with the cohort released in 2006, for which in-river migration resulted in only slightly diminished SAR rates (mean SAR= 0.65 in-river, 0.71 Ice Harbor trucked), the 2007 cohort of in-river migrants did experience depressed SARs (mean SAR= 0.34% in-river, 0.70 Ice Harbor trucked). The variability of SAR rates and relationship with environmental conditions may become clearer as additional years of adult returns are available. BPA Project No. 1989-108-00 (Salmon passage modeling and support) evaluated the differential post-hydrosystem survival of spring-run Chinook (1997-2006) experiencing different passage routes, estuary and ocean arrival time, river conditions and smolt condition. This analysis will be incorporated into the COMPASS model in the future. In a separate analysis, a size threshold effect observed in smolt survival rates was interpreted to reflect a functional relationship between juvenile size and predation susceptibility. This effect could hypothetically generate differential mortality rates of hatchery and wild release groups.

   In addition, the Corps commissioned a synopsis and literature review of differential delayed mortality (*D*), which also identified critical uncertainties. Then the Corps sponsored the Snake River Basin Differential Delayed Mortality Workshop in Portland in May 2011, in response to a request from regional fish managers for a summary of all pertinent information relevant to *D*. A draft report was produced and sent to the regional managers for review and comment. Results from the synopsis were presented at the Corps Annual AFEP review in December 2011, and the final report (Anderson et al. 2012) was released in April 2012. Better understanding of the interaction of factors affecting *D* could improve the results of real-time decisions about when, where, and which species of juvenile migrating salmon or steelhead to barge.

(Anderson et al. 2012) provides a database of research studies related to *D* of spring/summer and fall Chinook salmon and steelhead and a review of the research to synthesize the patterns and possible causes of *D*. The report first provides a framework in which specific factors of *D* can be related. These include (1) three main hypotheses (fish size, arrival date, and fish condition) with overarching theories that span all species and runs, (2) a comprehensive model, and (3) a culling model. It is important to note that many factors have opposing effects on *D*, and thus multiple factors need to be considered in the same framework.

The review of literature and discussions at the 2011 Differential Delayed Mortality Workshop identified 12 factors of *D*, which were further assessed. The authors found that *D* appears to vary with time of arrival into the FCRPS and travel time through it. Therefore, they attempted to identify general factors that may contribute to this pattern. The seasonal effect of passage timing on *D* most likely involves temporal changes in fish length, estuary and ocean predation, and ocean conditions. The correspondence of passage timing with fish physiology and disease appears to have secondary effects on *D*. Time-independent (i.e., non-seasonal) factors include dam operations (spill versus transport), barging conditions (e.g., alternative barging strategy), and adult straying during upriver migration. Factors that appear to have little influence on *D* include lower river (Bonneville Dam to river kilometer (rkm) 56) conditions, predation, and certain barging conditions (e.g., noise).

Pre-hydrosystem conditions appeared to be of moderate, but uncertain, importance to *D* because they include factors that indirectly relate to other drivers of *D*. The report hypothesizes that when $D < 1$ in the early season, barged spring/summer Chinook salmon and steelhead at the hydrosystem exit are smaller in length, have lower levels of osmoregulatory ability, slower travel rates, and greater susceptibility to predation in the estuary relative to their in-river (non-barged) counterparts. In mid-season, when $D > 1$, the barged fishes' osmoregulatory ability and length have increased and their travel time in the lower river and estuary has decreased, whereas the energetic reserves of in-river migrants have decreased. These factors are hypothesized to produce higher survival in barged fish than in the in-river fish during the middle of the migration season. When $D < 1$ at the end of the season, it is hypothesized higher surface-water temperatures increase disease and energy loss in barged fish. Thus, barged fish have lower survival rates than in-river migrants at the end of the season.

For fall Chinook salmon, it is hypothesized that the low survival of barged fish relative to in-river migrants throughout the season is caused by high surface-water temperatures, which decrease the general health and energetic reserves of barged fall Chinook salmon and increase disease prevalence. In addition, lower *D* for fall Chinook could involve the length differential between barged and in-river fish. To develop the roadmap of future research, 12 factors of *D* were categorized by the degree of importance to *D* (low, medium, high) and by the extent of data gaps and key uncertainties (limited, extensive). Promising areas for future research fall into three major categories: (1) fish condition, (2) fish behavior and (3) environmental conditions. Key research topics include (1) whether low *D* is associated with small-sized fish within and across species, runs, and rearing types; (2) which physiological conditions and pathogen prevalence are associated with low *D* in the lower river and estuary; (3) whether there is a collection bias of "weaker" fish in the juvenile bypass system and why; (4) what are the effects of the proportion of water spilled and the proportion of fish transported on *D* across a range of flow rates; and (5) which indices of estuary and ocean conditions are associated with *D*.

A multi-year analysis of PIT tagged Snake River hatchery steelhead and yearling Chinook salmon found a correlation between the number of juvenile bypass events and reduced adult return rates (Buchanan et al. 2011). However, the causative mechanism(s) of the reduced adult return rates were not identified. Individuals that were only bypassed at LGR, MCN, JD, or BON (and no other dams) showed no statistically significant reduction in expected adult returns, while individuals bypassed at either Little Goose or Lower Monumental produced fewer than expected adult returns. Juveniles bypassed at multiple dams, including dams that individually showed no effect, usually returned fewer adults than expected. One proposed mechanism for the observed correlation between JBS exposure and lower SARs was that JBS's are selective for weaker fish. This may explain why some JBS's are associated with reduced SARs and others are not. The ISAB has recommended further study of this selectivity mechanism. Several JBSs have been improved since the data in the multi-year study was collected. Many dams now have direct bypass to the river, and several dams have had their JBS outlets relocated. Future research will monitor the effects of these changes.

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

Multiple projects (including six BPA projects) were continued to fully address this subaction through review in the AFEP, with focus on Bonneville-Bonneville SARs (i.e., SARs based on migration from Bonneville to the ocean and back to Bonneville). Recent NMFS transport studies treat this issue with the expectation that the regional PIT Tag Monitoring Plan will help to address the details of this RPA. (See discussion of RPA Action 31 for further details.)

Under BPA Project No. 1991-051-00 (Modeling and Evaluation Statistical Support for Life-Cycle Studies), the program REALTIME monitored the timing of smolt migration of 51 stocks and ESUs through five different hydro projects. Smolt-to-adult ratios were updated for 179 stocks of coded wire tagged salmon and steelhead. Results were updated for 2011 from the ROSTER PIT tag analysis programs showing smolt survival, adult survival, SAR, transport-vs. in-river ratio, differential mortality (*D*) sorted by release year or stock/ESU of origin. PIT-tag analyses within ROSTER also found that SARs were reduced among steelhead smolts that had been by passed more than twice and among yearling Chinook smolts bypassed more than once. Under BPA Project No. 1989-108-00 (CRiSP model support), the differential post-hydrosystem survival rates of transported and in-river releases of Snake River hatchery spring Chinook were evaluated in order to update the COMPASS model. Timing of ocean entrance, coastal upwelling, and temperature exposure of smolts were the dominant factors predicting differential survival.

The Corps' seasonal transportation study continued through 2011; it combines the weekly estimated SAR with physical and biological data from the estuary and plume to determine factors that affect post-Bonneville survival and that may be useful as triggers to initiate transport. Overall, T:M ratios reported by NOAA show that transport is a benefit throughout most of the season for spring migrants (T:M > 1.0). The greatest transport benefit for wild Chinook salmon usually occurs after May 1, but in most years transport is beneficial by the 3rd week of April. Transport is beneficial to hatchery Chinook salmon and hatchery and wild steelhead starting April 15 in most years. 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 becomes even more beneficial later in the season.

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. Currently there are no plans to conduct a workshop in 2012.

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.)*

Four BPA projects were continued to fully address this subaction. Studies have been funded by BPA for more than a decade, and complementary projects (such as radio tag investigations in Snake reservoirs) have been funded by the Corps under the AFEP. In 2011, the Corps began a multiyear study using otolith microchemistry to determine migration and growth patterns of juvenile SRFC. Based on patterns of 87Sr/86Sr ratio, it was possible to differentiate four regional groups originating from lower and upper Snake River, Clearwater/ Salmon Rivers, and Tucannon/Grande Ronde/Imnaha Rivers.

A 3-year radio telemetry study of “reservoir type” fall-run Chinook juveniles in the lower Snake River Reservoirs (BPA Project No. 2002-032-00) found that 93 percent passed through one or more dams during winter, and mean displacement downstream was 7.5km/day This implies that most fall-run smolts undergo powerhouse passage during the winter, but it is unclear what survival rates are in winter or when turbines are unscreened, compared to the summer when temperatures are higher and predatory fish are more active.

Under BPA Project 1991-029-00, 5,275 fall Chinook redds were counted in the Snake River Basin in 2010. This reflects an increasing trend over the 20-year study. While some redd superimposition was observed, there is evidence that the population remains below capacity. Parr growth rates and reservoir velocity were estimated to have a linear correlation with parr-to-smolt survival rates because fast growth and downstream movement reduce exposure to predators. One implication is that density of hatchery releases should be controlled to avoid intraspecific competition for food. Smolts acclimated to river conditions had faster downstream movement and higher survival than directly released subyearlings. Tributary-reared parr had faster growth rates than individuals reared in the Lower Granite Reservoir.

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.*

In 2009, the Corps conducted physical studies at the ERDC observational turbine model to determine alternatives for runner, stay vane, wicket gate, and draft tube designs for new turbine runners at Ice Harbor Dam. The Corps advertised a contract for design, manufacture, and delivery of a fixed-blade runner for Unit 2, with an option for manufacture and delivery of an adjustable-blade runner for Unit 3. Voith Hydro was awarded the contract in 2010 and the first in-progress meeting for the fixed-blade runner took place at ERDC in June 2011. The objectives of this project are to develop and test a process through which fish passage can be effectively incorporated into turbine designs, and to determine how safe passage conditions can be for fish. The design criteria included, maximum sheer rates, minimum pressures, quality of flow, and minimizing strike. Power and efficiency are not directly being considered. Development continued in 2011 with the second iteration of the fixed-blade runner. 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.

The Corps completed a meta-analysis of juvenile salmonid turbine passage survival studies at John Day and McNary Dams. Survival was negatively correlated with tag burden; i.e., it appeared that tagged fish had a lower probability of surviving turbine passage than did untagged fish. However, turbine unit operations across these studies were too similar to allow a rigorous evaluation of turbine operation parameters and their effect upon survival probability.

7. *Investigate feasibility of developing PIT-tag detectors for spillways and turbines.*

In fiscal year 2011, the Corps initiated an effort to develop an Engineering Documentation Report that will include an evaluation of alternatives considered in developing a prototype Spillway PIT Tag Monitoring Project. The report will document the decision process used in evaluating alternatives such as project location, antenna location within the spillway, and scope or extent of the prototype project. The Corps will work with NMFS and other regional resource management offices in developing the report. Plans for prototype Spillway PIT tag detectors at Lower Granite Dam were developed in 2011.

8. *Evaluate new tagging technologies for use in improving the accuracy and assessing delayed or indirect hydro effects on juvenile or adult fish.*

2011 was the final year of BPA Project No. 2003-114-00 (Pacific Ocean Survival Tracking Project [POST]), which used ocean arrays deployed along the estuary, north and south of the Columbia River Mouth, in Willapa Bay, and at Lippy Point, BC, to detect direction and rates of travel of multiple populations of acoustically tagged yearling Chinook. 2011 was the first study year (since 2006) in which smolts transported to release below Bonneville had significantly lower survival rates than in-river groups. Transported smolts released in early May had travel times nine times longer through the plume than smolts transported in mid-May. Nearly all smolts migrated northward along the coast. Average survival through the lower estuary among Snake River groups was 81 (±4) percent for in-river releases and 78 (±4) percent for transported groups. Survival through the plume for the same groups was 23 (±5) percent and 14 (±5) percent, respectively.

Through the Corps Survival Methodologies Program, the effects of tagging juvenile Chinook salmon were studied in an effort to improve surgical techniques used for implanting acoustic transmitters. Based on this research and on input from regional experts, substantial progress was made on standardizing surgical tagging protocols. A final protocol document was finalized in 2010. Further study of surgical protocols in 2011 focused on the efficacy of a single suture following implantation of smaller acoustic tags and results were presented at the 2011 AFEP review.

The Juvenile Salmon Acoustic Telemetry System downsize project underway in 2011 has a goal of producing an acoustic tag small enough to be injected like a PIT tag reducing the need for actual surgical procedures in the future thus making tagging more efficient and reducing handling time and stress on tagged fish. Good development progress was made in 2011.

Based on the study results from Carlson et al. (2010) the Corps pursued development of an external tag for the purpose of reducing tag burden and survival estimate bias due to rapid decompression experienced by turbine passed fish. The final report was submitted in the fall of 2011 (Carlson et al. 2011) and presentations on this study were made at the AFEP conference in Late November 2011.

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.*

   A PIT-tag antenna installed in the John Day River near McDonald Ferry (river mile 20) in 2009 has been effective in the detection of adult salmon under BPA Project No.1983-319-00 (New Marking and Monitoring Techniques for Fish). The PIT-tag antenna was damaged during the spring freshet and was unable to record data after May 15th. Plans were made to repair and reinstall the antenna for 2012.

   See RPA 55.7 above for results of spillway detection feasibility evaluations.

RME Strategy 3 (RPA Actions 56–57)

A comprehensive list of all actions implemented by the Action Agencies for RPAs 56 and 57 is included in Section 3.

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.*

Eight BPA projects were continued with elements that support research in areas of the pilot study basins (Wenatchee, Methow, and Entiat River Basins in the Upper Columbia River Basin; the Lemhi and South Fork Salmon River Basins; and the John Day River Basin). The objectives of this research include quantifying the relationships between habitat conditions and fish productivity (limiting factors) and improving the development and parameterization of models used in the planning and implementation of habitat projects. Reclamation also funded work to support studies in the Methow River Intensively Monitored Watershed (IMW). These studies help quantify the relationships between habitat conditions and fish productivity and provide data for model development.

Beyond the 17 projects that were disassociated from this RPA in 2010, it was determined that 3 additional BPA projects identified in the 2010–13 Implementation Plan (FCRPS 2010a) were no longer necessary to fulfill the RPA.

Relationships of Fish Production to Habitat Condition

The BPA and Reclamation continued to fund research to understand the relationships between stream complexity (channel morphology, channel connectivity, riparian function) and fish productivity. In response to ISRP and Council questions, BPA funded the ISEMP to complete a retrospective "lessons learned" report that incorporated all of the data collected by the project between 2003 and 2011 (ISEMP 2011). ISEMP pioneered the use of new technologies that provide more precise and accurate means to characterize stream morphology. These technologies have since been adopted by the Columbia Habitat Monitoring Program (CHaMP). To monitor the effectiveness of this work ISEMP and CHaMP not only employ a traditional cross-section approach, but also methods that capture three-dimensional habitat surveys. The results that are generated from these survey methods were reported in the 2010 Annual Progress Report (FCRPS 2011).

In 2011, ISEMP (2011) and Ward et al. (2012) both reported on a technique that uses boosted regression trees to analyze the relationships between juvenile fish densities and habitat metrics. The results of this analysis can be used to determine the relative ranking in the importance of a habitat metric to fish populations. The relative importance of habitat metrics can be both species specific as well as basin specific. The ISEMP team used several years of data to show which habitat metrics are the most important to Chinook in the Wenatchee Basin (Figure 16).

The CHaMP program is investigating whether there is a common set of relationships between fish density and habitat improvements that can eventually be extrapolated to areas that don't have the level of data that the CHaMP subbasins have.

The boosted regression tree analysis is just one of many tools and models that have been applied by ISEMP and further refined during the pilot year of the CHaMP.

CHaMP Data Collection Summary

CHaMP collected habitat data during 399 unique visits, including repeat visits as part of two-variability studies and visits to sites in non-CHaMP Project IMWs monitored by ISEMP in the Entiat, Lemhi, John Day, and Asotin Rivers. Data collection at all sites followed CHaMP's standardized protocols and methodologies. For each site visit, 78 individual habitat metrics were measured or calculated, and these can be rolled up into 22 habitat indicators. These indicators may be calculated at the subbasin scale, for which CHaMP was originally designed, or at smaller scales, such as the assessment units used by expert panels or the reaches studied in IMWs (Ward et al. 2012). See Table 25 for a summary of the sites visited by location.

In addition, monitoring that was needed to infer relationships based on correlations between limiting factors, habitat actions, and productivity in support of RPA 3 (comprehensive evaluations) will also be addressed under RPAs 50.6 and 56.3.

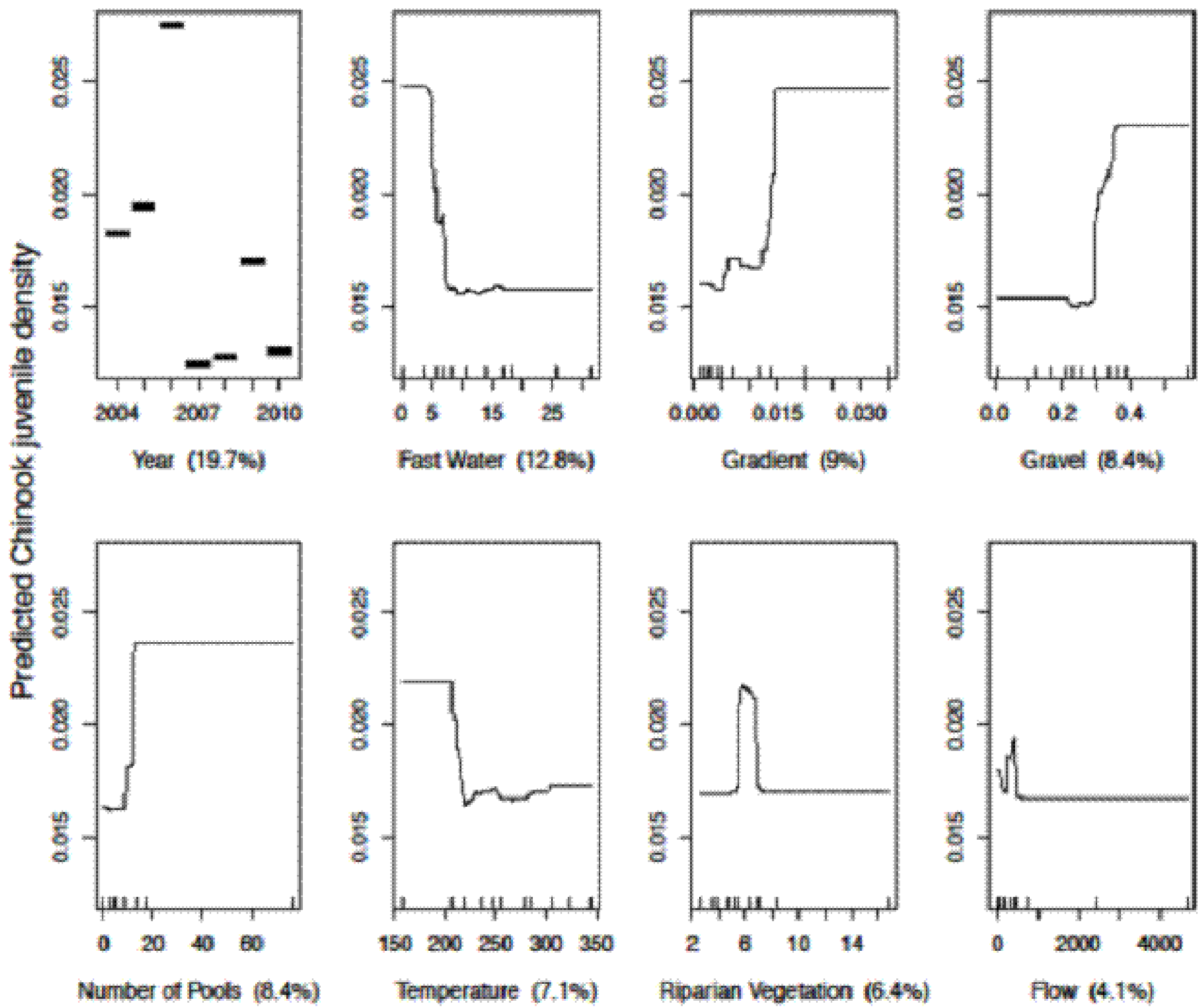


Figure 16. Partial dependence plots showing the marginal effect of the eight most important habitat metrics affecting juvenile Chinook densities, identified by a biological review team that analyzed fish density data and habitat data collected by ISEMP in the Wenatchee River subbasin 2004–10. The y-axis is the predicted value of juvenile density. Along the bottom of each plot, the tick marks show the deciles of the data for that habitat metric. For example, 90 percent of the sites visited had less than 20 pools per river kilometer.

Development of Models Using Limiting Factor Data

Lemhi IMW

The 2011 contract period was the ISEMP's third year of implementing the Lemhi River monitoring strategy. The primary goal of the Lemhi River portion of ISEMP is to identify and quantify the effects of habitat modifications on the productivity and survival of anadromous and resident salmonids within the Lemhi watershed. Within the Salmon Subbasin, ISEMP has begun a habitat and population status and trends monitoring project in the south fork Salmon River watershed and a habitat action effectiveness evaluation in the Lemhi River watershed. These initiatives are related through the application of a watershed model that views fish vital rates (survival/productivity, abundance, and condition) as a function of the quantity and quality of available habitat.

Table 25. Summary of 2011 Sites Surveyed with CHaMP Protocol and Tools

Subbasin	CHaMP Sites	ISEMP IMWs	Total Sites Surveyed With CHaMP Protocol and Tools
Methow	25		25
Entiat	16	60	76
Wenatchee	23		23
Tucannon	24		24
South Fork Salmon	25	8	33
Lemhi	25	17	42
John Day	50	9	59
Upper Grande Ronde	56		56
BPA-Funded Total	244	94	338

In addition to these sites funded through CHaMP or ISEMP, 10 sites in the Asotin were funded/surveyed by Washington SRSRB, and 13 sites were surveyed in coastal streams of California by the California Department of Fish and Game's Coastal Watershed Planning and Assessment Program.

These functions are constructed using both coarse-scale (e.g., geographic information system (GIS)) and fine-scale (e.g., site-scale, airborne light detection and ranging (LiDAR)) habitat measures. Once validated via the collection of empirical data within habitat classes, the model provides a statistical framework to assess the effects of different classes of habitat actions on life-stage specific vital rates (productivity/survival and condition) of anadromous and resident salmonids.

Additionally, the model includes survival functions enabling the user to alter survival rates (juvenile to emigrant and emigrant to adult) as necessary to compensate for hatchery production. The watershed model requires multiple years of adult escapement and juvenile abundance, survival, distribution, and growth data in order to generate capacity and freshwater productivity estimates. Tying these estimates to physical habitat at appropriate spatial scales (e.g., subwatersheds of the Lemhi River targeted for reconnection) similarly requires multiple years of ground-based surveys enhanced by remote sampling. Given that the ISEMP Project initiated sampling in 2009, 2011 marked the second year that adult return data were produced using PIT tagged fish from Lower Granite Dam tagging operations. The watershed model will be sufficiently populated for preliminary runs in 2013 for Brood Year 2010 juvenile production. During 2011, ISEMP cooperators continued the remote juvenile PIT-tagging, adult salmon and steelhead PIT tagging at Lower Granite Dam, site-specific habitat surveys, PIT array installations and operations, and the operation of rotary screw traps. Field crews tagged approximately 9,000 adult salmon and steelhead at Lower Granite Dam. Roving surveys within the Lemhi River tagged approximately 4,500 juvenile salmon and steelhead and rotary screw traps operations tagged approximately 5,000 additional juvenile salmonids. In addition to the 2 PIT antennas installed in 2010 in Canyon and Big Timer Creeks, in 2011 ISEMP cooperators installed two more instream arrays (in Little Springs Creek and Bohannon Creek) for a total of eight.

Entiat IMW

2011 marked the second year of pre-project monitoring in the Entiat IMW. 2012 will mark the first year of coordinated habitat restoration actions associated with the Entiat IMW. The Entiat IMW experimental design enables a quantitative evaluation of the potential benefits of habitat actions at several scales:

- Reach scale – changes over 200-300 meters of stream associated with one or more actions.
- Sub-watershed scale – aggregate of project or reach scale (e.g., juvenile tagging along the mainstem and Mad River to evaluate survival prior to emigration).
- Watershed scale – aggregate of impacts over the entire watershed (e.g., total abundance of juvenile emigrants as assessed at a screw trap located near the mouth of the Entiat River).

The habitat monitoring design is based on a single panel of sampling sites designed to assess changes in habitat complexity and the effect it may have on fish productivity. Salmonid responses relevant to changes in population performance, such as factors that are related to fitness or production, were monitored. This included parameters that are necessary for determining the long-term viability of salmonid populations, such as: freshwater production (smolts/spawner); survival (over summer and over winter); changes in life history patterns; and distribution (as measured by change in density, age-at-emigration, or observed movement of tagged individuals), and growth.

Estimates of population size and individual growth and movement for Chinook and steelhead at the reach scale are frequently updated to complement the population-scale effectiveness monitoring.

By pairing habitat and juvenile monitoring at each site, the Action Agencies can collect information on the mechanisms by which structures influence habitat quality and how the resulting changes influence fish performance. Juvenile abundance is estimated by a mark-recapture study using fish implanted with PIT tags. Fish are sampled over two consecutive days to allow for equal capture probabilities per sample event. The Action Agencies use a variety of capture methods (e.g., herding, e-herding, seining, angling, dipnetting). Captured fish are anesthetized, tagged with 12- or 9-millimeter (mm) PIT tags, weighed and measured, and revived and released near the site of capture. Fish sampling occurred during two time periods in 2011: summer (July/August) and winter (February/March) to obtain seasonal estimates of the response variables. Sampling during higher flows and winter conditions posed some challenges. This information will provide the responses and potential covariates at the highest resolution of comparisons (treatment/temporary control areas) but can be rolled up to address larger area comparisons as well.

Instream PIT tag detection antennas have been installed at six locations on the Entiat and Mad rivers. They will allow the Action Agencies to generate seasonal survival estimates and detect juvenile movement in or out of tributaries and along the mainstem as the fish travel around the watershed. Smolt abundance, size-at-emigration, and a growth rate for recaptures will be estimated from fish caught at the rotary screw trap at the mouth of the mainstem Entiat River as fish emigrate from the Entiat.

Methow IMW

Reclamation has taken the lead in organizing the Methow Intensively Monitored Watershed Project. Reclamation researchers have organized regular annual meetings for the past 4 years in the Methow River Basin. The first Methow IMW Report will be completed in 2012.

Six models jointly developed by Reclamation researchers and U.S. Geological Survey's Columbia River Research Laboratory (USGS-CRRL) will be used to evaluate fish populations and population processes. An aquatic production and full life-cycle visual model is under development in System Dynamic's STELLA® software to facilitate the testing of theoretical concepts. A mark-recapture model is being developed to assess annual survival at the population and select subpopulation levels. A juvenile life-cycle model coupled with a bioenergetic model and a smolt transition model will be used to evaluate relationships between habitat, energy transfer through fish food webs, and smolt production. Reclamation's Technical Service Center is developing a 2D hydraulic model to simulate surface and subsurface flow, temperature, and water residence times for use in evaluating climate change effects. This model will provide data for the estimation of key parameters in the habitat, food web and smolt production modeling. Model development will be completed by October 2012. There is a significant body of work in the literature that we have used to parameterize modules in the model. These models will be applied to evaluations of the Methow IMW habitat projects.

Reclamation is funding the USGS-CRRL in a long-term study of the Middle Methow River and its floodplain side channels to analyze the effectiveness of a channel reconnection and channel wood treatment project. The year 2011 constituted a full pre-treatment year for data collection by the USGS-CRRL in the Middle Methow. From the USGS-CRRL field sampling efforts since 2008, Reclamation gained much information on fish assemblage, fish abundance, fish growth, fish movement behavior, habitat availability, habitat quality, side-channel connectivity, and stream productivity. For the target fish (spring Chinook salmon and steelhead) the pretreatment study collected data on life history expression, age at smolting, survival by age and season, habitat use, and degree of use, retention, growth, survival, and successful smolting in the proposed treatment stream reach.

Thus far Reclamation researchers and USGS-CRRL have learned that habitat patches (main channel and different side channels) within the floodplain landscape hosted very different local food webs. Juvenile Chinook salmon and steelhead utilized all of these patches, indicating that these species are flexible enough to exploit a range of food resources across a variety of habitats. This flexibility may be particularly important in the Methow River, where results showed that non-target fish species (i.e., mountain whitefish and sculpin) dominate prey consumption in the main channel, resulting in potentially high competition for available food. In contrast, Chinook salmon and steelhead consumed a higher proportion of available prey in the side channels. The invertebrate food supply in the side channels generally far exceeds the fish demand, suggesting that greater anadromous salmonid populations could be sustained in these habitats. Why salmonid populations seem to be below carrying capacity is the subject of a modeling exercise and further field perturbation experiments.

Reclamation researchers and USGS-CRRL are partnering with the Yakama Tribe in the Methow River to study the nutrient enrichment of streams to increase salmon and steelhead production. Reclamation is further assisting the Yakama Tribe in the Upper Columbia Basin Nutrient Enhancement Project (BPA Project No. 2008-471-00). The goals of this project are to: (1) assess current nutrient concentrations and the trophic status of the Twisp River in north central Washington, relative to nutrient limitation on natural production of native anadromous salmonids; and (2) prescribe, implement, and evaluate a 5-year experimental nutrient addition treatment to increase natural production. Three years of pre-treatment monitoring show significantly poor (oligotrophic) nutrient conditions.

Reclamation also funded portions of a Winthrop NFH study to help answer some habitat-related questions. The goal of this project is to advance 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. The project has two main objectives: 1) improve survival and reduce fitness loss in Columbia River steelhead by minimizing unnatural selection on body size and other smolt characteristics, and 2) identify behavioral and physiological traits under selection through laboratory-scale research.

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 project continue to provide a means of evaluating the effectiveness of tributary mitigation actions.)*

Six BPA projects were continued that have elements that supported the implementation of habitat status and trend monitoring as a component of the pilot basin studies. As noted above in 56.1, 2011 marked the pilot year for the CHaMP program (2011-006-00). The purpose of the CHaMP program is to implement a standardized habitat status and trend monitoring protocol using a programmatic approach that standardizes data collection and management. In 2011, CHaMP implemented intense habitat monitoring in the following pilot watersheds: Methow, Entiat, Wenatchee, Tucannon, South Fork Salmon, Lemhi, John Day, and the Upper Grande Ronde. Using the information collected in 2011, CHaMP developed an initial habitat quality index that may potentially be used to track habitat conditions over time, and may also be used to help develop and prioritize restoration actions that directly affect the limiting factors or habitat impairments in each assessment unit of a population. For more details on CHaMP's efforts to develop standardized habitat status and trends monitoring please see the program's 2011 Pilot Year synthesis report (Ward et al. 2012).

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.*

Nine projects were implemented in 2011 to support this RPA. The ASMS was finalized in early 2010 but continued to be refined in 2011. The Action Agencies and NMFS BiOp RME workgroups for fish population and tributary habitat monitoring updated the

RME Recommendations Report in June 2010 to support the implementation of the ASMS which included fish population and habitat monitoring for at least one population per major population group. This strategy guided the development of the CHaMP which, as noted above, was implemented for the first time in 2011.

An example of a BPA funded project that implements habitat status and trend monitoring outside of the basins covered in 56.1 and 56.2 is the Okanogan Basin Monitoring and Evaluation Program (OBMEP). OBMEP (BPA Project No. 2003-022-00) successfully collected physical habitat data and estimates of the juvenile salmonid and invertebrate standing crops at 50 sites. OBMEP used a hierarchal, spatially balanced sampling design that covered the entire extent of anadromous fish habitat in the Okanogan River Basin. OBMEP also monitored water quality data in the mainstem and tributaries of the Okanogan River. Juvenile sockeye, Chinook, and steelhead out-migrant data was collected at the Highway 20 Bridge Rotary Screw Trap site. To facilitate coordination between OBMEP and other regional stakeholders, OBMEP biologists participated in 13 regional coordination efforts such as PNAMP, and the Upper Columbia Regional Technical Team. The OBMEP team attended CHaMP training in 2011 and will participate in the CHaMP program in future years.

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 Nos. 2010-034-00 (Upper Columbia Spring Chinook and Steelhead Juvenile and Adult Abundance, Productivity and Spatial Structure Monitoring) and 2003-017-00 ISEMP were continued to support action effectiveness pilot studies in the Entiat River Basin that were focused on treatments to improve channel complexity and fish productivity. Results of this project are still pending the return of adults who may have been affected by treatments as juveniles. BPA Project No. 2010-034-00 was continued in 2011 to support an increase in the intensity of monitoring of adult spawners and out-migrating juveniles. 2011 also marked the initial year of CHaMP. The Entiat Basin was one of 9 subbasins that were monitored 2011 as part of CHaMP's pilot season. CHaMP monitored 64 sites over two assessment units in the Entiat Basin while categorizing the Habitat Quality across the two assessment units.

2. *Pilot study in the Lemhi River Basin to study treatments to reduce entrainment and provide better fish passage flow conditions.*

   Two BPA projects continued to fully address the pilot study in the Lemhi River Basin to assess treatments to reduce entrainment and provide better fish passage flow conditions. The ISEMP program continued to monitor habitat and fish population density to support the evaluation of treatments to reduce entrainment and provide better fish passage flow conditions.

   ISEMP's work in the Lemhi watershed can serve as one example of watershed-level action effectiveness monitoring. ISEMP has developed an IMW in the Lemhi River Basin with the primary goal of testing the effectiveness of reconnecting numerous small tributaries to the mainstem Lemhi River. While tributary reconnections are the major restoration focus, the Lemhi IMW also evaluates additional habitat actions including channel modifications, riparian fencing, diversion removals and screening, and side-channel development (ISEMP 2011).

To test whether the reconnection of tributaries to the mainstem Lemhi has been effective, ISEMP has populated a watershed production model with data collected beginning in 2009, including data collected by the CHaMP program in 2011. In 2013, the model will have data for one complete brood year of Chinook, but ISEMP has started to test the model and has also produced some sample outputs that could be used for management decisions in the near future. Figure 17 shows potential response curves for adult spawners given three reconnection scenarios (e.g., existing connections only, high priority reconnections only, or both high and moderate reconnections). Again, this model has not been developed to the point that it is ready for use in decision making, but this example, using current data collected by ISEMP in the Lemhi, shows the potential of what could be applied to other basins as well. Other benefits that can potentially be derived from this model include the identification of limiting factors, the identification and comparison of effective project types, the ability to relate habitat improvements to survival improvements, the identification of appropriate RM&E, the evaluation of changes in habitat and fish populations, and the prediction of adult returns.

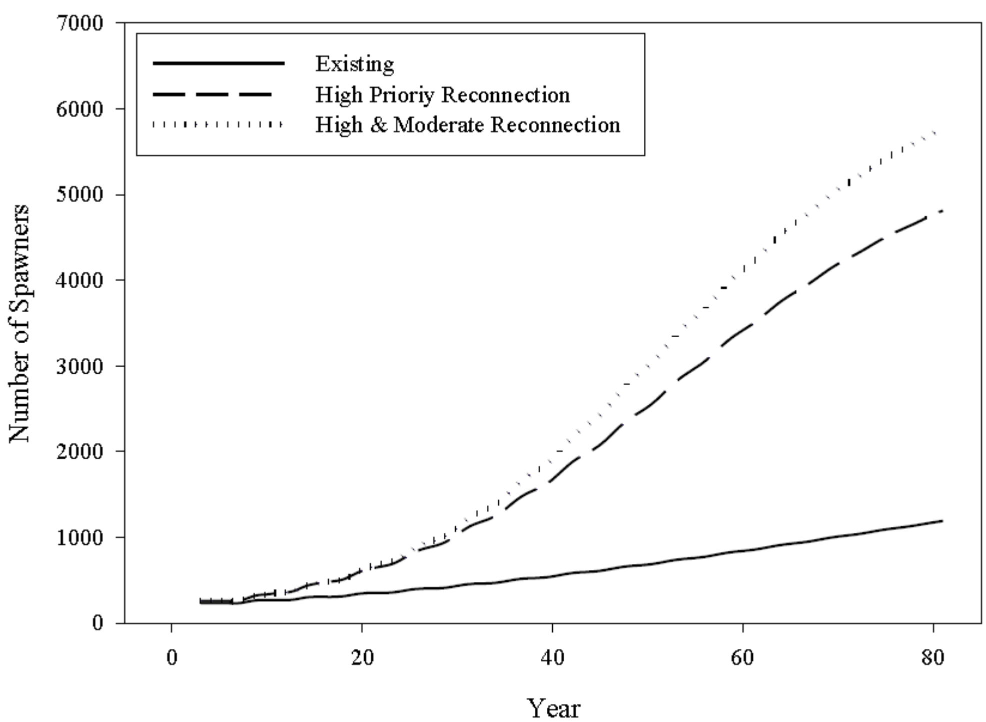


Figure 17. Number of spring/summer Chinook salmon adults returning to the Lemhi River given existing habitat, reconnection of high priority watersheds, and reconnection of high and moderate priority watersheds. (ISEMP 2011)

The provisional model results described above illustrate the utility of the watershed model as a tool for evaluating the outcomes of habitat restoration using the BiOp metrics of egg to smolt survival and adult abundance. This simple summary also demonstrates the value of the model for testing assumptions that guide habitat restoration. First, the model tests the assumption that freshwater survival is limited by habitat quantity and quality. Second the model tests the value of restoration scenarios. Third, the model predicts whether additional habitat restoration actions may be necessary to achieve the targeted improvement in freshwater survival. Finally, the provisional results demonstrate a clear link between habitat restoration and freshwater survival, a key assumption underlying the value of habitat restoration as an offsite mitigation tool. As importantly, the model places changes in freshwater survival into the context of future adult escapement. This component is particularly important given that initial increases in egg to smolt survival are predicted to be followed by decreases over time as a result of density dependence, although total smolt production would remain much higher than the "existing" scenario. Habitat restoration is predicted to stimulate a substantial increase in total adult abundance despite the short-lived nature of improvements in egg-to-smolt survival.

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.*

   Three BPA Projects — Nos. 1984-021-00 (John Day Habitat Enhancement), 1998-016-00 (Escapement and Productivity of Spring Chinook and Steelhead), and 2003-017-00 (ISEMP) — were continued to fully support 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, consequently, fish productivity. BPA Project No. 1984-021-00 (John Day Habitat Enhancement) is still implementing a habitat restoration action effectiveness monitoring program, and results are expected in the future. BPA Project No. 2003-017-00 (ISEMP) continued to evaluate changes in fish density relative to action implementation. Findings supported the effectiveness of reintroducing beavers on improving fish habitat condition as a treatment to channel incision. As presented under RPA 56.1 in the Action Agencies' 2010 FCRPS Annual Progress Report, in the Bridge Creek IMW in the John Day subbasin, results have shown that the ISEMP Project has restored fish habitat by assisting beavers to build stable dams, which help deposition of streambed materials and the reconnection of the stream to the floodplain to address channel incision and potential impacts on stream flows and summer water temperatures. Final results are pending further implementation of the study with additional habitat improvement actions scheduled to occur in 2013.

4. *Project and watershed level assessments of habitat, habitat restoration and fish productivity in the Wenatchee, Methow, and John Day basins.*

   Three BPA projects (including CHaMP and ISEMP) generate assessments to support project- and watershed-level monitoring of the effects of habitat restoration in the Wenatchee and John Day Basins. By implementing large-scale Intensively Monitored Watershed experiments such as those in Bridge Creek of the John Day River (discussed above in 57.3), these projects continue to develop and refine tools and to provide results that demonstrate the effectiveness of habitat restoration actions. See the 2003–11 retrospective report (ISEMP 2011) for a thorough description of the products and processes that can be used in these types of analyses.

   Reclamation continues to fund a long-term study of the Middle Methow River and its floodplain side channels to analyze the effectiveness of a channel reconnection and channel wood treatment project. The year 2011 constituted a full pre-treatment year for data collection by the USGS-CRRL in the Middle Methow. *Preliminary findings* from this work were reported under RPA action 56 of this report, and a summary of findings will be available in late 2012 as part of a Methow IMW report.

Reclamation continued funding a passage study in Beaver Creek, a tributary to the lower Methow River. PIT-tag interrogation stations were operated and maintained, including: the six-antenna multiplex unit at the Stokes property (rkm 4) and a single-antenna station upstream at rkm 12 (near UBR2; see Figure 18). During 2011, abundance estimates and habitat data were collected at two monitoring sites in Beaver Creek (UBR1 and UBR2). In August 2011, a stratified systematic sampling design was used in these two 500-meter sites to assess fish population abundance, density, and biomass. A total of 262 PIT tags were inserted in the target species collected during these surveys. Data from these interrogation stations were uploaded into PTAGIS. Databases were searched for tag reads to update tag recaptures.

The Beaver Creek Study shows that ESA-listed steelhead in the Methow basin quickly began utilizing habitat opened up by barrier removal. Anadromous *O. mykiss* (steelhead) entered the re-opened habitat in Beaver Creek in 2005, the first spawning season after barrier removal. Counts of anadromous *O. mykiss* into Beaver Creek decreased from 2005 to 2007 and then increased in 2008. These counts are consistent with other monitoring data such as redd counts in Beaver Creek and adult return counts to Wells Dam. Tag migration and interrogation data indicate that adult anadromous *O. mykiss* (steelhead) were migrating into upper Beaver Creek in 2007 and 2008, 2 to 3 years after barrier modification. Additional information is at: *https://www.salmonrecovery.gov/Files/2011 APR files/Corrections/AFS_Beaver_Creek_Study_2011[1].pdf*

A Reclamation-funded genetics study shows that juvenile steelhead tagged in Beaver Creek returned to Beaver Creek as adults, indicating the full establishment of anadromy in the study area. The migration of steelhead led to significant changes in the population genetic attributes at the first monitoring site (UBR1) upstream from the barrier in 2008 and 2009 within approximately one generation. Sites farther upstream did not show significant changes in population genetic attributes by 2008 and 2009, and likely require more time for the successful colonization of more individuals. Statistical analyses of genetics and tag movement data have been submitted for scientific review.

PIT-tag data indicate that juvenile steelhead that remained in Beaver Creek until smolting contributed more to the smolt population, but at somewhat older ages than those fish that left Beaver Creek in the fall or winter months. This is significant because, if young smolts were to return as adults at the same rate or at a greater rate, the overall population growth rate would be expected to increase. Biologists associated with our Methow studies speculate that we may create more successful young smolts by improving mainstem Methow River habitat.

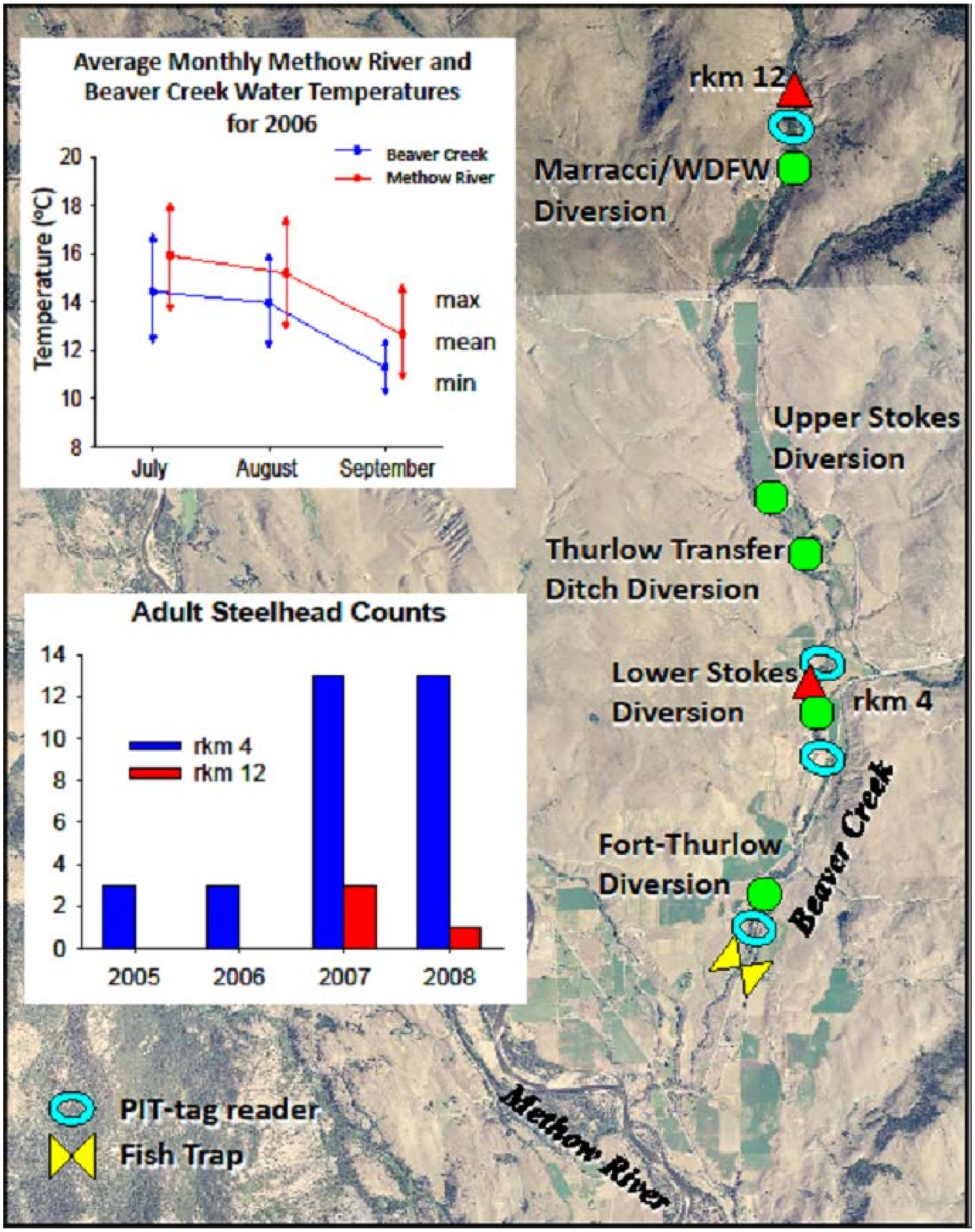


Figure 18. Map showing locations of irrigation diversions, PIT-tag readers, and fish traps in Beaver Creek, and charts showing adult steelhead counts and average monthly Methow River and Beaver Creek water temperatures.

Reclamation researchers and USGS-CRRL are partnering with the Yakama Tribe in the Methow River to study the nutrient enrichment of streams to increase salmon and steelhead production. Reclamation is further assisting the Yakama Tribe in the Upper Columbia Basin Nutrient Enhancement Project (BPA Project No. 2008-471-00). The goals of this project are to: (1) assess current nutrient concentrations and the trophic status of the Twisp River in north central Washington, relative to nutrient limitation on natural production of native anadromous salmonids; and (2) prescribe, implement, and evaluate a 5-year experimental nutrient addition treatment to increase natural production. Three years of pre-treatment monitoring show significantly poor (oligotrophic) nutrient conditions.

Reclamation funded the design for the Elbow Coulee side-channel reconnection project in the Twisp River, a tributary to the middle Methow River. The Elbow Coulee Side Channel Restoration Project was implemented to meet the following objectives: (1) re-establish a side channel to the Twisp River at river mile 6.6; (2) increase habitat complexity and large woody debris recruitment potential; (3) reduce stream energy to increase the potential for the accumulation of sediment and wood in the Twisp River; and (4) increase rearing habitat for native juvenile salmonids.

Monitoring results obtained since the end of construction in 2008 and through 2011 indicate that all four objectives have been met and that the project provides habitat for spring Chinook salmon, steelhead, and potentially bull trout. High flows activated the side channel each year. Young-of-the-year spring Chinook and steelhead were observed each year using the side channel. More fish are using the side channel than before the project. Water temperatures are conducive for fish rearing.

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.*

   Reclamation researchers hosted a modeling workshop in February 2011. We learned that a wide variety of habitat-fish models are being used in both retrospective (most) and prospective (seldom) modeling approaches. Models were used to analyze some "natural experiments," in which recent management decisions were not executed in a structured study design but were nonetheless subjected to intensive monitoring through other programs. The model results show great promise for assessing management alternatives. Mostly, statistical models are used. Suitable validation data sets are lacking. Mechanistic models are needed but rare. Reclamation is developing a Methow River life-cycle model, and a fish population and habitat processes mechanistic model in a system-dynamics framework. These modeling efforts are being tested in 2012. A Columbia River Basin full life-cycle model is under development by NWFSC and the Action Agencies. This effort will pull from many of the modeling efforts that were presented at the workshop. Reclamation's Methow model will be integrated into the Columbia Basin model.

RME Strategy 4 (RPA Actions 58–61)

Section 3 includes a comprehensive list of all actions implemented by the Action Agencies during 2011 for RPAs 58 through 61. Most of the RPA specifications either were fully covered by ongoing projects or would be fully covered with some additional work elements. This 2011 Annual Progress Report synthesizes key findings and products from work in 2011; however, some of this work is planned and executed across multiple years.

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.*

Two BPA projects and two Corps projects supported this subaction.

Corps AFEP 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) continued to establish scientific methods to quantify benefits from habitat restoration to listed salmon and steelhead in the LCRE through the development of indices for habitat connectivity, early life history diversity, and survival. In 2011, this project developed a conceptual species-habitat model that relates (1) habitat restoration benefits to juvenile salmon that enter and occupy restored habitats (direct benefits) and (2) restoration benefits to juvenile salmon that do not enter the site but benefit from resources exported from the site in the form of detritus and prey (indirect benefits). The model is organized into three basic tiers: physical, biotic, and salmon-related (salmon density, growth, and survival). Refer to Diefenderfer et al. (2012) for a complete description of this model. A companion numerical model will be developed in 2012.

Corps AFEP EST-P-09-01 also advanced methods to develop a survival benefit index by relating habitat change at a site scale to juvenile salmon fitness. Researchers concluded that:

> Many existing physiological methods for measuring benefits to juvenile salmon of habitat restoration are variable with life stage and time of year, and thus are not reliable indicators of habitat quality. New approaches are needed to measure and evaluate habitat restoration benefits on juvenile salmon. . . . The best growth measures to pursue for the purpose of indexing habitat benefits are related to tissue synthesis and degradation. This is because they indicate actual tissue synthesis, are not easily confounded by stressors like handling, are responsive to habitat conditions including prey accessibility and water quality, and have low statistical variability (Diefenderfer et al. 2012).

Physiological indicators of tissue synthesis and degradation will be examined in 2012.

BPA Project No. 2003-114-00 (Coastal Ocean Acoustic Salmon Tracking [COAST, formerly POST]) assessed early marine survival and ocean movements of Columbia River salmon stocks by measuring their movement and survival along the west coast of North America using an ocean tracking array. Estimating survival over the COAST array enabled comparison of relative survival from Bonneville Dam to Astoria, Astoria to Sand Island, Sand Island to Willapa Bay (north) and Cascade Head (south), and north to Vancouver Island. These data represent segment survival for the lower river, estuary, and plume. The magnitude of these survival estimates can also be contrasted with coastal ocean survival data for the same tagging cohorts as they migrate north to Canadian waters. Also, BPA Project No. 2003-007-00 (LCRE Ecosystem Monitoring) installed a PIT-tag detection system in Campbell Slough (Reach F, see Figure 19), which was operable and collecting tag data for about 7 weeks. Most of the fish detected were Chinook salmon, but sockeye salmon (from the Sawtooth Hatchery near Stanley, ID) were also found. These data may be used for further analysis to support this RPA.

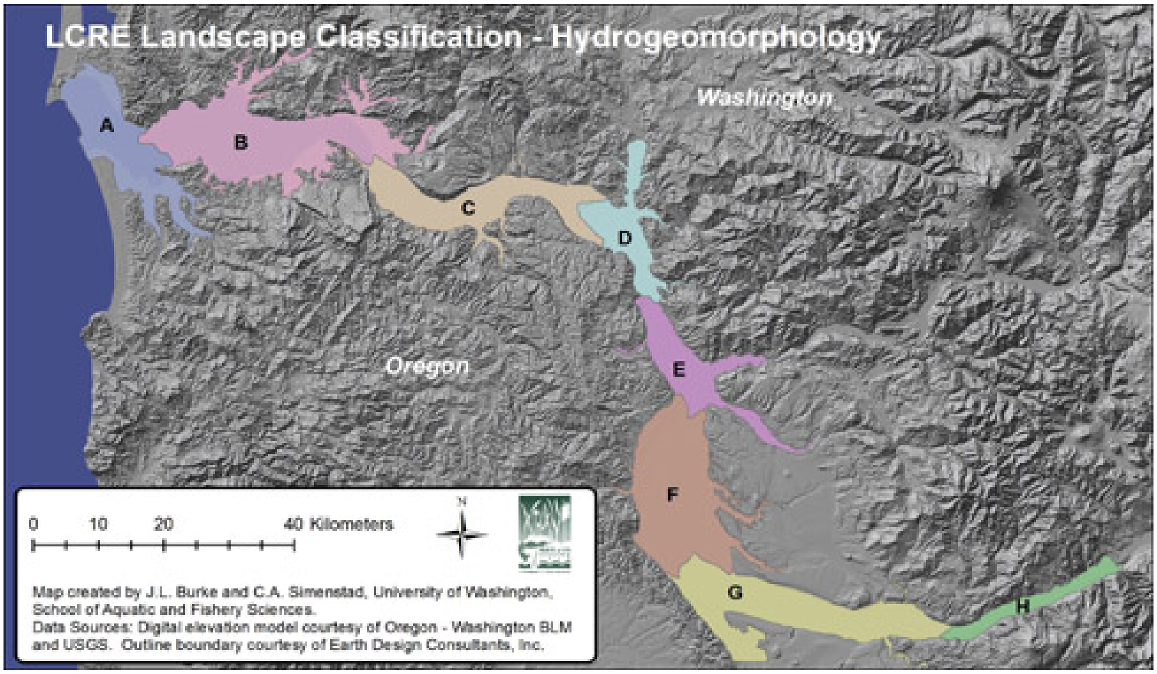


Figure 19. Map showing hydrogeomorphic reaches A-H for the Lower Columbia River and estuary (LCRE).

2. *Develop an index and monitor and evaluate life history diversity of salmonid populations at representative locations in the estuary.*

Three Corps projects were designed to fully address this subaction. In 2011, AFEP EST-P-09-01 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 the early life history diversity (ELHD) index for juvenile salmon in the LCRE. Juvenile Chinook salmon density and size class information were incorporated into the index. Size classes, derived from catch data were <61 mm, 61-90 mm, 91-120 mm, >120 mm (Sather et. al. 2011). Preliminary analysis suggests that the occurrence of different size classes of fish within the estuary or a given habitat represents trends in population specific attributes; thus at this time, the ELHD index is best used as a high-level indicator of changes in early life history diversity at a landscape or estuary scale (e.g., status and trends monitoring) (Diefenderfer et al. 2012). An expansion of the ELHD index will continue in 2012 with the incorporation of additional juvenile Chinook density data and other factors such as fish timing and genetic stock identity (including Interior basin stocks) to further investigate site-scale application and habitat associations.

AFEP EST-P-11-01 (Multi-Scale Action Effectiveness Research in the Lower Columbia River and Estuary) monitored and evaluated life history diversity of salmonid populations at representative locations in the estuary at Sandy River. Sather et al. (2012) found that:

> . . . juvenile salmon were most abundant at the Sandy River Delta (SRD) during spring months. As found in our previous work, unmarked Chinook salmon were the most commonly encountered salmonid. Snake River fall Chinook comprised 2% of unmarked juvenile Chinook salmon sampled for genetic identification at

SRD. Snake River spring Chinook were rarely encountered (representing 0.3% of those Chinook sampled for genetic identification) and mid and Upper Columbia spring Chinook were not represented.

Patterns associated with length frequency distribution were also similar to those previously reported by Sather et al. (2011) [i.e., Chapter 2 of Johnson et al. 2011]. Two distinct groups of unmarked Chinook salmon were captured at the SRD during winter months. The size and timing of these groups are indicative of subyearling and yearling life history groups. During the transition to spring months, the composition of unmarked Chinook salmon was predominantly small subyearling fish.

Sather et al. (2012) provides a more complete summary of results.

AFEP EST-P-10-01 (Columbia River Estuary Contribution to Salmon Recovery) monitored and evaluated life history diversity of salmonid populations at representative locations in the estuary (personal communication, Dan Bottom, NWFSC). In 2010–11 the researchers conducted bimonthly surveys of the genetic stock composition of juvenile Chinook salmon in mainstem, backwater, and tributary confluence habitats, through six tidal-fluvial reaches (C–H) of the LCRE (Figure 19). The surveys also characterized variations in salmon life history within and among genetic stock groups, including differences in fish size and times of estuary use, and the proportions of marked (i.e., known hatchery) and unmarked juveniles at each site.

From March 2010 through July 2011, subyearling Chinook accounted for 93 percent of those samples collected. Approximately 24 percent of the subyearlings and 82 percent of the yearling salmon were hatchery marked. Across all reaches and sampling periods, unmarked subyearling salmon displayed a wide diversity of life histories, as indicated by a broad size distribution (<40 mm to >120 mm), heavily skewed toward fry-sized individuals between 40 and 50 mm. In contrast, marked hatchery salmon exhibited a relatively uniform life history as indicated by a narrow range and normal distribution of sizes. Few marked individuals were <60 mm, and the dominant size class ranged between 80 and 90mm.

The greatest diversity of stocks was observed in reaches E and F (see Figure 19) — four genetic stocks each contributed more than 10 percent of the samples:

- Fall Chinook salmon from the Lower Columbia River ESU (i.e., the West Cascade Tributary and Spring Creek Group fall Chinook salmon genetic groups) were major contributors to samples collected in all six reaches of the upper estuary but composed larger proportions of fish in C-E (82%–65%) than in F (55%), G (55%), and H (26%). These two genetic groups also accounted for 83 percent of the outmigrant samples collected at Point Adams Beach.
- Upper Columbia River summer/fall run fish utilized nearshore habitats in all reaches, with relatively small proportions in reaches A and C-D (1%–5%) and increasing proportions in E (20%), F (21%), G (26%), and H (62%).
- Willamette River spring Chinook salmon juveniles accounted for an estimated 10 percent of the samples collected in Reach E, 15 percent in reach F, but less than 8 percent in other reaches.

Snake River fall run fish were relatively rare in our samples but occurred in reaches E-H, composing an estimated 4 percent of catches in reach H. Both the genetic stock survey and PIT monitoring results indicate that salmonid species and stocks throughout the basin enter shallow wetland channels. At the Russian Island emergent wetland channel, for example, the PIT detector recorded entry by Lower Columbia River coho (hatchery [H] and wild [W]) and fall Chinook (H), mid-Columbia River spring Chinook (H), Snake River steelhead (H and W) and fall and spring Chinook (H), Upper Columbia River steelhead (H) and spring Chinook (H and W), and Willamette River spring Chinook (W) (Dan Bottom, NWFSC, personal communication). The genetic results also reveal that many ESUs are capable of expressing multiple juvenile life histories. For example, we identified subyearling and yearling migrant spring Chinook from the Willamette River ESU, and several upper basin stocks known as yearling migrants produced subyearlings that utilized shallow estuarine habitats.

3. *Monitor and evaluate juvenile salmonid growth rates and prey resources at representative locations in the estuary and plume.*

Three BPA projects and one Corps project continued to address this RPA subaction. BPA Project No. 1998-014-00 (Ocean Survival of Salmonids) updated annual predictions of the relative productivity of the coastal waters off Washington and northern Oregon, including the Columbia River Plume. These results are summarized in Section 1 of this report and may be found in the project's annual report (NWFSC et al. 2011). In addition, BPA Project No. 2003-007-00 (LCRE Ecosystem Monitoring) continued to monitor prey availability (aquatic invertebrate sampling compared with taxonomic analysis of stomach contents), growth (otolith analysis), and habitat use by juvenile Chinook salmon and other fishes at three new tidal freshwater sites in Reach E. This project also resampled fish and prey availability at previously established monitoring sites to examine year-to-year trends in fish use and prey availability at long-term monitoring sites in Reaches A, C, F and H (see Figure 19 for reach locations). In 2011, emergent vegetation and open-water prey samples were collected, and corresponding diet samples were collected from individual Chinook salmon. The 2011 samples are currently being processed due to an extended field season (through December). In addition, otolith samples for growth rate estimation were collected from juvenile Chinook salmon at monitoring locations; analyses of these samples are underway.

Corps AFEP EST-P-11-01 (Multi-Scale Action Effectiveness Research in the Lower Columbia River and Estuary) monitored and evaluated prey resources at Sandy River Delta. The most important prey taxa in the diets of Chinook salmon, as indicated by the Index of Relative Importance, included dipterans, amphipods, and cladocerans, although the importance of these prey items was variable over time. Based on an "electivity" index, these taxa were never consumed in proportion to their abundance in the environment. Dipterans were taken at a lower proportion than would be expected, although they consistently accounted for large proportions of prey in gut contents of juvenile salmon.

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.*

Two BPA projects continued to support this subaction in 2011. BPA Project 1998-014-00 (Ocean Survival of Salmonids; NWFSC et al. 2011) examined the distribution and abundance of predators (piscivorous fish and birds) in and near the plume and adjacent nearshore ocean. The study revealed that predation by fish in the plume and nearshore ocean is affected by larger oceanographic conditions that control factors such as the presence of warm or cool surface waters in coastal areas and the availability of alternative prey for Pacific hake and other predators. Avian predation is a direct cause of mortality for juvenile salmonids and appears to affect juvenile salmon survival at a local level (in and around the plume and associated ocean-plume fronts).

In addition, BPA Project 1998-014-00 (Ocean Survival of Salmonids; NWFSC et al. 2011) trawled for predatory and forage fishes along a transect near Willapa Bay, WA. Willapa Bay was selected as the sole sampling transect in 2010 because of the catches of pelagic fish along this transect had been higher than those at the Columbia River transect in previous years (1998–2009). Example results are provided in Figure 20.

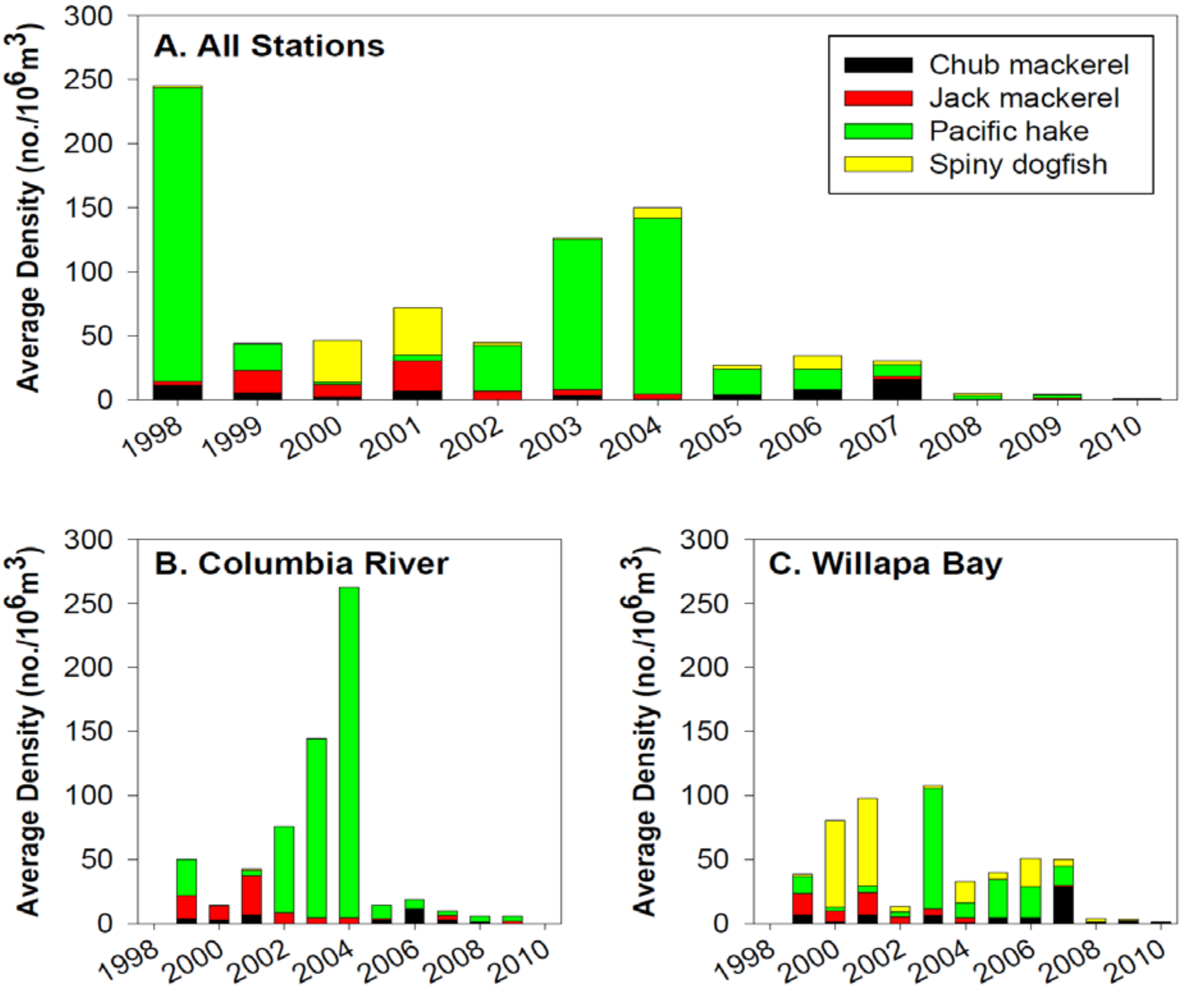


Figure 20. Annual average densities of predatory fish from (a) both Columbia River and Willapa Bay transects (1998-2010); (b) just the Columbia River transect (1998-2009); and (c) just the Willapa Bay transect (1998-2010). NWFSC et al. 2011.

Other findings from BPA Project 1998-014-00 included:

- Birds aggregated near the Columbia River mouth in both May and June.
- Year-round land-based surveys demonstrate avian predators are present near the river mouth in high densities through the entire May-September period of smolt outmigration from the Columbia River.

- Murres consumed juvenile Chinook during the July-September period.
- Regression of adult salmon returns on Caspian tern and double-crested cormorant abundance suggest that May bird abundance in the plume is inversely related to Chinook salmon returns.

For the estuary, BPA Project No. 2003-007-00 (LCRE Ecosystem Monitoring) also collected incidental information on predators in the LCRE through their habitat and fish monitoring program, including the location and abundance of predatory fish (e.g., Northern pikeminnow and small mouth bass).

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 RME.*

Two BPA projects addressed this subaction. BPA Project No. 2003-007-00 (LCRE Ecosystem Monitoring) collected bathymetric data and collaborated with a related Corps project (funded through the Corps' Lower Columbia River Estuary General Investigation Study) to develop a seamless elevation model for the LCRE that also incorporated recently acquired topographic LiDAR data sets. This product represents the most up-to-date, most comprehensive, and highest resolution elevation data set that has yet been generated for the LCRE. The two groups will work together to keep the terrain model current as future datasets become available. The terrain model has been provided to both USGS and the University of Washington to complete the LCRE Ecosystem Classification (see RPA 59.2). The terrain model and its component parts are available upon request from the Estuary Partnership in GIS format. This updated elevation model is now used by most (if not all) project sponsors who do habitat improvement planning and design, and is used by groups modeling physical processes in the estuary.

BPA Project No. 2003-011-00 (Columbia River Estuary Habitat Restoration) used technical assistance funding to collect bathymetry data for the East Fork of the Lewis River to support hydraulic modeling and assess feasibility of restoration actions.

2. *Establish a hierarchical habitat classification system based on hydrogeomorphology, ground-truth it with vegetation cover monitoring data, and map existing habitats.*

One BPA project was designed to address this subaction. BPA Project No. 2003-007-00 (LCRE Ecosystem Monitoring) continued to develop the Lower Columbia River Ecosystem Classification for the Columbia River estuary (Oregon-Washington, USA). The ecosystem classification is based on six hierarchical levels, progressing from the coarsest, regional scale to the finest, localized scale: (1) Ecosystem Province; (2) Ecoregion; (3) Hydrogeomorphic Reach; (4) Ecosystem Complex; (5) Geomorphic Catena; and (6) Primary Cover Class. The conceptual basis and preliminary application are available in Simenstad et al. (2011). The draft classification (mapping hierarchical levels, reaches, complexes and catenae, terrain model, and land cover) has recently been completed and is currently undergoing the required USGS final review process. The classification and land cover GIS files are available on request from the LCREP.

3. *Develop an index of habitat connectivity and apply it to each of the eight reaches of the study area.*

   One Corps project was designed to address this subaction. AFEP EST-09-P-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 habitat connectivity index for the LCRE. In 2011, researchers produced a prototype rapid-extraction dike map for the LCRE. The mapping data were derived from light detection and ranging (LiDAR) data via a computer-assisted GIS application. This same process is expected to provide an independently derived passage barrier layer (Diefenderfer et al. 2012).

   AFEP EST-09-P-01 also continued development and application of an area time inundation index model (ATIIM). The ATIIM characterizes hydrologic process metrics at a site, including maximum inundated area, maximum frequency and duration, inundated area, and water volume fluxes for the purpose of restoration planning. Work in 2012 will focus on making the ATIIM available to and usable by habitat restoration practioners. An ArcGIS extension of the ATIIM will be created, and the extension and accompanying user's manual will be housed in the ESRI ArcGIS Resource Center (*http://resources.arcgis.com/en/home/*), available for free public download. This tool will allow restoration planners with commonly available GIS capabilities to evaluate changes to maximum inundated area, maximum frequency inundated area, water volume fluxes, and habitat opportunity for use in restoration project planning.

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.*

   One Corps and two BPA projects continued to fully address this RPA subaction.

   BPA Project No. 2003-007-00 (LCRE Ecosystem Monitoring) monitored salmonid density, fish community composition, salmonid age-size structure, genetic stock identity, spatial and temporal distribution, growth rates and habitat characteristics in shallow-water habitats that support the evaluation of the relative importance of various habitat types to juvenile salmon fish performance and the ecological benefits of estuarine habitats. In 2011, juvenile salmonids and other fishes were monitored at three new tidal freshwater sites, three fixed sites were resampled, and a new fixed site was added in order to examine year-to-year trends in the above metrics at the sites. Sampling efforts in 2011 provided patterns of salmon occurrence at monitoring locations (see Figure 21). Overall, sampling indicated that unmarked juvenile Chinook, coho, and chum salmon are feeding and rearing in representative sites of the LCRE and was consistent with past data showing that emergent marsh tidal freshwater habitats are productive rearing areas for juvenile salmonids. For example, pilot results from the PIT-tag array in Campbell Slough indicated that hatchery Chinook salmon from locations as far away as the Dworshak Hatchery on the Snake River and juvenile sockeye salmon resided in Campbell Slough (Reach F, see Figure 19) for up to 12 days. These data are consistent with the Estuary Partnership's genetics information from previous years (Sagar et al. 2011) showing multiple Chinook salmon stocks at Campbell Slough.

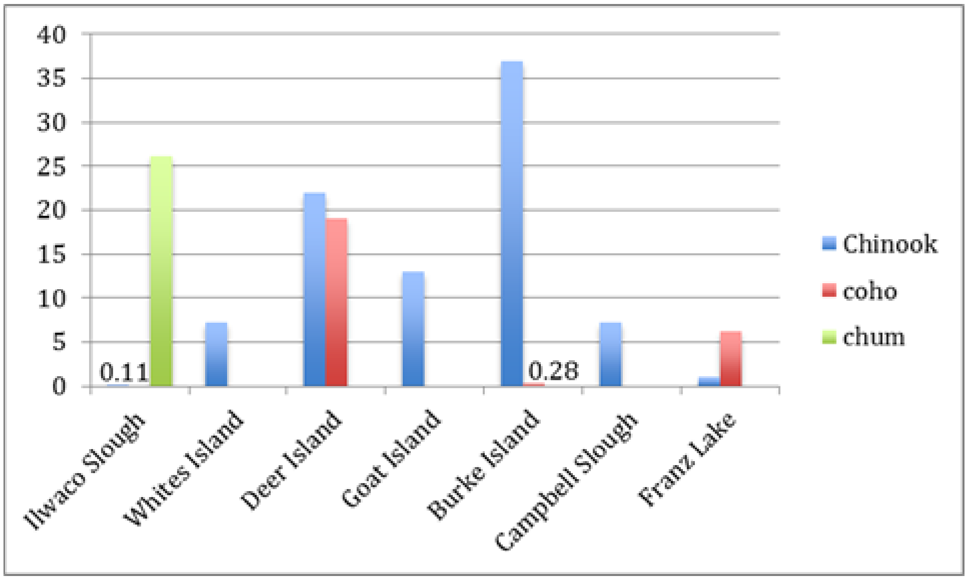


Figure 21. Marked and unmarked salmonid catch per unit effort per 1,000 square meters at the 2011 LCRE Ecosystem Monitoring sites (Sagar et al. 2012).

BPA Project No. 2004-002-00 (PNAMP) continued to develop the Integrated Status and Trend Monitoring (ISTM) Project Master Sample Tool to support revision of the ongoing estuary status and trend monitoring program. The ISTM project started evaluating the LCRE monitoring program for ESA-listed salmonids and a series of indicators based on priority management decisions, questions, and objectives from salmon recovery plans, Federal monitoring guidance, and overarching statewide and Columbia Basin strategies.

Corps AFEP EST-P-11-01 (Multi-Scale Action Effectiveness Research in the Lower Columbia River and Estuary) evaluated juvenile salmon use of shallow-water habitats at the SRD, rkm 188 to 202 and the lower river reach (LRR), rkm 110 to 141. Sather et al. (2012) presents a complete summary of results. Below is a brief synopsis of results from that report:

- Juvenile salmon (SRD) – Juvenile salmon were most abundant in spring months. As found in our previous work, unmarked Chinook were most common. Both subyearling and yearling unmarked Chinook were captured during winter months. Small, unmarked subyearling Chinook persisted from winter to spring.
- Residence time (SRD) – Juvenile Chinook and coho salmon resided in the off-channel area behind Gary Island near the SRD from February through April (mean 25 and 29 days, respectively). A portion of the tagged fish migrated out of the study area soon after release in February, as evidenced by the median residence times of 11 days for both Chinook and coho salmon. The median residence time for Chinook salmon in 2011 (11 days) was lower than it had been in 2010 (26 days; Johnson et al. 2011b). No interior basin stocks were tagged, hence residence times from February through April are not known for these stocks.
- Genetic stock groups (SRD and LRR) — Trends in genetic stock distribution of Chinook salmon are spatially and temporally consistent with past years' research, suggesting that major stock distribution patterns in Columbia River tidal

freshwater habitats may remain relatively stable across the years. These consistencies include both temporal (seasonal) and spatial (SRD vs. LRR) patterns for several different stocks. While the Chinook salmon juveniles in these habitats are primarily from three fall-run stock groups (Upper Columbia River Summer/Fall, Spring Creek Group Tule Fall, and West Cascade Tributary Fall), sampling consistently included smaller numbers of spring-run fish from both lower river and interior basin sources. Snake River fall Chinook made up 2 percent of unmarked juvenile Chinook salmon sampled for genetic identification at SRD. Snake River spring Chinook were rarely encountered (representing 0.3% of those Chinook sampled for genetic identification). Middle and Upper Columbia spring Chinook were not represented.

AFEP EST-P-10-01 (Columbia River Estuary Contribution to Salmon Recovery) evaluated juvenile salmon use of tidal freshwater habitats. The 2010-11 genetic surveys provided new data about the temporal patterns of estuary migration of salmon from different ESUs and stock-specific use of (1) mainstem, (2) backwater, and (3) tributary confluence habitats from Bonneville Dam to rkm 100 and near the estuary mouth (at Point Adams Beach). Genetic surveys documented all ESUs using shallow estuarine habitats except for Upper Columbia spring stocks:

- High proportions of Upper Columbia stocks were present in reaches F-H. See Figure 19 for a map of the reaches.
- Lower Columbia stocks were present in all reaches.
- Spring Creek Group fall Chinook were present in all reaches but were few in numbers after spring.
- Upper Columbia summer/fall juveniles were present during spring surveys in reaches E-H but exhibited a strong peak in July in reaches E (44%), F (44%), G (38%), and H (77%).
- During extreme flooding conditions in early July 2011, researchers documented large numbers of Chinook salmon accessing the forested floodplain in lower Multnomah Channel. Approximately 63 percent (n=90) were of Upper Columbia River summer/fall origin.
- Willamette River spring Chinook salmon, which occurred in reaches E and F in January and March, were nearly absent in May and July, and present again in September and November.
- Supplemental samples collected in the upper and lower ends of Multnomah Channel (Reach F) in April revealed use of off-channel habitats by Chinook salmon from a variety of genetic stock groups, but were dominated by Willamette River spring Chinook (52%) and Lower Columbia River fall Chinook (39%).
- A few Upper Columbia River spring Chinook were detected at the PIT monitoring site at Russian Island.

Stock-specific use and importance of particular habitat types will be the focus of the habitat surveys scheduled in 2012 and beyond.

5. *Monitor habitat conditions periodically, including water surface elevation, vegetation cover, plan community structure, primary and secondary productivity, substrate characteristics, dissolved oxygen, temperature, and conductivity, at representative locations in the estuary as established through RME.*

Nine AFEP and four BPA projects continued to address this RPA subaction.

BPA Project No. 1998-014-00 (Ocean Survival of Salmonids) substantially extended and revised the Climatological Atlas for the Columbia River plume and estuary, and circulation simulations were conducted to study the sensitivity to sea level rise of the plume/estuary metrics with fisheries relevance. BPA Project No. 2003-011-00 (LCRE Habitat Restoration) used standard protocols to monitor habitat (vegetation community composition, vegetation planting survival, sediment accretion, hydrology, and continuous water quality parameters), fish (fish communities, salmon growth, condition and genetic information), and macroinvertebrates (macroinvertebrate availability and those selected for by Chinook salmon). After October 2011 the contracted monitoring of 2003-011-00 was transferred to Project 2003-007-00 for future contracts.

BPA Project No. 2003-007-00 (LCRE Ecosystem Monitoring) surveyed sites for elevation; determined percent cover of vegetation along transects, and mapped prominent vegetation communities within the marsh. Since 2009, project sponsors have also measured channel cross sections, installed sediment accretion stakes at all sites, and collected sediment samples at new sites. In the 2011 sampling year, project sponsors also collected biomass data at all trend sites, excluding Cunningham Lake.

Observations from the 2011 monitoring year were generally consistent with patterns documented in previous years. Specifically, interannual hydrologic variability was a primary factor driving variability in vegetation cover, composition, and biomass. The hydrologic variability and the resulting inundation of the marshes also varied dramatically along the estuarine gradient, with high inundation and variability in the upper fluvial-dominated estuary and lower inundation and seasonal variability in the tidal-dominated lower estuary. Likewise, channel inundation also varied longitudinally and between different types of sites, affecting potential fish access to the sites. In general, the emergent marshes of the LCRE were diverse, productive systems with channels that provide access opportunity to juvenile salmonids throughout the LCRE.

AFEP EST-P-11-01 (Multi-Scale Action Effectiveness Research in the Lower Columbia River and Estuary) provided a preliminary characterization of site-specific water property attributes during four time periods throughout the year at the Sandy River Delta in 2011. Water properties attributes considered included: temperature, dissolved oxygen, total suspended solids, particulate organic carbon, nitrate, phosphate, and chlorophyll-a. Researchers noted that water properties differed greatly between seasons. A reduction in nutrients was observed as phytoplankton production increased during summer months and light levels increased. Total suspended solids and chlorophyll-a did not differ greatly between Sandy River Delta and the LRR. Sather et al. (2012) presents a complete summary of results.

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).*

Two BPA projects and one Corps project continued to address this RPA subaction.

In 2011, BPA Projects No. 2003-007-00 (LCRE Ecosystem Monitoring) and No. 2003-011-00 (LCRE Habitat Restoration) provided their final report and summaries of their

2010 Columbia River and Estuary Restoration Reference Site Study (Borde et al. 2011). The study includes new information on factors structuring shallow water vegetated habitats along the entire estuary gradient. The relationships between location, hydrology, and elevation provide valuable potential predictors useful in restoration planning, as well as evaluation of the rates and trajectories of restored sites. Restoration planners can use this information to more accurately excavate elevations when targeting certain habitat types and potentially improve their ERTG score via the "certainty of success" criteria.

Overall, project sponsors found the elevation range for the major habitat types (e.g., emergent marshes) to be small (i.e., <2 meters), which strongly suggests that elevations and hydrodynamics must be carefully considered in the design of wetland restoration sites, the analysis of differences between sites, and the trajectories and rate of development of restored sites. The invasive species reed canary grass covered the widest elevation range of any species. Data on elevation collected by this project should help plan actions to minimize the invasion of reed canary grass into new sites.

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.*

One BPA project and two AFEP projects continue to address this RPA subaction.

BPA Project No. 2003-011-00 (LCRE Habitat Restoration) was continued to evaluate the success of restoration projects and use this information to improve restoration project design. Since 2008, four Action Effectiveness Monitoring (AEM) restoration sites in the LCRE have been monitored, both pre- and post-restoration, for habitat, fish, and macroinvertebrates. The four AEM sites in this program represent different restoration activities, habitats, and geographic reaches of the LCRE. Monitored parameters follow standardized LCRE protocols and include habitat (vegetation community composition, vegetation planting survival, sediment accretion, hydrology, and continuous water quality parameters), fish (fish communities, salmon growth, condition and genetic information), and macroinvertebrates (macroinvertebrate availability and those selected for by Chinook salmon). Also in 2011, the AEM program sites were analyzed by comparing pre- and post-construction data and/or by comparing them to a reference site. The reference site study (BPA Project No. 2003-011-00) compared habitat conditions at these AEM sites to reference sites to further evaluate the effectiveness of restoration actions and inform restoration site design considerations.

Some "lessons learned" from this project include:

- *Scappoose Bottomlands site* — Project sponsors initially hypothesized that the lack of understory diversity was primarily caused by cattle grazing; however, it now appears that highly variable water levels play a significant role in plant community establishment. In addition, an unintended effect of cattle exclusion has been an increase in the dominance of reed canary grass and a decrease in facultative upland and marshy shore plant community. To ensure the success of this restoration project, longer-term monitoring is desired and weed management is recommended.
- *Sandy River Delta site* — At certain locations, distinguishing between individual native plants that are "installed" during site improvement and those that are naturally recruited has become increasingly difficult. While there is value in

independently assessing survival of installed plants, as well as natural recruitment, to do so reliably would require some means of marking or labeling plants during installation. A better indicator of progress toward reference site conditions may be the statistic for total native woody stems, which encompass both live planted and naturally re-established plants.

- *Fort Clatsop site* — The 2011 fish sampling modification to address several technical issues proved successful: Seining down the channel reduced escapement, provided a well-defined area in which to measure fish density, increased catch totals, and provided a more accurate representation of the fish density, abundance, and composition. This method will be continued in upcoming seasons at South Slough and Alder Creek.

Corps AFEP EST-P-11-01 (Multi-Scale Action Effectiveness Research in the Lower Columbia River and Estuary) contributed to site-scale, pre-restoration sampling for the proposed rechannelization at the Sandy River Delta and landscape-scale sampling (Lower River Reach). Restoration actions are pending. These data have been planned and collected such that meta-analysis of pre- and post-project data can be statistically analyzed. Pre-restoration conditions have been intensively evaluated at the Sandy River Delta, as documented above for RPA 58 and RPA 59.

Corps AFEP EST-09-P-01 (Evaluation of Life History Diversity, Habitat Connectivity, and Survival Benefits Associated with Habitat Restoration Actions in the Lower Columbia River and Estuary) evaluated plant community composition at 52 tidal wetlands (marshes, shrub, and forested areas) in the LCRE. Marshes, shrub wetlands, and forested wetlands were examined respective to their location and landforms, such as tributaries, islands, and bays. Three distinct wetland origins were considered: historically present, historically breached, and created. Summary statistics, including environmental tolerance ranges, will be provided for: vegetation (abundance, distribution, composition); sediment accretion rate; elevation; water temperature (time series); inundation (integrated water level and topography); channel morphology (relative channel depth and morphology); floodplain and channel substrate type (grain size, total organic carbon); and seasonal fish access potential (water depth). The data will be analyzed to determine the processes that form and maintain habitats as well as the rates at which plant communities and site geometry are developing. Seasonal patterns and ranges of potential salmonid access to tidal wetland sites would be quantified. These data will be available in the summer of 2012.

Corps AFEP EST-05-P-07 at Julia Butler Hansen National Wildlife Refuge evaluated pre- and post-habitat restoration conditions resulting from the installation of side-hinged, self-restrained tide gates, the purpose of which was to improve fish passage into and out of tidal slough habitats. In 2011, fish passage, presence, and distribution were evaluated at three previously closed sloughs (Hampson, Winter, and Indian Jack), two previously gated sloughs (Duck and Brooks), and two reference sloughs (Steamboat and South Hunting) from March 17 through June 23. Researchers compared fish passage, presence, and distribution before construction, after construction, and at the reference and control sites. Key findings from 2011 include:

- Juvenile salmon (Chinook, coho, chum salmon and coastal cutthroat trout) were captured at treatment, control, and reference sloughs. More juvenile salmon were collected at the treatment sloughs after tide gate installation or retrofit.

- Juvenile salmon density was highly variable; it was not uncommon to capture zero Chinook salmon in multiple seine pulls but then subsequently capture several. As such, researchers concluded that fish density was not a reliable indicator of juvenile salmon abundance.
- Juvenile salmon distribution increased extensively after construction at previously closed sloughs and at previously gated sloughs.
- Fish communities at the previously closed sloughs were very similar to those at the reference sloughs; however, this relationship was not observed between the two previously gated sloughs and the two reference sloughs.

In summary, installation of self-regulating tide gates at Hansen National Wildlife Refuge has increased juvenile salmon access to tidal sloughs. Juvenile salmon were captured in more treatment slough reaches after the self-regulating tide gates were installed; and the fish community structure in the previously closed sloughs showed increased similarity to fish community structure in the reference sloughs. From other work at Tenasillahe Island (part of the refuge), researchers observed fish surviving, and with high measured growth rates within refuge sloughs during summer, in spite of high water temperatures (7 day average daily maximum water temperature over 16º C). Juvenile salmon use of tidal slough habitats in summertime is not well understood. These data and findings are documented in Johnson and Whitesel (2012), along with an account of fish passage capabilities of side-hinged, self-restrained tide gates; a characterization of mainland slough habitats; and a description of changes in fish community and habitat quality with the reintroduction and/or improvement of the return of tidal exchange.

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.*

Corps AFEP EST-02-P-04 published the levels-of-evidence analytical approach to estimate the cumulative effects of habitat restoration (Diefenderfer et al. 2011) and presented the approach at the National Conference for Ecosystem Restoration. In addition, researchers applied this analytical approach of cumulative effects analysis at three paired restoration and reference sites: Crims Island, Vera Slough, and Kandoll Farm. They will be assessing four lines of evidence: ecological relationships, meta-analysis, net ecosystem improvement, and analysis of spatial and temporal synergies. This analysis will be available in the summer of 2012. Corps AFEP EST-P-11-01 (Multi-Scale Action Effectiveness Research in the Lower Columbia River and Estuary) will continue to apply this analytical framework at site, landscape, and estuary scales.

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 nearshore ocean environments to the viability and recovery of listed salmonid populations in the Columbia River Basin.*

Three BPA projects continued to address this RPA subaction. In the estuary, BPA Project No. 2003-007-00 (LCRE Ecosystem Monitoring) monitored juvenile salmon use of wetland habitats in the LCRE, supporting the planning and adaptive management of restoration actions. In shallow-water habitats, monitoring included salmonid density, 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 that would support the relative importance of early life history of salmon populations in tidal freshwater of the Lower Columbia River. In 2011, juvenile salmonids and other fishes were monitored at three new tidal freshwater sites in Reach E, and four fixed sites were resampled to examine year-to-year trends in the above metrics at the sites. Overall, for the seasonal trends of salmonid capture, the project sponsors encountered few salmonids during their extended fall and winter sampling. However, they observed a small number of Chinook and coho at Franz Lake during late fall sampling, consistent with Sather et al. (2009) and Johnson et al. (2011), showing the presence of juvenile Chinook and coho salmon at Sandy River Delta sites in December.

In the plume and nearshore environment, BPA funded Projects 1998-014-00 (Ocean Survival of Salmonids), and 2003-009-00 (Canada-USA Shelf Salmon Survival Study). These studies support an ongoing research partnership between BPA, NMFS (NOAA), and the Department of Fisheries and Oceans Canada. These programs study juvenile salmon as they enter the ocean and during their first few months of marine residence, and they also monitor the ocean conditions experienced by these fish. The primary focus of both projects is to determine the physical, biological, and ecological mechanisms that control survival of salmon during their early marine life. By collecting comparable and complementary biological and oceanographic data, these projects provide broad coverage of the plume and continental shelf waters exploited by Columbia River juvenile salmon. BPA also funded a third ongoing ocean study, Project 2003-114-00, Coastal Ocean Acoustic Salmon Tracking (COAST), which was initiated in 2005 by Kintama Research Services, Ltd. Acoustic tags were used to track juvenile Chinook salmon migration and mortality through the Columbia River hydropower system and into the coastal ocean. Annual survival rates of acoustic-tagged smolts in the coastal ocean varied by a factor of 5 or more and tracked NOAA's annual assessment of ocean conditions, demonstrating that the coastal ocean survival estimates seem to track ocean conditions well (Jacobson et al. 2012). Research by these BPA-funded ocean projects has produced the following new insights as to when mortality occurs during the juvenile migration and which factors affect the survival of Columbia River juvenile salmon during early ocean residence.

Corps AFEP EST-P-11-01 (Multi-Scale Action Effectiveness Research in the Lower Columbia River and Estuary) has to-date conducted site-scale, pre-restoration sampling for the proposed rechannelization at the Sandy River Delta, and it has done landscape-scale sampling in the LRR. Restoration actions are pending; however, the research findings derived from this study address critical uncertainties and information gaps in the LCRE. Sather et al. (2012) presents a complete summary of results. Key findings from SRD and LRR include:

- Fish community composition — Trends in fish community composition at SRD are similar to those observed during previous years of sampling (see Johnson et al. 2011). Beach seine catches were dominated by native taxa; non-native species composed approximately 21 percent of the total catch. Summer and fall yielded the highest densities for native (excluding salmon) and non-native taxa, respectively. Eight species accounted for 98 percent of the total catch (Sather et al. 2012, Table 3.1). Fish community composition was similar across broad expanses of tidal freshwater segments in the LRR. Fish assemblages were most closely explained by seasonal trends as opposed to trends linked to sites, habitat strata, or study region.

- Fish densities were higher in the LRR than in the SRD.
- A total of 50 marked (known hatchery origin) Chinook salmon captured in the SRD were analyzed genetically. Most of the hatchery fish were from the Spring Creek Group Tule Fall (49%) and Upper Columbia Summer/Fall (35%) stock groups. Four other stock groups contributed small proportions to the marked fish mixture (2%–4%). Of seven marked juveniles sampled at SRD Site B in April 2011, three yearling-sized fish were estimated with high probabilities to be spring Chinook salmon. These yearlings were from the Snake River, Middle and Upper Columbia River, and West Cascade stocks.
- Unmarked and marked Chinook salmon — A greater proportion of unmarked Chinook salmon were captured in the LRR and a higher proportion of marked hatchery Chinook salmon were captured at SRD. Unmarked Chinook salmon sampled at SRD were significantly larger than those sampled from LRR sites. This trend was not apparent for the marked hatchery Chinook salmon sampled from the two study regions.
- Fish Diet Overlap – Dietary overlap was generally weak at SRD during months in which the gut contents of both Chinook salmon and resident species were collected, suggesting low potential for interspecific competition between Chinook salmon and the four resident species that were examined. Researchers noted that these results are preliminary and do not necessarily represent year-round dietary shifts and overlap. Future field investigations will consider more frequent sampling or the use of time-integrated information (e.g., stable carbon isotopes) to elucidate shifts in diet (i.e., variability in diet overlap) and better inform inferences about competitive interactions between sympatric species.

Corps AFEP EST-P-10-01 (Columbia River Estuary Contribution to Salmon Recovery) — The estuary-wide genetic surveys provided coarse-scale data on the seasonal timing and estuary distributions of each ESU, a first step toward identifying the reaches and habitats frequented by at-risk stocks, including important listed ESUs/DPSs from the Interior Columbia basin. The results from the 2010–11 genetic surveys are being used to design higher resolution studies targeting particular tidal-fluvial habitats, including but not limited to those that may be used by at-risk stocks. Genetic surveys documented all ESUs using shallow estuarine habitats except for Upper Columbia spring stocks. A few Upper Columbia spring Chinook also were detected at the PIT monitoring site at Russian Island (Dan Bottom, NWFSC, personal communication). As noted above, estuary distributions varied by ESU, with relatively high proportions of Upper Columbia stocks in reaches F-H and Lower Columbia stocks in the other estuary reaches. Reach F was selected for the higher resolution studies scheduled in 2012 because of the habitat complexity and high diversity of Chinook stocks near the Willamette River confluence. This reach hosted a mixture of representatives from lower river, upper river, and Willamette River ESUs.

2. *Continue work to define the causal mechanisms and migration/behavior characteristics affecting survival of juvenile salmon during their first weeks in the ocean.*

In 2011, three BPA-funded projects supported studies to define the causal mechanisms and migration/behavior characteristics affecting survival of juvenile salmon during their first weeks in the ocean. BPA Projects 2003-009-00 (Canada-USA Shelf Study), 1998-014-00 (Ocean Survival of Salmonids), and 2003-114-00 (Coastal Ocean Acoustic Salmon Tracking) all continued to examine causal mechanisms affecting survival such as food-web structure and growth conditions in the plume and coastal ocean. Results demonstrate that food-web structure is set by currents determined by large-scale atmospheric forces, and that differences in circulation patterns account for differences in prey abundance, composition, and quality at the lower trophic levels. The distribution and abundance of predators and forage fish are also influenced by circulation patterns. Food-web structure and predation affects the growth and survival of juvenile salmonids in their first weeks in the ocean. These projects have also determined that the migration and behavior of juvenile salmonids vary depending on the salmonid population and ocean conditions; migration rates during the first months at sea are higher during years of poor ocean conditions, suggesting juveniles may modify their migratory behavior based on ocean conditions.

For example, BPA Project 1998-014-00 (Ocean Survival of Salmonids) completed an individual-based model of salmon growth and coastal migration to qualitatively compare how local environmental conditions affect the migration pathways of virtual fish. Project sponsors modeled how fish would respond to local conditions throughout the plume and nearshore environments. This tool enables project sponsors to track virtual fish through the system as they dynamically respond to local environmental conditions, such as temperature or ocean currents, that could be predicted based on different management scenarios. It also can be used to estimate the potential response to climate change. These findings may be used to predict how fish migratory pathways may change under different scenarios. Fish performance was summarized in terms of spatial distribution and growth under various behavioral and management scenarios, indicating that relatively minor behavioral differences can result in dramatically different spatial distributions. (See Figure 22.)

The Corps-funded seasonal effects of transportation study continues to collect marine environmental data to identify specific conditions when transporting juveniles will result in the greatest adult return rates. This marine data will be analyzed with the weekly SAR data being collected by the Action Agencies in order to evaluate what estuary and ocean conditions are optimal for releasing transported fish with the goal of increasing adult returns. Water temperature has been identified as a key variable in explaining variation in SARs. Other variables will continue to be evaluated in modeling efforts.

3. *Investigate the importance of early life history of salmon populations in tidal freshwater of the lower Columbia River.*

Four BPA projects and two Corps projects continued to fully address this RPA subaction.

BPA Project Nos. 2003-007-00 (LCRE Ecosystem Monitoring) and 2003-011-00 (Columbia River Estuary Habitat Restoration) surveyed sites to refine the fish habitat catena detailed in RPA subaction 59.2. BPA Project 2003-007-00 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 that would support the relative importance of early life history of salmon populations in tidal freshwater of the Lower Columbia River. In 2011, juvenile salmonids and other fishes were monitored at three new tidal freshwater sites, three fixed sites were resampled, and a new fixed site was added in order to examine year-to-year trends. This project sponsor encountered few salmonids during the extended fall and winter sampling in 2011, and full results are provided in the project’s annual report (Sagar et al. 2012).

BPA Project No. 2009-020-00 (UW-CBR Internal Statistical/Technical Support to BPA) provided technical assistance on an “as needed” basis, particularly with regard to BPA Project No. 2003-114-00 (COAST).

Corps AFEP EST-P-11-01 (Multi-Scale Action Effectiveness Research in the Lower Columbia River and Estuary) investigated the importance of early life history of juvenile salmon in tidal freshwater habitat of the LCRE. The following is a brief synopsis of findings reported in Sather et al. (2012) regarding juvenile salmon use of tidal freshwater habitats:

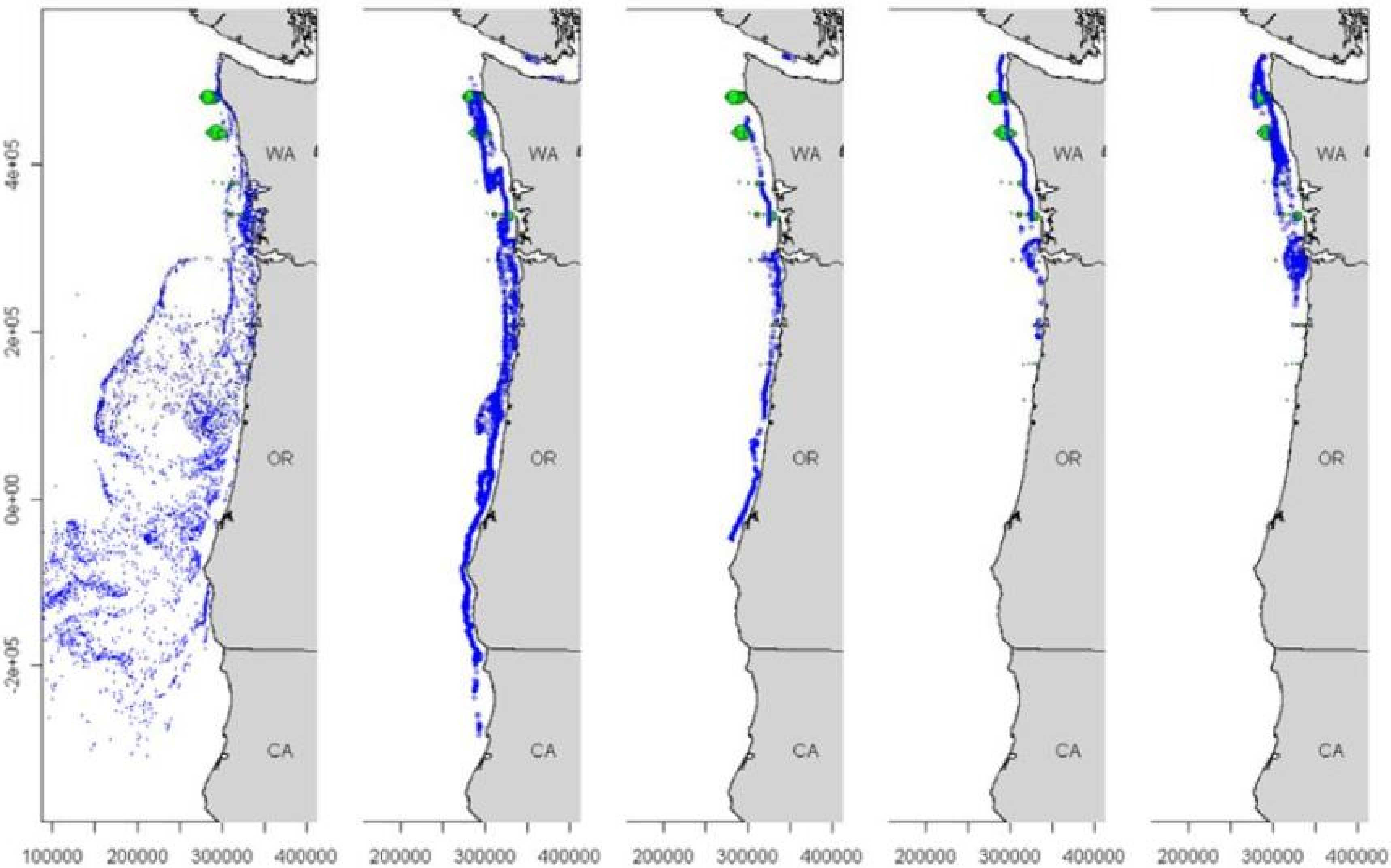


Figure 22. Locations of 10,000 simulated fish after a 60-day period ending 25 June 2004. Behaviors ranged from no behavior (passive particles, in the far left panel) to fish actively swimming north and optimizing water depth (far right panel).

- Residence time — Juvenile salmon (Chinook and coho) used tidal freshwater portions of the LCRE for extended periods from mid-winter through early spring months. No interior basin stocks were tagged, hence residence times from February through April are not known for these stocks.
- Bioenergetics — Feeding rates and gross conversion efficiency were sufficient for the allocation of energy to somatic growth for juvenile salmon.
- Seasonal timing — Abundance of juvenile Chinook salmon generally decreased during summer and fall months and increased in winter. Two size classes (fry and yearling) of unmarked Chinook were observed in winter. Acoustic telemetry of tagged fish (>95 mm) suggests that juvenile salmon are residing in shallow, tidal freshwater habitats during winter (see Section 3.3.2 in Sather et al. 2012, and see Johnson et al. 2011b). Future investigations to tag smaller juvenile salmon will provide further information on this topic.
- Juvenile salmon density — Highest densities of juvenile salmon were observed in the spring; the majority of which were quite small in size (e.g., fry to parr). Mean seasonal density estimates were not calculated for different genetic stock groups.

Corps Project AFEP EST-P-10-01 (Columbia River Estuary Contribution to Salmon Recovery) initiated a series of otolith studies in 2010-11 to determine the contribution of tidal freshwater habitats to the successful return of spawning adults. The laboratory and field studies were designed to (1) develop new indicators for reconstructing juvenile salmon residency in the tidal freshwater environment, and (2) validate methods for back-calculating juvenile salmon sizes based on otolith measurements. Major work elements included:

- Otoliths from juvenile salmon were examined to determine whether otolith barium is a valid indicator of juvenile salmon residency in the tidal freshwater reaches of the LCRE. Results showed that otolith barium was present in juvenile salmon at all main-channel sampling sites in the upper estuary (reaches D–H), but values differed significantly between these sites and several tributaries (Cowlitz and Hamilton Creek). Researchers concluded that water chemistry information would be needed to further evaluate whether otolith barium can be used to reconstruct salmon entry into tidal freshwater environments.
- Strontium markings were examined as an alternative to the barium method. Juvenile salmon from the Coweeman River were artificially marked with strontium chloride to evaluate whether tidal freshwater entry and residency can be determined based on adult otoliths. In this method, residency in tidal freshwater habitats might be inferred from the relative strengths of strontium isotopic signatures seen in their otoliths, indicating the proportion of artificial strontium (applied to downstream migrants) and natural strontium (incorporated when juveniles later enter the brackish portion of the estuary). Analysis of the Coweeman marking experiment is continuing.
- The accuracy of back-calculating fork lengths and residence times was tested. These methods are important to collate with early life-history reconstructions derived from salmon otolith measurements. Individuals held in laboratory tanks were artificially marked with strontium to compare known fish sizes at various ages with back-calculated estimates. Results from these experiments are still being analyzed.
- The chemistry of adult Chinook otoliths from the Grays River and Coweeman River was analyzed. Similar adult otolith analyses are planned for six other

Columbia River tributaries (Lewis, Willamette, Sandy, Priest Rapids, Wenatchee, and Methow), for a total of eight river basins representing 12 or 13 different salmon stocks. Following these results, a suite of indicator populations will be selected for the purpose of tracking variability in the early life history types that contribute to adult returns from a diversity of ESUs.

BPA Project No. 1989-107-00 (Statistical Support for Salmon) provided statistical support, as needed.

4. *Continue development of a hydrodynamic numerical model for the estuary and plume to support critical uncertainties investigations.*

One BPA and one Corps project continued to address this RPA subaction.

BPA Project No. 1998-014-00 (Ocean Survival of Salmonids) updated annual predictions of the relative survival of juvenile coho and Chinook salmon in the Columbia River plume based on ocean conditions. The Science and Technology University Research Network (SATURN) is an integrated system of networked sensors, platforms, models, data, analyses, and social processes whose outputs can function as a "virtual Columbia River." This project employed the virtual Columbia River space-time simulation environment (*http://www.stccmop.org/datamart/virtualcolumbiariver*) to characterize contemporary plume variability and understand the role of the plume in salmonid survival through multiple representations of circulation processes, variability, and change in the estuary and shelf environments.

Corps AFEP EST-P-10-01 (Columbia River Estuary Contribution to Salmon Recovery) adapted an existing numerical model for the estuary and plume to the tidal freshwater portion of the estuary by extending the modeling grid upriver to Beaver Army Terminal. Simulations using the new grid were calibrated based on the performance of the model for mainstem elevations. We simulated daily forecasts of circulation based on one full year (2000) of a simulation database. The results identified the need for further refinements in the local grid and changes in ocean boundary conditions for the model. We began exploratory computation of salmon habitat opportunity indices in the tidal freshwater portion of the estuary, based on previously developed criteria for water depths, velocities, and temperatures. Continuous updates were made in the database for circulation and associated habitat opportunities. Plans for 2012 include detailed habitat-opportunity modeling in Reach F using a higher resolution grid. We also will explore methods for integrating the results of the habitat modeling into salmon life-cycle models. Of particular interest will be methods for using salmon performance measures within the estuary (as influenced by habitat opportunities and capacities) to promote the viability and recovery of populations.

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.*

Nine BPA projects were continued and two were initiated to fully address this RPA subaction. For example, BPA Project No. 2008-508-00 (Power Analysis Catch

Sampling Rates) evaluated run timing and upstream migration mortality of adult Chinook and sockeye salmon and steelhead through PIT-tagging at Bonneville Dam. In August 2011, WDFW and the Pacific States Marine Fisheries Commission, with funding from the BPA, implemented PIT-tag sampling concurrent with the ongoing fisheries sampling for biological data and coded wire tags in the treaty and non-treaty commercial fisheries. The purposes of this monitoring program are to: (1) report PIT-tagged fish sampled to PTAGIS, (2) develop estimates of PIT tags sampled in fisheries, and, (3) where possible, develop estimates of harvest by PIT-tag group.

2. *Evaluate methods to develop or expand use of selective fishing methods and gear.*

Four projects were continued to fully address this RPA subaction. The Action Agencies continued to support investigations of alternative gear and modifications to existing gear strategies for fisheries in the Columbia River Basin. They support development of selective gear methods to reduce hatchery surpluses consistent with Hatchery Scientific Review Group recommendations. BPA Project No. 2007-249-00 (Evaluate Live-Capture Fishing Gear for Salmon) focuses on evaluating the feasibility and efficacy of various live-capture selective fishing gears to harvest hatchery-origin Chinook while protecting natural-origin Chinook in the Upper Columbia and Okanagon rivers. Work continued into 2011 with high success at capturing sockeye with the use of tangle nets at the mouth of the Similkameen River. In addition to gear testing, selective fishing can involve modifications to time and area management. BPA Project No. 1993-060-00 (Select Area Fisheries Enhancement) continues to investigate and implement the use of off-channel terminal fishing locations in concert with hatchery rearing and acclimation protocols to offer commercial and sport fishers harvest opportunities even when conventional mainstem fisheries are severely constrained or eliminated because of ESA limitations.

3. *Evaluate post-release mortality rates for selected fisheries.*

Three BPA projects were continued to support this RPA. BPA Project No. 2007-249-00, which evolved into 2008-185-00 (Evaluate Live-Capture Fishing Gear for Salmon), incorporated monitoring protocols to assess fish condition after capture, holding, and release. Work continued in 2011.

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.*

Fourteen BPA projects were continued to address this RPA subaction. BPA has funded the recovery and stock identification of coded-wire tags since the early 1980s. In 2008, four BPA-funded projects implemented recovery efforts in ocean and in-river fisheries as well as some limited spawning ground surveys. In addition, many hatchery O&M projects contain resources directed toward the recovery and stock identification of coded wire tags. The RME Workgroup encouraged additional sampling effort on the spawning grounds. This may require shifting some effort from the ocean fisheries to in-river monitoring. The RME Workgroup also recommends that contracts include language to improve quality assurance/quality control, analysis, and data management.

5. *Investigate the feasibility of genetic stock identification monitoring techniques.*

Twenty-nine BPA projects were continued in 2011 to address this RPA subaction. Projects falling under this RPA subaction are primarily large-scale and comprehensive projects that are vital to gaining a better understanding of genetic identification techniques and the application of these techniques to tracking populations and/or the lineage of individual fish. These projects also look at the relationship between genetics and environmental adaptation.

For example, BPA Project No. 2009-005-00 (Influence of Environment and Landscape on Salmonid Genetics), a BPA-funded CRITFC Project focusing on environmental influences on salmon genetics, has two high-level project objectives:

a. Evaluate the genetic structure of natural populations of salmonids relative to their environment and identify candidate markers associated with traits that are related to adaptation of steelhead and Chinook salmon populations.

b. Incorporate laboratory/hatchery experiments with controlled environmental variables in order to validate the phenotypic response of fish with given genotypes.

The project has just completed year one of the study, which focused on the first objective of identifying candidate SNP markers under selection. The project has successfully identified candidate markers associated with thermal adaptation and anadromy in natural populations of steelhead. Additionally, the project found that populations exhibited a highly significant pattern of isolation by temperature, and those individuals adapted to the same environment had similar allele frequencies across candidate markers, indicating selection for differing climates. These results indicate that several genes are involved in adaptation of redband trout to differing environments.

Another project, BPA Project No. 2008-907-00 (the Genetic Assessment of Columbia River Stocks) combines four interrelated studies that contribute to addressing this RPA through the discovery and evaluation of SNP markers in salmon and steelhead; the expansion and creation of genetic baselines for multiple species (Chinook, steelhead, sockeye, and coho); implementation of the GSI programs for mainstem Chinook fisheries; and lastly, GSI of fish passing Bonneville Dam (steelhead and Chinook). Significant progress has been achieved in this project in the last 3 years. SNP discovery goals were achieved with successful development of 22 new assays for Chinook salmon and 24 new assays for steelhead. These newly discovered SNP markers will be combined with existing SNP markers to generate genetic baselines and for two applications of GSI. For genetic baseline expansion, 96 SNP markers were successfully genotyped in 32 new Chinook salmon collections and 192 SNP markers in 61 steelhead collections from the Columbia River Basin. Results from population genetics analyses suggest SNPs are a class of markers that perform well for distinguishing populations, and these baselines will be useful for estimating stock composition in GSI applications. Results also indicated that some loci may be candidate markers and valuable for analyses based on selective divergence. Future work will include the newly developed SNP baseline of steelhead populations to analyze recent years 2009–10 of steelhead.

RME Strategy 6 (RPA Actions 63–65)

A comprehensive list of all actions implemented by the Action Agencies for RPA Actions 63 through 65 is included in Section 3.

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.)*

   Sixteen BPA projects were continued to monitor the effect of safety-net and conservation hatchery programs. All ongoing BPA-funded safety-net and conservation program projects to implement RPAs 41 and 42 have monitoring and evaluation elements to evaluate effectiveness. Additionally, in some cases there is a separate project identified to monitor effects on the viability and recovery of targeted populations. For example, BPA Project Nos. 1998-007-02 (Grande Ronde Supplementation O&M and M&E on Lostine River), 1998-007-03 (Grande Ronde Supplementation O&M on Catherine Creek/Upper Grande Ronde River), and 1998-007-04 (Grande Ronde Spring Chinook on Lostine/Catherine Creek/Upper Grande Ronde Rivers) all operate on the Grande Ronde River and also monitor supplementation activities there. Additionally, BPA Project No. 2007-083-00 (Grande Ronde Supplementation M&E on Catherine Creek/Upper Grande Ronde River) has been implemented to comprehensively monitor and evaluate the effectiveness of supplementation in recovering spring Chinook salmon populations in the upper Grande Ronde River.

   BPA Project No. 2007-402-00 (Snake River Sockeye Salmon Captive Broodstock) continues to address the Snake River sockeye program and is being expanded to include rearing facilities for juvenile fish; construction at Springfield hatchery is underway. This project is specifically addressing requirements of this RPA subaction regarding the effect of safety-net programs on the recovery of targeted populations of salmon.

   BPA Project No. 1989-096-00 (Genetic M&E Program for Salmon and Steelhead) monitored and evaluated the genetic characteristics of supplemented salmon and steelhead in the Snake River Basin using SNPs. This project has collected nearly 4500 Chinook and 3300 steelhead samples for tier 2 monitoring and tier 3 pedigree analysis.

   BPA Project No. 1998-007-02 (Grande Ronde Supplementation Monitoring and Evaluation on Lostine River) continued to assess supplementation of spring Chinook in the Lostine River. Total spawner abundance was estimated at 3,852 with 1,073 estimated to be natural origin spawners. BPA Project 1998-016-00 (Escapement and Productivity of Spring Chinook and Steelhead) continued to address this RPA by monitoring a reference stream (John Day River Basin). It was estimated that hatchery origin fish composed 5 percent (n=560) of the 11,334 steelhead estimated in the basin. In addition to monitoring proportionate estimates of strays versus wild, research will continue to investigate the impact of these strays.

2. *Determine the effect that implemented hatchery reform actions have on the recovery of targeted salmon and steelhead populations.*

   Three projects addressed this RPA subaction in 2011. BPA Project No. 1993-056-00 (Advance Hatchery Reform Research) is a comprehensive RME project focused on investigating advanced hatchery reform across relevant Chinook, sockeye, and steelhead populations. This project was expanded and is currently investigating the development of local broodstocks in Winthrop NFH, Touchet, and Tucannon steelhead programs. Recent findings from this project revealed that steelhead smolts that were reared for 2 years survived to the first point of detection at significantly higher rates than 1-year-old smolts. Additionally, using a combination of pituitary follicle-stimulating hormone beta and testicular AMH, the proportion of males initiating puberty could be estimated. These findings have strong implications for broodstock management of Chinook salmon.

Two projects were begun in 2010 and continued in 2011 in order to address this RPA subaction on steelhead and Chinook populations in the Tucannon River: BPA Project Nos. 2010-050-00 (Evaluation of the Tucannon Endemic Program) and 2010-042-00 (Tucannon Expanded PIT-Tagging). 2010-042-00 reported that 2,855 summer steelhead were PIT-tagged at the smolt trap during 2011.

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 RRS feasibility study for Snake River fall Chinook to completion in 2009.*

   Nine BPA projects were continued to support this RPA subaction. BPA Project No. 2010-033-00 (Study Reproductive Success of Hatchery and Natural Origin Steelhead in the Methow) was begun in 2010 to investigate the reproductive success of hatchery and natural origin steelhead in the Methow River Basin. Early findings in 2011 detected a slight difference in the reproductive success of hatchery and naturally produced fish as measured by juveniles produced; this project is designed to evaluate reproductive success over multiple generations. These preliminary results are similar in some respects to those of other steelhead reproductive success studies, but drawing any major conclusions at this time would be premature.

   BPA Project No. 2003-039-00 (M&E Reproductive Success and Survival in Wenatchee River) completed data collection in 2010 and reported on final findings in 2011. Some relevant and important findings include:

   a. When spawning location is taken into account, the differences in reproductive success between hatchery and wild female fish become statistically insignificant.
   b. Hatchery origin remains a significant factor affecting fitness of males even after accounting for spawning location.
   c. Hatchery origin was a negative determinant of reproductive success in the hatchery environment for males, but for females hatchery origin was positive to neutral.
   d. Hatchery fish with mixed parentage (one hatchery parent and one wild parent) appeared to differ more in fitness from the “pure” crosses (HH or WW) than the pure crosses did from each other. One pattern that did seem consistent with domestication selection, however, was that second-generation hatchery fish produced significantly more adult offspring when spawned in the hatchery than

hatchery fish with any first-generation wild ancestry (WW, WH, or HW). In the wild environment, hatchery fish that were produced by a hatchery female and wild male seemed to have consistently lower reproductive success than other combinations of hatchery and wild ancestry.

e. Some of these traits are likely to be quite heritable and therefore subject to short-term evolution due to natural and artificial selection in this system. For example, preliminary analysis of male age of maturity suggests both a strong correlation between parent and offspring age at maturity and a clear difference between the hatchery and natural environments in typical age at maturity.

f. Significant differences among reaches were found for most habitat variables suggesting that habitat quality and quantity does influence spawning site and redd characteristics (Because target sample sizes have not been met, conclusions regarding differences in spawning site and redd characteristics of hatchery and naturally produced spring Chinook salmon should be considered preliminary).

g. Many of the variables measured in this study have not been reported for spring Chinook salmon or any other salmonids and the relative importance of all variables to survival and ultimately reproductive success is unknown. Additional analysis of all data is needed after data regarding reproductive success has been analyzed.

h. As the sample sizes increases over time, the relationship between redd characteristics and spawner density may provide important information on competition among females on the spawning grounds.

BPA Project No. 2003-054-00 (Evaluate the Relative Reproductive Success of Hatchery-Origin and Wild-Origin Steelhead Spawning Naturally in the Hood River) investigated the genetic contribution of resident fish, both natural and residualized hatchery, on the anadromous steelhead population. Results showed that the absolute fitness of both hatchery and wild fish is very low, averaging around 0.16. Given the large number of offspring with missing parents, the simplest conclusion is that most of the production of steelhead in this population is being accomplished by resident fish, not by returning steelhead. Whether this resident population contains a large number of residualized hatchery fish or is composed of mostly wild fish (as in the winter run) remains to be seen. The mechanism behind the strong fitness decline observed in first and second generation winter-run steelhead from the Hood River is unknown. First-generation hatchery fish had nearly double the lifetime reproductive success (measured as the number of returning adult offspring) when spawned in captivity than did wild fish spawned under identical conditions. This result strongly suggests adaptation to captivity.

2. *Determine if properly designed intervention programs using artificial production make a net positive contribution to recovery of listed populations.*

Thirty-six projects were continued and three were initiated to address this RPA subaction.

BPA Project No. 1988-053-04 (Hood River and Pelton Ladder Evaluation Studies) continued and, in 2011, found that (1) quantifying residualism is problematic and not yet possible; (2) outmigration timing of hatchery origin steelhead was the same as that of natural origin steelhead; and (3) hatchery origin steelhead are residualizing, but the rate of residualization cannot be quantified and, hence, it cannot be determined which release strategy is better.

In 2011, BPA Project No. 1991-029-00 (RM&E of emerging issues and measures to recover the SRFC ESU) reported that (1) natural subyearlings have a much more diverse juvenile life history than production subyearlings and (2) post-release performance is much more similar between natural and surrogate subyearlings than between natural and production subyearlings. Additional findings show that that acclimation of hatchery subyearlings at the Captain John Rapids acclimation facility enhanced post-release performance and reduced the potential for interaction with natural subyearlings. Researchers speculate that either competition for food or food quality may be responsible for lower growth rates of fish that rear in Lower Granite Reservoir.

BPA Project No. 1995-063-25 (Yakima River Monitoring and Evaluation – Yakima/Klickitat Fisheries Project) reported in 2011 that there are annual differences in selection pressures and variability between individuals within populations and therefore it is important to evaluate behavioral studies for multiple years using large numbers of families. The findings suggest that stock differences and domestication influences do not affect the types and relative frequencies of behaviors that are used and that differences in dominance and aggression observed were likely due to an interaction between genetic changes that occurred from fish culture, differences in stocks, and variations from year to year. In addition, the project's analysis of hatchery mating on the spawning grounds indicates that hatchery managers are not likely to significantly affect jack production rates of upper Yakima River spring Chinook salmon through broodstock spawning protocols when jacks as a proportion of all males utilized do not exceed 60 percent and when the total proportion of males represented by jacks passing above the Roza Adult Monitoring Facility does not exceed 70 percent. There is an apparent paradox in hatchery origin fish: expressing younger age at maturation while also exhibiting smaller size at maturity. As fish aged, the effects of the project's growth treatment on body size diminished, while the effects of the fish's immediate environment (brood year effects) became more pronounced. The growth modulation treatment's effect on SARs was most pronounced in the earlier maturing age 3 fish and to a lesser degree in age 4 fish, as reflected in age composition differences.

BPA Project No. 2010-085-00 (Columbia River Hatchery Effects Evaluation Team [CRHEET]) is planned for implementation in 2013. After several formal discussions and letters amongst key parties (NMFS, BPA, NPCC, CRITFC and additional regional entities), NMFS determined that the best course of action would be to delay implementation of CRHEET until 2013. Throughout 2012, BPA will assist NMFS in determining the scope of CRHEET and will maintain the necessary communication with the region required in the creation of such an extensive regional coordinated effort.

3. *In collaboration with the other entities responsible for steelhead mitigation in the Methow River, BPA will fund a new RRS study for ESA-listed steelhead in the Methow River. BPA will also fund a new RRS 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.*

BPA Project No. 2010-033-00 (Study Reproductive Success of Hatchery and Natural Origin Steelhead in the Methow) is being implemented to support this subaction. The RRS study for ESA-listed steelhead in the Methow River that was on a "fast track" in 2009 was implemented in 2010 and reported some initial results in its 2011 report (Snow et al. 2012). To date, this project has found few differences between the hatchery and wild fish released upstream of the Twisp River weir that would influence productivity. Although a slight difference was detected in the reproductive success of hatchery and naturally produced fish as measured by juveniles produced, this project is designed to evaluate reproductive success over multiple generations. These preliminary results are similar in some respects to those of other steelhead reproductive success studies, but drawing any major conclusions at this time would be premature.

NMFS and other regional technical experts provided technical assistance to the BPA in 2010 and 2011 to support the development of a targeted solicitation for studies to determine fall Chinook hatchery/wild RRS and/or effects of hatchery programs on productivity of the SRFC salmon ESU. The project proposal process was under discussion in 2011 for initiating at the end of 2012 in order to begin implementation in 2013.

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.*

Three BPA projects continue to support this RPA subaction. Continued studies on the efficacy of hatchery fish released into the Snake River include BPA Project Nos. 1983-350-03 (Nez Perce Tribal Hatchery M&E) and 1991-029-00 (RM&E of Emerging Issues and Measures to Recover the Snake River Fall Chinook Salmon ESU). BPA Project Nos. 1998-010-03 (Spawning Distribution of Snake River Fall Chinook Salmon) and 1998-010-04 (M&E Performance of Juvenile Snake River Fall Chinook Salmon from Fall Chinook Acclimation Project) were merged into Project No. 1991-029-00.

In 2011, BPA Project No. 1991-029-00 reviewed status of SRFC recovery, in particular the criterion that requires the lower Snake River to support 1,250 redds constructed by natural-origin females. The project reported that redds exceeded 1,250 during 6 years, and the maximum redd count of 2,944 exceeded the capacity estimate of 2,570. Over the 13 study years (1998–2010), the mean (± standard error) parr-to-smolt survival was significantly higher for early emerging and migrating fish (45.3±6.3%) than for later emerging and migrating fish (37.4±4.7%). The investigators suggest that parr growth and reservoir velocity were directly proportional to parr-to-smolt survival because fast growth and downstream movement reduces the time fish are vulnerable to predators. Additionally, the investigators found that acclimated subyearlings (1) usually passed downstream faster on average than directly released subyearlings, (2) always passed downstream earlier than directly released subyearlings, and (3) always survived during early seaward migration at higher rates than directly released subyearlings. The investigators found less potential for interaction between acclimated and natural subyearlings than between directly released and natural subyearlings. Growth from rearing areas to Lower Granite Dam was 0.87 mm/d, 0.94 mm/d, and 0.58 mm/d for fish tagged in the upper, lower, and reservoir reaches, respectively. Analysis of subyearling diets showed that, in the river, aquatic insects were consumed most, but in reservoir habitats, mysids and the amphipods often dominated the diet. The investigators speculated that either competition for food or food quality may be responsible for lower growth rates of fish that rear in Lower Granite Reservoir

2. *Estimate fall Chinook hatchery program effects on the productivity of the fall Chinook salmon ESU.*

   Three BPA projects continued to support this subaction: BPA Project Nos. 1983-350-03 (Nez Perce Tribal Hatchery M&E) and 1991-029-00 (RM&E of Emerging Issues and Measures to Recover the Snake River Fall Chinook Salmon ESU). Reports from 1991-029-00 suggest that any anthropogenic activity which reduces growth of juvenile salmonids during rearing has the potential to reduce juvenile survival and, hence, population productivity. Additionally, the investigators concluded that (1) natural subyearlings have a much more diverse juvenile life history than production subyearlings, and (2) post-release performance is much more similar between natural and surrogate subyearlings than between natural and production subyearlings. Investigators also concluded that acclimation of hatchery subyearlings at the Captain John Rapids acclimation facility enhanced post-release performance and reduced the potential for interaction with natural subyearlings. The investigators speculated that either competition for food or food quality may be responsible for lower growth rates of fish that rear in Lower Granite Reservoir.

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.*

   NMFS and other regional technical experts provided technical assistance to BPA in 2010 to support development of targeted solicitations for the new SRFC RRS 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 M&E under development in order to meet and satisfy research needs identified in the HGMP. The Action Agencies and NOAA have agreed that there are necessary prerequisite studies which need to be conducted prior to the implementation of an RRS study or other studies of hatchery effects in SRFC.

RME Strategy 7 (RPA Actions 66–70)

A comprehensive list of all actions implemented by the Action Agencies for RPA Actions 66 through 69 is included in Section 3.

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 No. 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. Results are further reported at *http://www.birdresearchnw.org*. The Action Agencies also funded Caspian tern monitoring at the alternate habitat sites identified in the Caspian Tern Management Plan.

The Caspian tern colony on East Sand Island in the Columbia River estuary, the largest of its kind in the world, consisted of about 7,000 breeding pairs in 2011 which was significantly smaller than in 2010 and the smallest the colony has been since it became fully established in 2001. During the 2011 nesting season the available nesting habitat was decreased to 2 acres, from the historical level of 5 acres in previous years. The Caspian terns completely failed to raise young at the East Sand Island colony in 2011 because of other predators. Additional replacement habitat at another location may need to be constructed if it is deemed necessary to further reduce the amount of existing tern nesting habitat in achieving the goal of relocating more of the East Sand Island tern colony to alternative sites as part of the Caspian Tern Management Plan.

Caspian terns nesting at the East Sand Island colony consumed about 4.8 million juvenile salmonids (95% CI = 4.0 to 5.6 million) in 2011, which was lower but not significantly different from the smolt consumption estimates for the previous two years. Since 2000, the average number of smolts consumed by Caspian terns nesting on East Sand Island was 5.3 million per year, less than half the annual consumption of juvenile salmonids by Caspian terns in the Columbia River estuary prior to 2000, when the breeding colony was located on Rice Island. Further reductions in smolt consumption by Caspian terns nesting on East Sand Island will require a significant reduction in the size of the tern colony; future management plans are designed to reduce the size of the East Sand tern colony to about one-third its pre-management size.

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.

Avian monitoring was conducted by BPA, Reclamation, and the Corps. BPA Project No. 1997-024-00 (Avian Predation on Juvenile Salmonids) provided for the monitoring of the double-crested cormorant colony on East Sand Island. Colony size, reproduction rates, diet composition, and predation rates are monitored to determine the effect of the colony on juvenile salmon. Results are discussed below and further reported at *http://www.birdresearchnw.org*.

East Sand Island is home to the largest double-crested cormorant colony in western North America, consisting of about 13,000 breeding pairs in 2011, which is about the same size as the previous year. Double-crested cormorants nesting at this colony consumed approximately 22.6 million juvenile salmonids (95% CI = 16.4 to 28.8 million) in 2011, the highest smolt consumption estimate ever recorded at the East Sand Island cormorant colony. For the past three years at East Sand Island, smolt consumption by double-crested cormorants has been significantly greater than that by Caspian terns. Management options to reduce or limit smolt losses to the double-crested cormorant colony on East Sand Island are under consideration. To reduce predation on juvenile salmonids by double-crested cormorants in the Columbia River estuary, it will be necessary to reduce the size of the cormorant colony on East Sand Island. Non-lethal management approaches, such as limiting nesting acreage and relocating a portion of the colony to alternative colony sites along the Pacific coast, seem appropriate for the cormorant colony on East Sand Island. As was the case with Caspian tern management in the Columbia River estuary, any management of double-crested cormorants to reduce smolt losses in the estuary will likely require analysis under the National Environmental Policy Act, a process that is currently underway.

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.

As part of a comprehensive monitoring and evaluation program to assess avian predation on the Columbia Plateau, multiple projects were completed in 2011 by the Corps and Reclamation to support development of an Inland Avian Predation Management Plan. This Inland Avian Predation Management Plan is currently being developed by the Action Agencies, including evaluation of potential management scenarios, and is expected to be released in 2012 for public and agency review. RM&E during 2011 included monitoring the impacts of avian predators on juvenile salmonids on the Columbia Plateau, development of a "synthesis report" summarizing pertinent RM&E efforts between 2004 and 2009, and completion of a "benefits analysis" assessing potential benefits to anadromous juvenile salmonids from potential reductions in avian predation on the Columbia Plateau. These RM&E efforts focused on the major native piscivorous colonial waterbirds nesting on the Columbia Plateau region, including Caspian terns, double-crested cormorants, American white pelicans, California gulls, and ring-billed gulls. In addition, a study was conducted to assess whether the new wire array structures at John Day and The Dalles Dams are adequately protecting outmigrating juvenile salmonids.

In 2011, habitat-based RM&E efforts focused on monitoring the impacts to juvenile salmonids at the primary avian colonies on the Columbia Plateau. These included the Caspian tern colonies on Goose and Crescent Islands and the double-crested cormorant colony on Foundation Island, as these two bird species still appear to be responsible for most of the smolt losses to avian predators on the Columbia Plateau. In 2011, the largest breeding colonies of Caspian terns in the Columbia Plateau region were on Crescent Island (in McNary Pool near Pasco, WA) and on Goose Island (Potholes Reservoir, near Othelo, WA), where a nearly equal number (ca. 420) of breeding pairs nested in 2011. Caspian tern nesting success at both colonies was also similar (ca. 0.3 young raised per nesting pair) in 2011. In 2011, salmonid smolts represented 84 percent of tern prey items at the Crescent Island colony, the highest percentage ever recorded at that colony, and 24 percent of tern prey items at the Goose Island colony. The largest colony of double-crested cormorants on the mid-Columbia River was on Foundation Island (in McNary Pool), where 318 pairs nested in 2011. Diet sampling during 2005–10 indicated that about 50 percent (by mass) of the Foundation Island cormorant diet was juvenile salmonids during May (the peak of smolt out-migration), while less than 10 percent of the diet was salmonids during early April, June, and July.

An estimated 36,918 PIT tags from 2011 migration year salmonid smolts were deposited by birds on their nesting colonies in the Columbia Plateau region. PIT-tag recoveries indicated that smolt losses in 2011 were highest for Crescent Island terns (11,734 PIT tags), followed by Foundation Island cormorants (8,376 PIT tags) and Goose Island terns (6,387 PIT tags). PIT tags recovered from the Caspian tern colony on Goose Island in Potholes Reservoir were almost exclusively from Upper Columbia River salmonid ESUs or populations, while PIT tags recovered on other bird colonies in the Plateau region consisted of smolts from Upper Columbia, Snake, and Middle Columbia ESUs. Results indicate that Caspian terns from the Goose Island colony in Potholes Reservoir consumed an estimated 8.9 percent of the ESA-listed steelhead (*O. mykiss*) PIT tagged and released at Rock Island Dam on the Upper Columbia River, the highest ESU-specific predation rate determined for an inland bird colony in 2011. Predation rates by Crescent Island terns on Snake River steelhead (ca. 1.9%) and by Foundation Island cormorants on Snake River steelhead (ca. 1.8%) were also notable in 2011 and comparable to those reported in previous years (2007–10). Predation on salmonid smolts by American white pelicans nesting on Badger Island and by California and ring-billed gulls nesting on Crescent Island and Miller Rocks was relatively minor (generally <0.5% per ESU) in comparison to that of tern and cormorant colonies on the Columbia Plateau in 2011.

California and ring-billed gulls have nested in large numbers on islands on or near the middle and Upper Columbia River, but these gulls have generally consumed few fish and even fewer juvenile salmonids. In 2011, the number of gulls counted on the Miller Rocks colony was 5,750 — up slightly from the 5,533 gulls counted on colony during the 2010 breeding season. The number of gulls utilizing Miller Rocks during the breeding season has increased about 160 percent since 1998. Similarly, the American white pelican colony on Badger Island in McNary Pool has experienced significant growth since the late 1990's, increasing from about 100 adults on-colony in 1999 to about 2,200 adults on-colony in 2011.

A draft report discussing research results will be released in 2012, and results will also be reported at *http://www.birdresearchnw.org*.

As part of a comprehensive study analyzing the impact of piscivorous avian predators on the survival of juvenile salmonids, the USGS–Oregon Cooperative Fish and Wildlife Research Unit completed a synthesis report focused on Columbia Plateau research efforts between 2004 and 2009 (Roby et al. 2011). The synthesis focused on the major native piscivorous colonial waterbirds nesting in the Columbia Plateau region, including Caspian terns, double-crested cormorants, American white pelicans, California gulls, and ring-billed gulls.

Within the Columbia Plateau region, overall numbers of breeding Caspian terns remained relatively stable from 2004 to 2009 at between 800 and 1,000 breeding pairs at five colonies. The two largest breeding colonies were on Crescent Island in the mid-Columbia River and on Goose Island in Potholes Reservoir. Overall numbers of breeding double-crested cormorants in the Columbia Plateau region decreased during the study period, from about 1,500 breeding pairs to about 1,200 breeding pairs at four separate colonies. The largest breeding colony by far was at the north end of Potholes Reservoir. Numbers of breeding American white pelicans increased at the Badger Island colony on the mid-Columbia River, the sole breeding colony for the species in the State of Washington. Overall numbers of breeding gulls, the most numerous piscivorous colonial waterbirds in the region, declined during the study period. Potential limiting factors for piscivorous colonial waterbirds nesting in the Columbia Plateau region include human disturbance, mammalian predation, availability of suitable nesting habitat, inter-specific competition for limited nesting habitat, and food availability. Overall breeding numbers of Caspian terns and double-crested cormorants in the Columbia Plateau region are an order of magnitude less than the numbers of these two species nesting in the Columbia River estuary, whereas California gulls, ring-billed gulls, and American white pelicans are far more numerous in the Columbia Plateau region than in the estuary.

Bioenergetic modeling methods were used to estimate prey consumption by Caspian terns nesting at Crescent Island and double-crested cormorants nesting at Foundation Island, both located in the mid-Columbia River just below the confluence with the Snake River. Taken together, the Crescent Island tern colony and the Foundation Island cormorant colony consumed approximately 1 million juvenile salmonids annually during 2004–09. Estimated annual consumption of smolts by Foundation Island cormorants ranged from 470,000 to 880,000, while that of Crescent Island terns ranged from 330,000 to 500,000. Consumption of salmon smolts by the Crescent Island tern colony declined during the study period, tracking a decline in colony size. Consumption of steelhead (*O. mykiss*) did not decline, however, perhaps reflecting greater steelhead availability in later years due to reduced transportation rates of Snake River steelhead. There was no apparent trend in smolt consumption by Foundation Island cormorants during the study period. Relative to salmonids, consumption of lamprey was minor, with fewer than 10,000 lamprey macropthalmia consumed per year by both colonies combined.

PIT tags from salmonid smolts were recovered on nine different piscivorous waterbird colonies in the Columbia River Basin to evaluate avian predation on juvenile salmonids during the 2004–09 study period. These nine bird colonies had the highest numbers of smolt PIT tags present of any in the Columbia Basin. Minimum estimates of predation rates based on PIT tag recoveries were used to determine which salmonid stocks were most affected by avian predation and which bird colonies had the greatest impact on smolt survival. This system-wide evaluation of avian predation indicated that Caspian terns and double-crested cormorants nesting on East Sand Island in the Columbia River estuary were consuming the highest proportions of available PIT-tagged smolts. However, Caspian terns and double-crested cormorants nesting at colonies in the Columbia Plateau region appear to have high consumption rates on specific salmonid stocks.

Predation rates by Crescent Island terns on Snake River summer steelhead (7.7%) and by Goose Island terns on Upper Columbia summer steelhead (10.0%) were of notable concern during the study period. Predation rates by Foundation Island cormorants on Snake River summer steelhead (2.0%) and Snake River sockeye (1.7%) were not as high, but notable. Predation rates by gulls and pelicans nesting in the Columbia Plateau region were minor (generally <0.5% of available smolts) compared to smolt losses from other inland tern and cormorant colonies. Hatchery smolts were often more susceptible to avian predation relative to their wild counterparts, although exceptions were numerous. Smolts out-migrating in June and July were generally consumed at higher rates by birds than smolts of the same stock that out-migrated earlier (April or May). Predation rates on PIT-tagged smolts that were adjusted for colony size (i.e., smolt consumption per bird) were substantially higher for terns and cormorants nesting at colonies in the Columbia Plateau region than for those nesting in the estuary. Thus, while inland colonies of terns and cormorants are much smaller than their counterparts in the estuary, inland colonies seem to be more reliant on salmonids as a food source. This greater reliance on salmonids, coupled with lower diversity of available salmonid stocks compared to the estuary, is responsible for the unexpectedly high impact of some inland tern and cormorant colonies on specific stocks of salmonids, particularly steelhead.

The synthesis report (Roby et al. 2011) also provided a summary of a study investigating factors that influence susceptibility of juvenile salmonids to avian predation using juvenile steelhead from the threatened Snake River stock. Steelhead smolts (n = 25,909) were captured, externally examined, marked with PIT tags, and released to continue outmigration during 2007–09. Recoveries of steelhead PIT tags on the Crescent Island Caspian tern colony indicated that steelhead susceptibility to tern predation increased significantly with declining steelhead external condition, decreased water discharge, decreased water clarity, and increased steelhead length up to 202 mm (fork length), but decreased for larger steelhead. Recoveries of PIT tags on the Foundation Island double-crested cormorant colony indicated that steelhead susceptibility to cormorant predation increased significantly with declining steelhead external condition, plus steelhead of hatchery origin were more susceptible compared to their wild counterparts. These results indicate (1) that steelhead susceptibility to avian predation is condition- and size-dependent and is influenced by both river conditions and rearing environment (hatchery vs. wild) and (2) that at least a portion of the smolt mortality caused by avian predation in the mid-Columbia River is compensatory.

From October 2007 to February 2010, the abundance, distribution, and diet of double-crested cormorants overwintering on the lower Snake River in eastern Washington were assessed in order to investigate the potential impacts from cormorant predation on survival of ESA-listed fall Chinook salmon that overwinter in the lower Snake River. A monthly average of 256 cormorants was observed on this reach of the lower Snake River. The overall diet composition of cormorants was highly variable and changed as winter progressed. The most prevalent prey types were centrarchids (34.3% by mass), followed by shad (15.0%). Fall Chinook salmon composed an average of 3.4 percent by mass of the cormorant diet. Biomass consumption of all salmonids by overwintering cormorants was estimated at 3,100 to 11,000 kg, or about one-third of the estimated salmonid biomass consumption by cormorants nesting at Foundation Island. The bulk of the diet of overwintering cormorants, however, consisted of non-native fishes that compete with or depredate juvenile salmonids.

Based on this synthesis of research efforts on the Columbia Plateau between 2004 and 2009, it appears the greatest potential for increasing survival of smolts from ESA-listed salmonid stocks by managing inland avian predators would be realized by focusing management efforts on Caspian terns nesting at colonies on Crescent Island, Goose Island, and the Blalock Islands. Reductions in the size of these tern colonies would enhance survival of Upper Columbia River and Snake River steelhead stocks in particular. More limited enhancement of smolt survival for Snake River steelhead and Snake River sockeye could be achieved by managing the double-crested cormorant colony at Foundation Island. Management of other inland piscivorous waterbird colonies in the Columbia Plateau region would provide relatively small and perhaps undetectable increases in stock-specific smolt survival. However, further analysis is necessary in order to translate smolt consumption and predation rate estimates into assessments of the potential benefits for threatened and endangered salmonid populations by reducing avian predation in the Columbia Plateau region. (See Lyons et al. 2011 for this additional analysis, which is discussed below.) The results are further discussed within the Roby et al. (2011) report.

In order to provide guidance for the development of the Inland Avian Predation Management Plan on where potential management actions are most warranted, an analysis was completed to assess the potential benefits to anadromous juvenile salmonids from potential reductions in avian predation on the Columbia Plateau. Using predation rate data based on recoveries of smolt PIT tags from piscivorous colonial waterbird colonies and the framework of a simple deterministic, age-structured, matrix population growth model, potential changes in smolt survival due to reductions in avian predation were translated into corresponding increases in the average annual population growth rate (λ) at the ESU/DPS level. Estimates were produced for a range of reductions in avian predation and for a range of levels of compensatory mortality. The greatest potential benefit from reductions in predation by birds from a single colony in the Columbia Plateau region was for Upper Columbia River steelhead when predation by Caspian terns nesting on Goose Island is reduced; an increase in λ as great as 4.2 percent (for hatchery-raised smolts) or 3.2 percent (for wild smolts) was possible if predation were completely eliminated and compensatory mortality did not occur. Potential benefits for Snake River ESUs were lower, in part because significant portions of those ESUs are transported and thus inaccessible to avian predators in the Columbia Plateau region. Cumulative potential benefits for eliminating predation by birds nesting at all five Columbia Plateau nesting colonies considered in the analysis were generally comparable to estimates of benefits from dispersing approximately two-thirds of the large Caspian tern colony in the Columbia River estuary; benefits were greater, however, for Upper Columbia River steelhead from eliminating predation by birds nesting at the five Columbia Plateau colonies. While management strategies to reduce avian predation on outmigrating smolts on the Columbia

Plateau will not by themselves recover ESA-listed salmonid populations, reductions in avian predation could result in increases in salmonid population growth rates comparable to some other salmonid recovery efforts in the Columbia Basin, particularly for Upper Columbia River and Snake River steelhead populations.

During 2011, biologists with NMFS and Pacific States Marine Fisheries Commission collaborated with researchers from Oregon State University and Real Time Research to quantify the effects of predation on PIT-tagged salmonids by piscivorous waterbirds throughout the Columbia River Basin. NMFS sampled, or assisted in sampling of, recently vacated nesting and loafing sites utilized by Caspian terns (*Hydroprogne caspia*), cormorants (*Phalacrocorax* spp.), gulls (*Larus* spp.), and pelicans (*Pelecanus* spp.) at colonies in the Columbia River estuary, near the Snake River confluence, on the Columbia Plateau, and other locations to assess the impacts of piscivorous colonial waterbirds. NMFS evaluated the vulnerability of fish by species, run, rear type, origin, and in-river or transport migration history by calculating weighted seasonal predation rates of fish previously detected at or released from dams located upstream of avian colonies. In addition, NMFS PIT- tagged and released approximately 3,000 subyearling fall Chinook salmon from four hatcheries downstream of Bonneville Dam—Big Creek Hatchery, Deep River net pens, North Toutle Hatchery, and Warrenton Hatchery—to document vulnerabilities of fish released into the Lower Columbia River. The final report for this project will be completed by mid-2012.

In 2011, the Corps' Fish Field Unit (FFU) was tasked with a final year of determining whether the new wire array structures at John Day and The Dalles Dams are adequately protecting outmigrating juvenile salmonids. FFU's objectives were to (1) determine species composition and numbers of piscivorous birds, (2) estimate fish consumption and attack location of gulls, and (3) determine the effectiveness of intense boat hazing and avian deterrent line arrays at John Day and The Dalles Dams. Unlike previous years, no lethal take was permitted for gut analysis purposes. Monitoring in 2010 and 2011 indicates hazing from boats and the improved avian line arrays were successful in reducing avian predation on outmigrating juvenile salmonids. While there were differences in the number of fish consumed between 2010 and 2011, FFU attributes the decreases in fish consumption to natural variation in the number of foraging gulls, not to the level of deterrent effort. Overall, the management objective of reducing predation through improvements to wire structures and hazing programs was achieved in both years.

RPA Action 69 – Monitoring Related to Marine Mammal Predation

As part of RPA 69, the Corps continued to monitor sea lion predation at Bonneville Dam in 2011. For a more comprehensive summary of 2011 monitoring efforts, refer to the field report by Stansell et al. (2011).

1. *Estimate overall sea lion abundance immediately below Bonneville Dam. (Initiate in FY 2007-2010 Projects.)*

   Two projects were continued to fully address this RPA subaction. From January 1 to May 31, 2011, the Corps continued to visually monitor the abundance of California and Steller sea lions in the Bonneville Dam tailrace observation area (Figure 23 and Table 26). 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.

2. *Monitor the spatial and temporal distribution of sea lion predation attempts and estimate predation rates. (Initiate in FY 2007-2010 Projects.)*

Two projects were continued to fully address this RPA subaction. In 2011, 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.

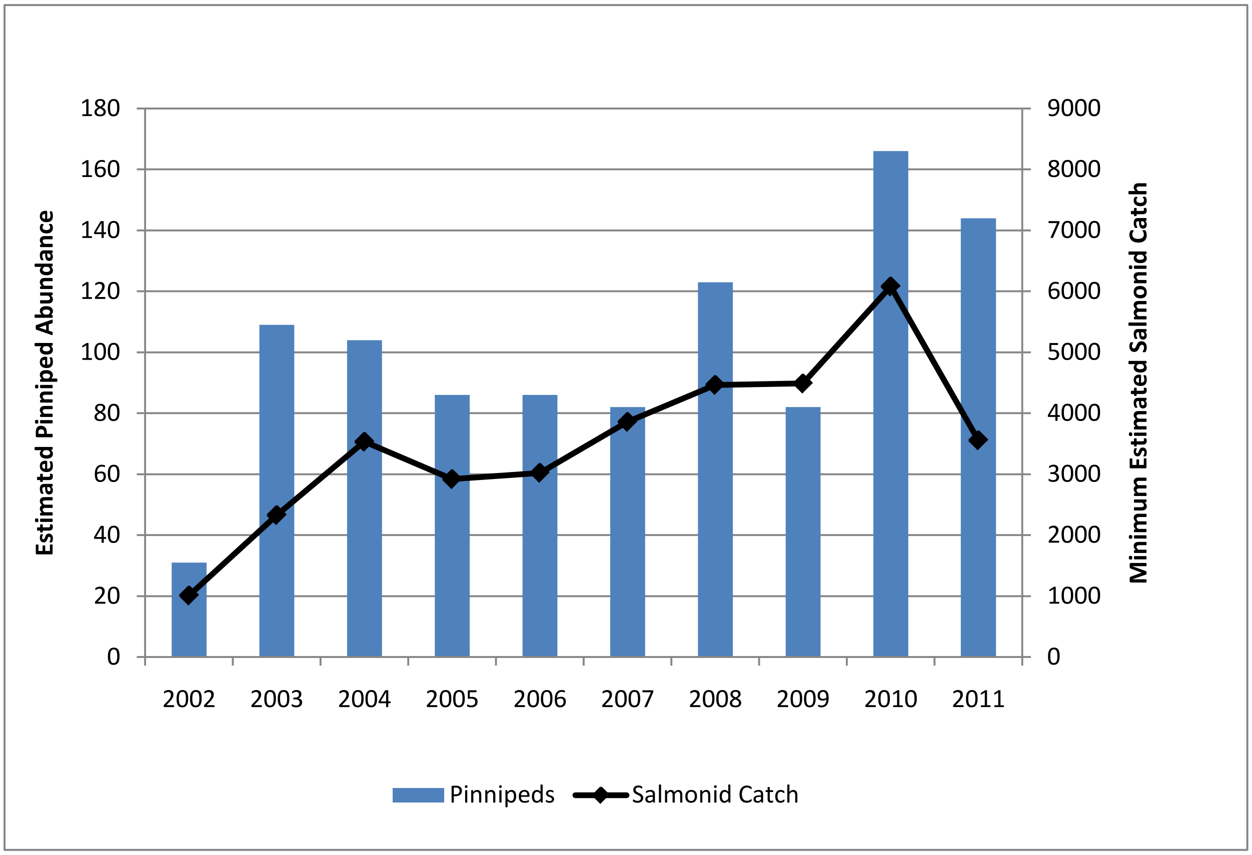


Figure 23. Estimated minimum number of adult salmonids consumed by pinnipeds and estimated total number of pinnipeds observed at Bonneville Dam, January 1–May 31, from 2002 to 2011. Note: In 2005, regular observations did not start until March 18. Pinnipeds observed included California sea lions, Steller sea lions, and harbor seals. Data for 2011 are 3,557 estimated salmonids caught and 144 estimated pinnipeds, the majority now being Steller sea lions.

The expanded adult salmonid catch estimate for the Bonneville Dam tailrace observation area was 1.6 percent (*n*=3,557) of the adult salmonid run at Bonneville Dam from January 1 through May 31, 2011. The adjusted estimated catch was 1.8 percent of the run (*n*=3,970). California sea lions were the primary salmonid predator, accounting for 71 percent (*n*=1,550) of the 2,186 observed salmonid catches. This percentage was lower than seen in previous years, as observed salmonid catch by Steller sea lions increased from 0.3 percent (*n*=12) in 2007 to 29 percent (*n*=636) of total observed salmonid take in 2011 (Table 26).

Chinook salmon were the most commonly identified salmonid prey species, composing approximately 92 percent (*n*=2,010) of observed adult salmonid catch in 2011. The expanded Chinook catch estimate for the Bonneville Dam tailrace observation area was 1.2 percent (*n*=3,298) of the Chinook run through June 15, 2011. Note that this time period differs from the passage season used for total salmonid estimates and includes the Columbia River spring Chinook passage season at Bonneville Dam, which extends beyond the period during which sea lions are present. Steelhead composed approximately 8 percent (*n*=176) of observed adult salmonid catch during the same period.

Table 26. Summary of Estimated Catch of Salmonids by Pinnipeds at Bonneville Dam, 2002–11

Year	Bonneville Dam Salmonid Passage (Jan. 1–May 31)			Expanded Salmonid Catch Estimate		Adjusted Salmonid Catch Estimate	
		Observed Catch	% of Run (1/1 to 5/31)	Estimated Catch	% of Run (1/1 to 5/31)	Estimated Catch	% of Run (1/1 to 5/31)
2002	281,785	448	0.2%	1,010	0.4%	—	—
2003	217,943	1,538	0.7%	2,329	1.1%	—	—
2004	186,770	1,324	0.7%	3,533	1.9%	—	—
2005	81,252	2,659	3.1%	2,920	3.5%	—	—
2006	105,063	2,718	2.5%	3,023	2.8%	3,401	3.1%
2007	88,476	3,569	3.9%	3,859	4.2%	4,355	4.7%
2008	147,534	4,243	2.8%	4,466	2.9%	4,927	3.2%
2009	186,060	2,960	1.6%	4,489	2.4%	4,960	2.7%
2010	267,194	3,910	1.4%	6,081	2.2%	6,321	2.4%
2011	223,380	2,186	1.0%	3,557	1.6%	3,970	1.8%

Note: Total salmonid passage counts include all adult salmonids that passed Bonneville Dam January 1–May 31. "Expanded" estimates correct for the fact that observers are not present at all locations at all times. "Adjusted" estimates further correct to account for catch events where the prey species could not be identified.

Steelhead, which are present in the Bonneville Dam tailrace throughout the winter and spring, composed the majority of salmonid catches until the spring Chinook salmon run began. Of the total pinniped catch for 2011, California sea lions consumed 73.9 percent of the Chinook and 34.4 percent of the steelhead (Table 27). These are lower than 2010 figures (83.6% and 86.8%, respectively) largely because fewer California sea lions were present in 2011 than in 2010, but also because of the much later arrival of California sea lions in 2011 (February 21) than in 2010 (January 8). Earlier arriving pinnipeds, typically Steller sea lions, take steelhead until late March.

Table 27. California Sea Lion 2011 Catch Estimates: Chinook vs. Steelhead

	Percent of Total Pinniped Catch Taken by California Sea Lions (raw observed catch)	Expanded Catch Estimate (California sea lions)
Chinook	73.9%	2,438
Steelhead	34.4%	89

Physical barriers, including SLEDs and floating orifice gates, have prevented sea lions from entering the fishways. During daylight hours, dam-based USDA Wildlife Services agents contracted by the Corps, and boat-based crews from ODFW, WDFW, and CRITFC, used nonlethal pyrotechnics and rubber bullets to harass sea lions in the dam tailrace. Harassment appeared to temporarily alter the behavior of some sea lions but did not prevent continued predation by habituated pinnipeds.

With funding from the BPA, ODFW and WDFW used two floating sea lion traps deployed along the PH2 corner collector and two in the old navigation lock channel of PH1 to capture California sea lions. A ruling by the 9th Circuit Court of Appeals in November 2010 halted any lethal removal of California sea lions by the States for most of the 2011 spring season. However, the States continued to trap, brand, and tag sea lions under permit. The sea lions were weighed, branded (if not already), and some were tagged and then released. Of the 18 different California sea lions trapped in 2011, four that had already been branded were given acoustic and/or GPS tags (C287, C930, C971, and C06), three were branded and given acoustic and/or GPS tags (C011, C012, C013), and six were branded only (C010, C014 through C018). The other five were already branded and were given no tags. All of these were then released. Six were on the list for removal but were released, as the States no longer had the removal permit. In addition, one California sea lion on the list for removal was trapped in Astoria, Oregon, in mid-May during a short period when the States had been granted a removal permit, and this animal was euthanized.

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 2011 through BPA- and Corps-funded efforts. Physical barriers were effective at preventing sea lions from entering the fishways, but acoustic deterrents were no longer deployed as they had shown no visible effect over 5 years of use. Harassment with nonlethal pyrotechnics and rubber bullets appeared to temporarily alter the behavior of some sea lions, but did not prevent continued predation by habituated pinnipeds.

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.

1. *Continue to update and estimate the cumulative benefits of sustained removals of northern pikeminnow since 1990.*

One BPA project was continued to fully address this RPA subaction. BPA Project No. 1990-07-700 (Development of Systemwide Predator Control) contains an extensive biological evaluation component implemented primarily by ODFW. This program component annually collects and validates biological field data and updates the benefit model with the previous year's data. The 2011 estimated reduction in potential predation was 38 percent, based on the 2011 exploitation rate of 15.6 percent for pikeminnow 250 millimeters in fork length or larger and the cumulative effect of previous years' removals.

2. *Continue to evaluate if inter and intra compensation is occurring.*

One BPA project was continued to fully address this RPA subaction. The NPMP annually assesses whether compensation is occurring as a result of cumulative removals to date. The program evaluation showed no indication of compensation by smallmouth bass, walleye, or channel catfish.

3. *Evaluate the benefit of additional removals and resultant increase in exploitation rate's affect on reduction in predator mortality since the 2004 program incentive increase.*

   One BPA project was continued to fully address this RPA subaction. Exploitation rates since the implementation of the monetary incentive increase in 2004 have significantly exceeded the average exploitation rate of the previous 14 years. System-wide exploitation in 2011 of northern pikeminnow was 15.6 percent based on a numerical catch of 159,833 from a sport reward and dam angling fishery. A significant increase and resultant benefit have been observed since the monetary incentive program was increased in 2004. Some of this may be a result of additional tagging research and the validation of annual tag loss estimates.

4. *Develop a study plan to review, evaluate, and develop strategies to reduce non-indigenous piscivorous predation.*

   In December 2009, the project sponsors submitted for review of the ISRP for the NPCC, the proposal titled "Understanding the influence of predation by introduced fishes on juvenile salmonids in the Columbia River Basin: closing some knowledge gaps." As a result of a set of regional workshops held in 2009, the Action Agencies continued to implement a project to evaluate the influence of juvenile American shad on growth and condition of piscivorous predators in John Day Reservoir. Observations in the fall and early winter of 2011 represent the first year in a 3-year study to address this issue. Results indicate juvenile shad make up a significant portion of the fish diet of smallmouth bass and walleye in the fall.

RME Strategy 8 (RPA Actions 71–72)

RPA Action 71 – Coordination

The Action Agencies will coordinate RME 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 2011, 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 2012. 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 2011, 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.*

In 2011, BPA continued to work with NPCC staff in coordinating its Fish and Wildlife Program project planning and review efforts. In 2011, BPA and the NPCC completed the RME and Artificial Production Categorical Review (ISRP 2010) to support a comprehensive evaluation of the Fish and Wildlife Program's research and monitoring projects and hatchery program. BPA and the Council developed programmatic conditions to address ISRP concerns, which BPA started to address in FY 12 funding recommendations. For example, BPA and the Corps also developed a draft CEERP Strategy and Action Plan to support a 2012 Synthesis and Evaluation Memorandum to address Estuary RM&E issues. While Reclamation and BPA worked on a Tributary Habitat Monitoring Framework with the Northwest Fisheries Science Center and Regional Office. BPA and Council continue coordination through monthly program meetings and participation in Council meetings.

3. *Supporting the standardization and coordination of tagging and monitoring efforts through participation and leadership in regional coordination forums such as PNAMP.*

Four BPA projects and one Reclamation project were continued to fully support this subaction. For example, BPA Project Nos. 1994-033-00 (FPC), 1996-020-00 (Comparative Survival Study), 1996-043-00 (Johnson Creek Artificial Propagation Enhancement), and 2004-002-00 (PNAMP) participated in the PIT-tagging plan workshops to standardize and coordinate tagging approaches. In addition, BPA Project No. 2004-002-00 (PNAMP), continued development and support for the protocol library production tool *www.monitoringmethods.org* to support documentation of protocols to capture monitoring designs for data collection and analysis methods for various indicators and metrics. In 2011, new contract requirements, added to all BPA monitoring RM&E contracts, required documentation of protocols with standardized methods on the *monitoringmethods.org* web site for contracted Statements of Work. MonitoringMethods.org provides a place where monitoring practitioners can document methods and protocols or find information from other participants, as well as definitions of monitoring terminology (metrics and indicators) that is important to them. MonitoringMethods.org also hosts a Community Forum to promote information exchange and coordination/collaboration between regional monitoring practitioners about topics of interest to this community. Content from *monitoringmethods.org* will be used to help develop "Methods Review" sessions with practitioners that PNAMP will plan in 2012.

Reclamation directly participated in PNAMP by providing staff support for the PNAMP steering committee, as well as funding for its two coordinators and a database expert. Reclamation provided technical expertise for two major PNAMP committees.

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.*

Eleven BPA projects were continued support this subaction. For example, in addition to actions discussed under RPA 71.3 in 2011, most BPA projects associated with this RPA worked BPA Project No. 2004-002-00 (PNAMP) with a Reclamation and Corps cost-share that supported regional RM&E coordination through PNAMP. This resulted in multiple workshops, white papers, and tools in 2011.

PNAMP's Coordinated Assessments Project, in collaboration with CBFWA, and StreamNet was an effort to develop integrated data-sharing for anadromous-fish-related data among the comanagers (State fish and wildlife agencies and Tribes) and action agencies of the Columbia Basin. The initial focus of the project was on three VSP abundance indicators for salmon and steelhead: natural-origin spawner abundance, smolt-to-adult return ratio, and recruit-per-spawner (link to overall work plan). The intent of this data-sharing strategy was to provide the framework and technical tools to support data sharing across disparate systems from the local level to the regional level, and to ensure that comparable data from different sources can be combined to facilitate assessment at the regional scale.

PNAMP's ISTM demonstration project is intended to demonstrate the approaches to and utility of integrating the collection of information to address multi-scale questions about the status and trends of fish (salmon, steelhead, and potentially bull trout), and physical, chemical, and biological attributes in stream networks. The overall intent is to assist PNAMP's participating members in developing strategic action plans for monitoring in the bi-State Lower Columbia River demonstration area, as well as to demonstrate the general approach to developing such plans for other areas in the Pacific Northwest. The ISTM effort will provide entities tasked with monitoring fish populations and aquatic habitat in the Pacific Northwest with a roadmap for integration of scientifically sound monitoring programs intended to meet the needs of decision-makers and managers. Specifically, it will apply this approach and develop recommendations for integrated monitoring plans for salmon, steelhead, and potentially bull trout populations listed under the ESA, and their habitats in the Lower Columbia area. Among the many monitoring components, key features of this effort are improved understanding of the extent and qualities of existing information, key gaps, and how a region-wide "master sample" concept can be applied to select sampling locations where appropriate. The ISTM effort is being accomplished using a collaborative approach involving PNAMP participants and other local partners. Anticipated PNAMP products include the development of design, analysis and implementation tools; coordination to integrate actions into planning; the implementation of efforts addressing fish recovery and watershed health in the demonstration area; and products summarizing the approaches, tools, guidance, and results from the demonstration project for possible use in other parts of the Pacific Northwest.

PNAMP Reports, Work plans, White papers, posters, and presentations produced January 1, 2011 – December 31, 2011 are provided at:

- PNAMP Budget History 2005–11 — *http://www.pnamp.org/document/3600*
- PNAMP 2011 Organizational Survey: Summary of Responses — *http://www.pnamp.org/document/3601*
- CRB Collaborative Data Sharing Strategy: Salmon and Steelhead Population Abundance and Productivity Indicators — *http://www.pnamp.org/document/3546*
- PNAMP Metadata Tool Recommendations — *http://www.pnamp.org/document/3296*
- PNAMP 2010 Annual Report — *http://www.pnamp.org/document/3280*
- AFS 2011 Data Management Symposium Abstract — Advances in Data Management and Dissemination — *http://www.pnamp.org/document/3294*
- PNAMP 2011 Work Plan in Brief — *http://www.pnamp.org/document/3275*

- Overview of the PNAMP ISTM Habitat Group — Goals, Objectives, Approach and Timeline — *http://www.pnamp.org/document/3278*
- Coordinated Assessments for Salmon and Steelhead Phase III Workplan — *http://www.pnamp.org/document/3537*
- PNAMP Habitat Data Sharing Prospectus — *http://www.pnamp.org/document/3609*
- Coordinated Assessments Core Team Work Plan — summer 2011 — *http://www.pnamp.org/document/3448*
- Phase II Work Plan For Coordinated Assessments for Salmon and Steelhead — DRAFT — http://www.*pnamp*.org/document/3258
- ISTM Workgroup: Developing Tools to Assist in the Regional Development and Coordination of Large-Scale Aquatic Monitoring Programs — *http://www.pnamp.org/document/3489*
- Habitat Data Sharing — Context — *http://www.pnamp.org/document/3504*
- High-Level Indicators for Habitat Data Sharing — *http://www.pnamp.org/document/3505*
- Coordinated Assessments — Gaps, Needs, and Priorities — *http://www.pnamp.org/document/3391*
- Coordinated Assessments — Reports from the Field: Preliminary results — *http://www.pnamp.org/document/3393*
- Coordinated Assessments Data Gathering — Preliminary Results — *http://www.pnamp.org/document/3393*
- Data Sharing Workshop to Support Coordinated Assessments — Phase II presentation — *http://www.pnamp.org/document/3360*
- PNAMP Presentation to the Great Northern Landscape Conservation Cooperative — *http://www.pnamp.org/document/3370*
- OSU Master Sample docs — guidance doc, tutorial guide — see documents in Pisces.

Lastly, Project 2003-007-00 supported the LCREP Science workgroup to help coordinate BPA and Corps implementation of monitoring and research programs for the Columbia River Estuary.

BPA Project 2008-505-00 (StreamNet Library) has finished contribution to this RPA and has transferred it to Tribal Data Network Project (2008-507-00).

5. *Coordinating the further development and implementation of Hydrosystem, Tributary Habitat, Estuary/Ocean, Harvest, Hatchery, and Predation RME through leadership and participation in ongoing collaboration and review processes and workgroups.*

Two BPA projects were continued to support the collaboration of the current Action Agencies, NMFS, and the NPCC on implementation planning, annual/comprehensive progress reporting, and adaptive management of RME strategies. In 2011, the NPCC's RME/Artificial Production Categorical Review (ISRP 2010) was concluded, which validated the incorporation of the Action Agencies/NMFS/NPCC RME RPA workgroup 2010 RPA Recommendation Report into project proposals for BPA's Fiscal Year 2012 contracts. Minor modifications for two RPA actions (56 and 50) were identified and captured for tributary habitat and fish population monitoring sections of this APR. Further revisions to the report will be completed in 2012 such that revisions would support the development of the 2014–18 FCRPS BiOp Implementation Plan.

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.*

   As stated in the 2010-2013 FCRPS Implementation Plan (FCRPS 2010a) "Action Agencies are actively participating in regional forums and accomplishing this sub-action through sub actions 71.1-71.5 above. No subsequent needed actions have been identified at this time."

RPA Action 72 – Data Management

The Action Agencies will ensure that the information obtained under the auspices of the FCRPS RME 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 RME 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 RME pilot studies in the Wenatchee River, John Day River, Upper Salmon River, and Columbia River Estuary. (Initiate in FY 2007-2009 Projects)*

   One Reclamation and eight BPA projects were continued to support this sub-action. For example, BPA Project Nos. 1988-108-04 (StreamNet – Coordinated Information System/Northwest Environmental Database [NED]), 1989-062-01 (Annual Work Plan for CBFWA), and 2008-727-00 (Regional Data Management Support and Coordination) continued support for completion of Phase 2 of the implementation of the 2011 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, some initial steps were taken to facilitate habitat data sharing and management through PNAMP with support of the ISEMP Project (2003-017-00).

   While it was not PNAMP's role to collect data or provide analysis of data, rather to provide coordination, documents and work plans related to the Coordinated Assessments Project are available at the Habitat Data Sharing Project (*http://www.pnamp.org/project/3129*), and at the ISTM demo project (*http://www.pnamp.org/project/3266* and *http://www.pnamp.org/project/3132*) on the PNAMP website.

   BPA Project No. 2004-002-00 (PNAMP) continued the mission of NED in PNAMP through regional coordination of the Data Management Leadership Team (DMLT). Reclamation supported ongoing regional RME coordination through the PNAMP (see http://*www.pnamp.org* for information on PNAMP's 2011 accomplishments), completion of a major database to catalog monitoring protocols (Monitoring Methods), and the transfer of that technology to an NMFS contractor to integrate protocols into a region-wide data dictionary that is being coordinated through PNAMP.

   BPA Project 2008-505-00 (StreamNet Library) has finished contribution to this RPA and has transferred it to Tribal Data Network Project (2008-507-00).

Reclamation has taken the lead in organizing the Methow Intensively Monitored Watershed Project and has organized regular annual meetings for the past 4 years in the Methow River Basin. Reclamation contracts with the University of Idaho for data management related to the IMW to ensure that data are archived appropriately. Reclamation will complete the first Methow IMW Report in 2012.

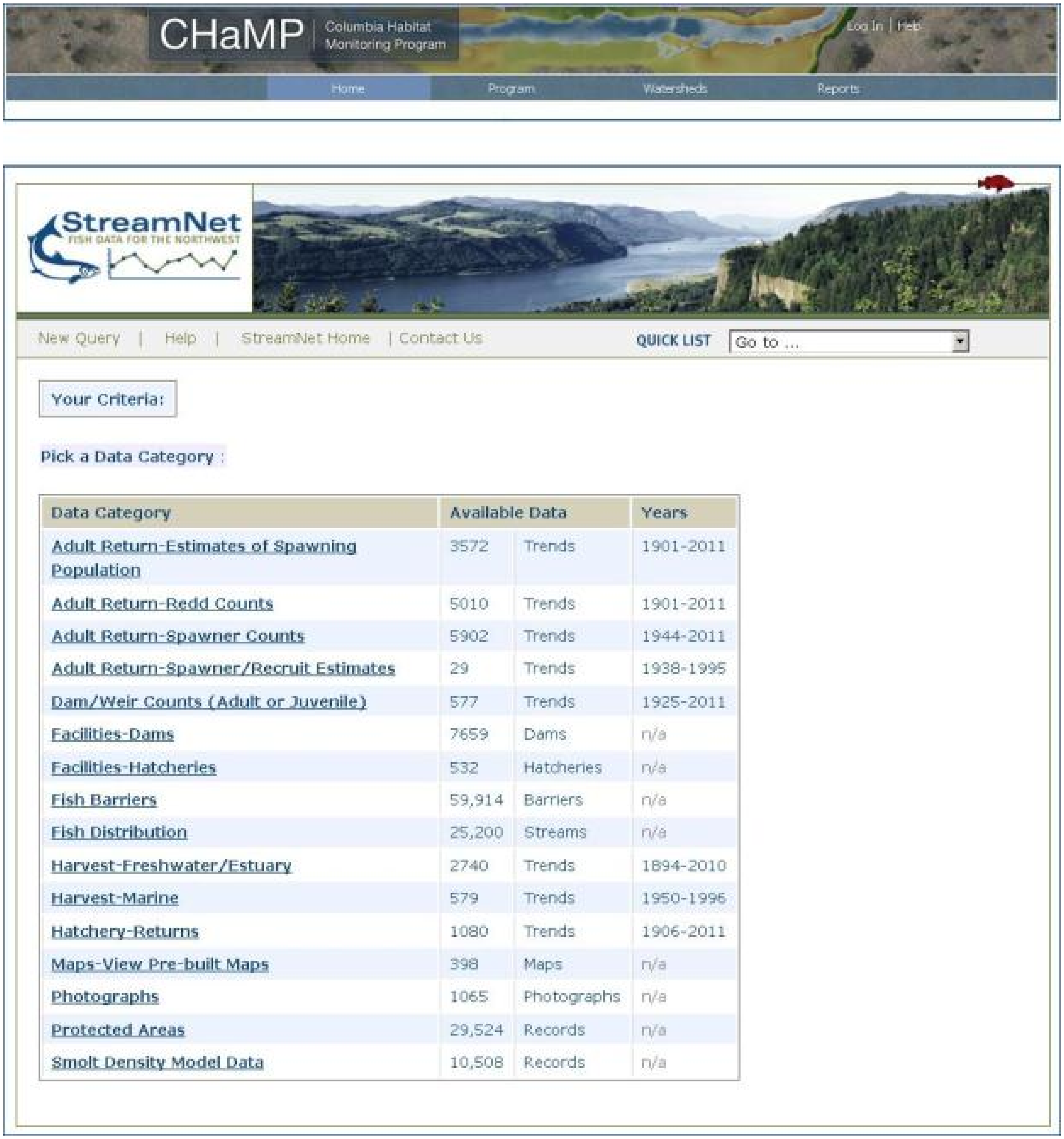
2. *Contribute funding for data system components that support the information management needs of individual Hydrosystem, Tributary Habitat, Estuary/Ocean, Harvest, Hatchery, and Predation RME. (Initiate in FY 2007-2009 Projects.)*

Seven BPA projects were continued to address this subaction. Results and modifications to major data systems may be found at *www.champmonitoring.org* for Tributary Habitat Status and Trend Data, while improvements to StreamNet's fish data may be found at *http://www.streamnet.org/* (Figure 24), and improvements to the PTAGIS PIT-tag database are at *http://www.ptagis.org/*.

In collaboration with BPA, the Corps began development of a data system for managing estuarine habitat and fish data.

Through a contract with Reclamation, the University of Idaho began constructing Data Harvester software for the Methow IMW project. The data identification process through model and analysis development (use cases) is being done in parallel with the Data Harvester development. A database to compile important metadata for all datasets will be available. After evaluating several metadata software tools (e.g., Mercury, Metavist), we identified Morpho as the most current and effective tool for our metadata. Reclamation hired a Methow data coordinator to assist the University of Idaho in the initial data and metadata harvest from all the Methow IMW cooperating entities. A field data and parameter list for model data inputs and outputs is under development. The entities are providing data and metadata in a standard format. The use of models as a data identification process greatly facilitates the coordination of data harvest by communicating directly the need and proposed use of the data. This pilot approach is being coordinated with PNAMP.

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.)*



Data Category	Available Data		Years
Adult Return-Estimates of Spawning Population	3572	Trends	1901-2011
Adult Return-Redd Counts	5010	Trends	1901-2011
Adult Return-Spawner Counts	5902	Trends	1944-2011
Adult Return-Spawner/Recruit Estimates	29	Trends	1938-1995
Dam/Weir Counts (Adult or Juvenile)	577	Trends	1925-2011
Facilities-Dams	7659	Dams	n/a
Facilities-Hatcheries	532	Hatcheries	n/a
Fish Barriers	59,914	Barriers	n/a
Fish Distribution	25,200	Streams	n/a
Harvest-Freshwater/Estuary	2740	Trends	1894-2010
Harvest-Marine	579	Trends	1950-1996
Hatchery-Returns	1080	Trends	1906-2011
Maps-View Pre-built Maps	398	Maps	n/a
Photographs	1065	Photographs	n/a
Protected Areas	29,524	Records	n/a
Smolt Density Model Data	10,508	Records	n/a

Figure 24. Screenshot from the web pages of CHaMPMonitoring.org and streamnet.org.

Eight ongoing BPA projects were continued, one new project was initiated, and one project's association was transferred to another project to support this subaction. To support development of salmonid VSP attribute data management strategies, BPA Project Nos. 1988-108-04 (StreamNet – Coordinated Information System/Northwest Environmental Database), 1989-062-01 (Annual Work Plan for Columbia Basin Fish and Wildlife Authority [CBFWA]), and 2004-002-00 (PNAMP) were contracted to support participation in the Coordinated Assessments Project. The data management strategies for multiple agencies were published by PNAMP in *Columbia River Basin*

Collaborative Data Sharing Strategy: Salmon and Steelhead Population Abundance and Productivity Indicators, which is available at *http://www.pnamp.org/sites/default/files/ca_basinwide_data_sharing_strategy_final_draft_nov_10.pdf*. Ongoing coordination efforts to implement regional data management strategies through the Coordinated Assessment Project and through the PNAMP DMLT will be continued to support timely reporting of VSP information to the NOAA Salmon Population Summary Database.

The PNAMP funding for BPA Project No. 2004-002-00 continued to provide staff for coordination or work sessions and regional collaboration discussion by the DMLT to continue implementation of NED recommendations.

BPA Project No. 2008-505-00 (StreamNet Library) has finished contribution to this RPA and has transferred it to Tribal Data Network Project (2008-507-00).

Reclamation actively participates as a steering committee member of the PNAMP in the planning and development of regional monitoring programs.

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.*

   The Action Agencies successfully implemented programs following government contracting requirements with quarterly and/or annual project implementation reporting. BPA continued to implement the Pisces program to track project implementation to support accordance and evaluations of project effectiveness.

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.*

   In addition to the Pisces and Taurus project implementation reporting tools (*www.cbfish.org*), BPA and the Corps began development of tools with Sitka Technologies for tracking planned restoration activities. To further support coordination and planning of monitoring projects, BPA contracted PNAMP through Project 2008-727-00 to develop a monitoring locator tool, which is currently in development with Sitka Technologies. Ongoing work will continue in 2012 to support further development of the tools outside of the estuary to help plan and coordinate future restoration and monitoring actions. These tools developed for planning and reporting purposes may provide the most up-to-date information about the status of actions and projects being implemented and help when complete.

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 RME 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 35 and 37. These data for BPA and Reclamation currently are tracked in the Pisces database and reported in the Taurus database at *www.cbfish.org* for BPA-funded actions. Actions for which Reclamation provides technical assistance are tracked in a separate database. Because these databases were developed in the early 2000s, they currently include only a subset of the metrics contained in Katz et al. (2006). However, up until 2008, NOAA had independently integrated BPA project data into its Pacific Northwest Salmon Habitat Restoration Project Tracking (PNSHP) database. To address the 2008–10 BPA project metric data gap for the NOAA Pacific Coastal Salmon Recovery Fund (PCSRF) System, BPA also began a process to add to the NOAAPCSRF/PNSHP database all Pisces habitat restoration projects not documented in the crosswalk tool from 2008 to 2010. Completion of the task is planned for May 2012. In 2011 the crosswalk to the PCSRF program metrics for BPA's Pisces Program was finalized for all agreed metrics to ensure consistency with other NMFS regional database tracking systems. For all project metrics collected in 2011 and into the future, data will be automatically sent to NOAA for compliance with this RPA. This list of metrics and guidance is available at *http://www.cbfish.org/WorkElement.mvc/Landing*.

Pending further discussion with NOAA, Fiscal Year 2013 riparian restoration projects lists of "Species Removed" or "Species Planted" are to be documented in final project reports rather than in the Pisces tracking system to comply with Katz et al. (2006) documentation and current PCSRF data dictionary requirements. By the end of 2012, BPA will have met the needs of the RPA subaction.

Lastly, project 2010-075-00 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. Results of the project will be available in 2012.

Adaptive Management Implementation Plan (AMIP) Actions

In September 2009, the FCRPS 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 NMFS 2010 Supplemental BiOp. The following section provides information on AMIP actions implemented by NMFS and the Action Agencies in 2011. Although many of these actions were under way or completed in 2011, some will be implemented later in the BiOp period.

AMIP Reference	Action Description
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
II. B	Reintroduction
II. C	Predator & Invasive Species Controls
II. D	Spill
AMIP Category: III Enhanced Research Monitoring & Evaluation	
III. A	Enhanced Life-Cycle Monitoring for Evaluation of Contingencies
III. B	Adult Status & Trend Monitoring
III. C	Juvenile Status & Trend Monitoring
III. D	Habitat Condition Status & Trend Monitoring
III. E	Intensively Monitored Watersheds
III. F	Climate Change Monitoring & Evaluation
AMIP Category: IV Contingency Plans in Case of Early Warning or Significant Fish Declines	
IV. A	Expanded Contingency Process
IV. A.1.	Early Warning Indicator for Chinook Salmon & Steelhead
IV. A.2.	Significant Decline Trigger for Chinook Salmon & Steelhead
IV. A.3.	Contingency Plan Implementation for Snake River Sockeye Salmon
IV. B	Rapid Response Actions – Hydro, Predator Control, Harvest, Safety Net Hatchery Programs
IV. C	Long-Term Contingency Action – Hydro, Reintroduction, Predator Control, Harvest, Conservation Hatcheries, Hatchery Reform, John Day Reservoir Operation at MOP, Breaching Lower Snake River Dams
AMIP Category: Amendments	
Amendment 1	Identify the use and location of adult salmon thermal refugia in Lower Columbia and Lower Snake Rivers
Amendment 2	Assess feasibility of adding adult PIT-tag detection systems at The Dalles Dam and John Day Dam
Amendment 3	Action Agencies to provide temperature data for NOAA's regional temperature database.
Amendment 4	Action Agencies to provide tributary habitat effectiveness study data for NOAA's regional climate change database.
Amendment 5	Action Agencies will provide available invasive species and site-specific toxicology information for consideration by the expert panels.
Amendment 6	Action Agencies will assist NOAA to develop or modify existing studies that address the Ad Hoc Supplementation Workgroup Recommendations Report.

AMIP Category II – Acceleration and 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 Estuary MOA 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 Estuary MOA, 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.

See RPA Actions 36 & 37 for discussion of estuary habitat actions and implementation status.

II. B. Reintroduction

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.

- *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.*
- *The NWFSC will evaluate the costs and benefits of the alternative reintroduction strategies and techniques.*

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 RIOG.

Actions 1 and 2 are completed. NOAA's NWFSC 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. The paper reviewed the conditions under which reintroductions were likely to be successful and the biological benefits and costs of different techniques. The scientists described their recommendations in McClure et al. (2011).

Based on this review, NMFS and the Action Agencies determined that, where an important evolutionary lineage or ESU is likely to go extinct without intervention, a safety-net hatchery program to preserve fish for later reintroduction would be appropriate in a long-term contingency plan. Recovery of Sawtooth Valley (Snake River) sockeye salmon, which reached critically low abundances in the early 1990s, provides a good example of the role that a safety-net hatchery can play in reintroduction.

II. C. Predator and Invasive Species Controls

The Action Agencies and NOAA Fisheries will move forward in the three highest priority areas to establish baseline information for future predator control activities:

- *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*
- *Catfish: document the distribution and predation rates of channel catfish*

- *Smallmouth bass: document whether removals of smallmouth bass in areas of intense predation could reduce the mortality of juvenile salmonids*

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.

Completed on schedule in 2010.

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 operation for this time period as set forth in the RPA.*

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.

AMIP Category III – Enhanced Research Monitoring & Evaluation (Actions A-F)

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 (VSP) 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.

The ISRP's review of the ASMS was completed in February 2011 (ISRP and ISAB 2011). Work to address ISRP comments is ongoing. The revised ASMS will be integrated with the Columbia Basin Fish & Wildlife Program through inclusion in the Northwest Power and conservation Council's Monitoring, Evaluation and Research Report.

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 2011 to satisfy year 2 of the 3-year process. NOAA NWFSC continued to implement and distribute the Species Lifecycle Analysis Modules (SLAM) developed to date. Additional models developed by the

Interior Columbia Technical Recovery Team were ported to SLAM and tested, such as the downriver Tule stock. NWFSC also implemented a database that supports the models. Quarterly workshops with the Oversight Committee were held on schedule. Three workshops on SLAM configuration and operation were convened across the region during the summer for potential agency and contracted users. The modeling has made progress in the following areas:

- Modeling of hatchery-wild interactions based on ongoing analyses,
- Incorporating habitat relationships into life cycle models,
- Continued development of hydro scenarios for rapid response and long-term contingency planning, including initiation of COMPASS recalibrations and construct for John Day drawdown and Lower Snake River dam breaching,
- Steelhead and subyearling Chinook salmon life-history characterizations,
- Initiation of estuary effects distribution, and
- Climate change scenario characterizations.

III. B. Adult Status & Trend Monitoring

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.

Mechanisms for data reporting and dissemination were completed on schedule in 2010.

NOAA's NWFSC created the SPS 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

By December, 2011, the Action Agencies will enhance the existing monitoring of juvenile production and survival. This will ensure that at least one population per MPG is being monitored to better inform decisions regarding what Rapid Response and Long-term Contingency Actions will be taken if an adult trigger is tripped, as well as informing viability assessments. In addition to allowing the detection of downturns in natural freshwater production and juvenile survival, this monitoring will help to assess climate change impacts. The Action Agencies will develop a strategy to improve the management and timely reporting of juvenile salmon and steelhead monitoring data by December, 2010.

The strategy was completed on schedule in 2010. Consistent with ISRP comments, BPA proceeded with partial implementation and evaluation in 2011 for CHaMP and associated paired fish population monitoring. Full implementation will follow, likely in 2013, based on additional ISRP review. (See III. D below.)

III. D. Habitat Condition Status & Trend Monitoring

By December, 2011, the Action Agencies will expand habitat status and trend monitoring (for at least one population or watershed per MPG) and support updated modeling of the expected benefits of habitat actions. By December, 2011, the Action Agencies will also ensure monitoring of appropriate *metrics across a diversity of ecological regions and habitat types to assess responses to climate change.*

In 2011, BPA proceeded with partial implementation and evaluation of CHaMP consistent with ISRP comments. Full implementation will follow, likely in 2013, based on additional ISRP review. Analysis and utilization of CHaMP data continued and will be included in annual synthesis reports.

III. E. Intensively Monitored Watersheds

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 Potlach 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.

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:

1. *Timely funding and implementation of intensive habitat actions to ensure, where practical, an adequate treatment effect*

2. *Sufficiently diverse representation of IMWs (geographically and with respect to limiting factors) and appropriate monitoring (e.g., temperature, flow) to detect climate change impacts*

3. *Results are applicable to future habitat planning and for the implementation of Rapid Response Actions*

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 review process and review by the NPCC. Results will be coordinated with the RIOG and reported annually to the region.

Completed on schedule in 2010. In 2011, the Action Agencies assessed and summarized the results from existing monitoring, including responses to 2011 comments from the ISRP. The report is being developed and will be provided in the summer of 2012.

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.*

   NWFSC conducted a 2011 update on their extensive review of the literature on climate science and oceanographic conditions relevant to Columbia Basin salmonids (Attachment A). The NWFSC states that the effects of global climate change are being felt across the U.S. and in the Pacific Northwest. Average daily temperatures have increased over the past few decades. The frequency of extreme precipitation events has also increased. Hydrological impacts are most evident in rain-snow transient watersheds, where discharge has increased in the winter and decreased in the summer, producing earlier peak flows and lower low flows since 1962.

The NWFSC notes that:

> . . . new information from 2011 publications was generally consistent with previous analyses in reporting ongoing trends in climate consistent with climate change projections and negative implications for salmon. A few studies focused on areas that did not receive much attention in our previous report, and thus provide new information. These areas include the expected loss of significant portions of the marine distribution, albeit mainly in the second half of this century, the current risk of hypoxia in the Columbia River estuary, as well as documented and projected rates of evolutionary changes in migration timing. Disease impacts on migration survival documented in Fraser River sockeye warn of the potential for a very rapid decline in survival, unlike the linear projections generally forecasted, with little managerial recourse. Several papers demonstrated how cumulative effects of climate change over the entire life cycle are likely to be much higher than previously predicted from effects on individual life stages.
>
> Finally, new adaptation plans for the [Pacific Northwest] are being developed but institutional barriers to climate change adaptation for some agencies and water use sectors create challenges for effective response.

The extensive mitigation program currently being funded by the Action Agencies is consistent with, and responsive to, the climate change mitigation recommendations of the ISAB. As the ISAB stated: “Mitigating for changes in hydrology and temperature in tributaries that are caused by climate change will involve many of the same approaches that have been initiated in the basin to date.” With respect to hydrosystem operations, the ISAB noted: “To the extent that hydrosystem operations are flexible, there are opportunities to mitigate for some climate change impacts in the mainstem, estuary and plume.” Most of the ISAB’s recommendations for modified hydrosystem operations are in fact being implemented by the Corps today.

Finally, the Action Agencies believe that the 2010 Supplemental BiOp’s conclusion remains sound. The BiOp concluded that: “New observations and predictions regarding physical effects of climate change are within the range of assumptions considered in the 2008 BiOp and the AMIP.” The Supplemental BiOp went on to state: “New studies of biological effects of climate change on salmon and steelhead provide additional details on effects previously considered and suggest that adult migration conditions in the mainstem lower Columbia may need particular attention through monitoring and proactive actions.” The BiOp also included additional RPA actions requirements to address this concern.

Habitat conditions and action effectiveness information will be collected and managed in the following databases to allow changes to be tracked over time:

- Ocean Conditions / Indicators — NOAA will use its existing database *http://www.nwfsc.noaa.gov/research/divisions/fed/oeip/a-ecinhome.cfm*).
- Stream habitat conditions will be monitored across the Columbia River Basin beginning in 2011. All data from this program will be managed and distributed through a web-based data system (*http://www.champmonitoring.org*).
- Stream habitat restoration and conservation actions are compiled region-wide by NWFSC staff and managed and distributed on a web-based data system, which is

being migrated to a new system. Status of the migration is available at *https://www.webapps.nwfsc.noaa.gov/pnshp/*.

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.*

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 NWFSC funded tributary habitat action effectiveness monitoring for RPA 56 and 57, the ISEMP Project No. 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 (SATURN) within the Center for Coastal Margin Observation & Prediction Science and Technology University Research Network. 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 NWFSC Project No. 1998-014-00 (Ocean Survival of Salmonids) may be found at the NOAA 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 and 37, 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 review of new climate change literature provided by NOAA under AMIP Action 3 [AMIP pg. 25] is being shared with the tributary habitat expert panels in preparation for the workshops in 2012.

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.

Additionally, the Corps obtained funding from the Institute for Water Resources in 2011 to begin a pilot study to evaluate how we may include climate change considerations in our ecosystem restoration planning process for the Lower Columbia River and estuary.

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.*

   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.*

   Enhanced monitoring in 2011 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. 1. – Early Warning Indicator for Chinook Salmon & Steelhead: *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.*

Completed in 2011. The NWFSC developed a forecasting tool that satisfies this requirement. It has been agreed among the respective Federal agencies that the tool will be used in conjunction with existing early warning indicators to help determine whether a species is likely to fall below the "significant decline" threshold within the following 2 years, based on 2 years of adult return information. Data are presently available that would allow the toll to be used to analyze the Snake River spring Chinook salmon ESU. Additional data are being gathered to allow expanded coverage, initially to Snake River steelhead and Upper Columbia River spring Chinook salmon.

Background on Schedule Change: In November 2010, NOAA discussed the change to the completion date for this project from December 2010 to fall 2011 with the Regional Implementation Oversight Group (RIOG). This did not increase the risk to the listed species because the information available to NOAA as of December 2010 (including the previous season's dam counts) indicated that the early warning indicator had not been tripped.

IV. A.2. – Significant Decline Trigger for Chinook Salmon & Steelhead: *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.*

Completed on schedule in 2010.

IV. B. Rapid Response Actions

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.

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:

1. *Hydro Actions: The Corps will implement, in coordination with NOAA Fisheries and the other Action Agencies, hydrosystem actions that will increase the survival of the species in question beyond the current juvenile dam passage performance standards. Specific actions will be based on the most recent data available and might include targeted spill and changes in fish transportation operations based on recent survival data. The federal agencies, in collaboration with the RIOG and appropriate technical groups, will review the current status of biological research and discuss where additional project survival benefits could be gained for the species in question.*
2. *Predator Control: BPA and the Corps, in conjunction with the USFWS and the States, will implement more aggressive, targeted efforts to control predatory fish, birds, and invasive species to increase survival of listed fish. This will include a temporary increase in the pikeminnow sport fishery reward program and increased hazing of birds in close proximity to the dams.*
3. *Harvest: All fisheries that affect the species of concern, including ocean, mainstem, and terminal will be reviewed by NOAA Fisheries to assess whether existing harvest management agreements provide adequate protection. Under the United States v. Oregon agreement, if the performance measure of any indicator stock declines for three consecutive years when compared to the base period, any party may request that an analysis of the decline is conducted. The analysis must*

be completed within one year. After review of the analysis, the parties may make recommendations to modify the agreement. If it is determined that additional protection is necessary, NOAA Fisheries will use existing procedural provisions of the agreements to seek consensus among the parties to modify the agreements.

4. *Safety-Net Hatchery Programs: BPA and NOAA Fisheries use safety-net hatchery programs to address short-term extinction risk. By December 2011, the federal agencies will consult with the RIOG and identify opportunities and further processes to implement safety-net programs that could be used for each interior species. BPA is the primary agency for safety-net hatchery program implementation. Such actions may require additional approvals and NEPA reviews. The goal is to establish safety-net programs within one year at existing hatchery facilities where only minor facility modifications are needed.*

The Rapid Response plan addressing actions 1-4 above was completed on schedule in 2011 (ACOE et al. 2012). Additional time was provided, by mutual agreement between the Action Agencies and NOAA, for the regional sovereigns to review and comment through the RIOG. The Plan was subsequently modified to incorporate comments and was delivered to NOAA on February 7, 2012.

IV. C. Long-term Contingency Actions: *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 will then be implemented as soon as practicable thereafter. Unlike the Rapid Response Actions, all of which have been determined to be implementable within 1-12 months of a triggering event, each Long-Term Contingency Action has a unique timeline for implementation depending on its complexity.*

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:

1. *Phase II Hydro Actions*
2. *Reintroduction*
3. *Predator Control*
4. *Harvest*
5. *Conservation Hatcheries*
6. *Hatchery Reform*

   The long-term contingency plan that addresses action 1 through 6 above was completed on schedule in 2011 (ACOE et al. 2012). Additional time was provided, by mutual agreement between the Action Agencies and NOAA, for the regional sovereigns to review and comment through the RIOG. The Plan was subsequently modified to incorporate comments and was delivered to NOAA on February 7, 2012.

7. *John Day Reservoir at Minimum Operating Pool from April – June*

   The draft John Day to Minimum Operating Pool Study Plan was submitted to NOAA in December 2011 on schedule and will be out for regional review in March 2012.

8. *Breaching Lower Snake River Dams: 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.*

Completed in 2010.

AMIP Category: Amendments

Amendment 1

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.

In 2011, a draft biological analysis was completed. A draft water quality analysis was initiated in 2011 as well, with anticipated completion in March 2012 and subsequent regional review undertaken to complete on schedule in June 2012.

University of Idaho researchers were tasked in 2011 with updating their previous thermal refugia report. This will be combined with the Corps' information on temperature mapping and tracking information to fulfill the requirement of this action.

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 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.

A study was begun in 2011 to assess alternatives for PIT detection in John Day and The Dalles Dam ladders in 2011. Based on an initial assessment of sites at both dams and per regional coordination, the direction is focused on detection at The Dalles Dam ladders.

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 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 within 6 months following the establishment of a regional database and annually thereafter. NOAA anticipates having a regional database established no later than 2012.

NOAA and the Action Agencies are satisfying this requirement by submitting data developed for FCRPS BiOp RM&E to the U.S. Forest Service'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 in its efforts to use existing tributary habitat effectiveness studies, IMWs, and the NOAA enhanced lifecycle modeling to track climate change impacts. Starting in September 2011, the Action Agencies will annually provide NOAA 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 NWFSC is currently developing enhanced lifecycle modeling capability with some funding assistance from the Action Agencies. In addition, the review of new climate change literature provided by NOAA under AMIP Action No.3 [AMIP pg. 25] is being shared with the expert panels. See also response to AMIP III.D.

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.

Completed on schedule. Consistent with the AMIP, the Action Agencies shared with the expert panels information on the presence of invasive species or site-specific toxicology that was submitted by any appropriate State or Federal agency by October 1, 2011. The information will be considered as appropriate during the expert panel evaluation process, which occurs in 2012. Additionally, it is expected that as the local watershed groups refine and validate the limiting factors in the pertinent watersheds, the presence of invasive species or toxic substances will be considered as part of that effort.

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 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 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 and BPA have postponed implementation of the CRHEET until 2013. NMFS, BPA, Tribes, and others are undertaking an extensive ESA consultation process on FCRPS mitigation hatchery programs. These consultations require significant involvement from many of the people proposed to participate in CRHEET. Recognizing this overlap, BPA agreed with NMFS that 2013 would be a more appropriate time for implementation of CRHEET, which can then be informed by the outcomes of the consultations.

References, Citations, and Sources of Data

In Text	Complete Title
ACOE 2011a	Army Corps of Engineers. 2011. 2011 Dissolved Gas and Water Temperature Monitoring Report. *https://www.salmonrecovery.gov/Files/2011 APR files/2011_Dis_Gas_and_Wtr_Temp_Rpt.pdf*
ACOE 2011b	Army Corps of Engineers. 2011. 2011 Dissolved Gas Monitoring Plan of Action. *Appendix B of* 2011 Dissolved Gas and Water Temperature Monitoring Report. *https://www.salmonrecovery.gov/Files/2011 APR files/2011_Dis_Gas_and_Wtr_Temp_Rpt_AppB.pdf*
ACOE 2011c	Army Corps of Engineers, Northwestern Division. 2011. Fish Passage Plan 2011. *https://www.salmonrecovery.gov/Files/2011 APR files/2011_Fish_Pass_Pln.pdf*
ACOE 2011d	Army Corps of Engineers, Northwestern Division. 2011. 2011 Annual Fish Passage Report, Columbia and Snake Rivers, for Salmon, Steelhead, Shad, and Lamprey. *https://www.salmonrecovery.gov/Files/2011 APR files/2011_Ann_Fish_Pass_Rpt.pdf*
ACOE et al. 2012	U.S. Army Corps of Engineers, Bonneville Power Administration, U.S. Bureau of Reclamation, and NOAA Fisheries. 2012. Rapid Response and Long-Term Contingency Plan for the FCRPS Adaptive Management Implementation Plan. *https://www.salmonrecovery.gov/Files/2011 APR files/2011_RRandLTC_Plan.pdf*
Anderson et al. 2012	Anderson J.J., K.D. Ham, and J.L. Gosselin. 2012. Snake River Basin Differential Delayed Mortality Synthesis, Final Report. PNWD-4283, prepared for the U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington, by Battelle–Pacific Northwest Division, Richland, WA. *https://www.salmonrecovery.gov/Files/2011 APR files/Anderson_et_al_PNWD-4283_Diff_Delayd_Mort_Final.pdf*
Borde et al. 2011	Borde, A.B., V.I. Cullinan, H.L. Diefenderfer, R.M. Thom, R.M. Kaufmann, K.E. Buenau, and J.P. Sagar. 2011. Lower Columbia River and Estuary Restoration Reference Site Study, 2011. Pacific Northwest Division. *https://www.salmonrecovery.gov/Files/2011 APR files/Borde_et_al_2012_Reference_Site_Study.pdf*
BPA et al. 2010a	Bonneville Power Administration, U.S. Bureau of Reclamation, and U.S. Army Corps of Engineers. 2010. 2011 Water Management Plan. *https://www.salmonrecovery.gov/Files/2011 APR files/2011_Water_Mgmt_Plan.pdf*
BPA et al. 2010b	Bonneville Power Administration, U.S. Bureau of Reclamation, and U.S. Army Corps of Engineers. 2010. 2011 Total Dissolved Gas Management Plan. Appendix 4 *of* 2011 Water Management Plan. *https://www.salmonrecovery.gov/Files/2011 APR files/2011_TDG_Management_Plan_App4.pdf*
Buchanan et al. 2011	Buchanan, R.A., J.R. Skalski, R.L. Townsend, K.D. Ham. 2011. The effects of bypass passage on adult returns of salmon and steelhead: an analysis of PIT-tag data using the program ROSTER. Report to U.S. Army Corps of Engineers, Walla Walla District. *https://www.salmonrecovery.gov/Files/2011 APR files/Corrections/Buchanan_et_al_2011_Bypass_Effects_Final_Report.pdf*

In Text	Complete Title
Carlson et al. 2010	Carlson, T.J., R.S. Brown, J.R. Stephenson, A.J. Gingrich, B.D. Pflugrath, A.H. Colotelo, A.E. Welch, P.L. Benjamin, J.R. Skalski, A.G. Seaburg, and R.L. Townsend. 2010. Assessment of barotrauma in untagged and tagged juvenile Chinook salmon exposed to simulated hydro turbine passage. Prepared by Pacific Northwest National Laboratory for the U.S. Army Corps of Engineers, Portland, Washington, under Contract DE-AC05-76RL01830. *https://www.salmonrecovery.gov/Files/2011 APR files/Carlson_et_al_2010_Barotrauma_Chinook.pdf*
Carlson et al. 2011	Carlson, T.J., Z.D. Deng, R.S. Brown, A.H. Colotelo, J.J. Martinez, B.D. Pflugrath, T.K. Abel, J.M. Janak, A.P. LeBarge, J.R. Stephenson, R.P. Mueller, and A.G. Seaburg. 2011. Design, production, and assessment of a neutrally buoyant externally attached acoustic transmitter for studying behavior and survival of juvenile salmonids. Prepared by Pacific Northwest National Laboratory for the U.S. Army Corps of Engineers, Portland, Washington, under Contract DE-AC05-76RL01830. *https://www.salmonrecovery.gov/Files/2011 APR files/Carlson_et_al_2011_External_Acoustic_Tag.pdf*
Crawford and Rumsey 2011	Crawford, B.A., and S.M. Rumsey. 2011. Guidance for monitoring recovery of Pacific Northwest salmon & steelhead listed under the Federal Endangered Species Act. National Marine Fisheries Service, Northwest Region. *https://www.salmonrecovery.gov/Files/2011 APR files/New Folder 3/Crawford_and_Rumsey_2011_Guid_Monit_Rcvry_Salmn_Stlhd_2011.pdf*
Diefenderfer et al. 2011	Diefenderfer H.L., G.E. Johnson, N.K. Sather, J.R. Skalski, E.M. Dawley, A.M. Coleman, K.G. Ostrand, K.C. Hanson, D.L. Woodruff, E.E. Donley, Y. Ke, K.E. Buenau, A.J. Bryson, and R.L. Townsend. 2011. Evaluation of Life History Diversity, Habitat Connectivity, and Survival Benefits Associated with Habitat Restoration Actions in the Lower Columbia River and Estuary, Annual Report 2010. PNNL-20295 Final, Pacific Northwest National Laboratory, Richland, WA. *https://www.salmonrecovery.gov/Files/2011 APR files/New Folder 3/Diefenderfer_et_al_2011_Diversity_Connct_Surv_Bens_2010.pdf*
Diefenderfer et al. 2012	Diefenderfer, H.L., A.M. Coleman, Y. Ke, G.E. Johnson, K.E. Buenau, E.M. Dawley, N.K. Sather, J.D. Tagestad, and J.R. Skalski. 2012. Evaluation of Life History Diversity, Habitat Connectivity, and Survival Benefits Associated with Habitat Restoration Actions in the Lower Columbia River and Estuary, Annual Report 2011. Pacific Northwest National Laboratory, Richland, WA. *https://www.salmonrecovery.gov/Files/2011 APR files/Corrections/Diefenderfer_et_al_2012_Diversity_Connectivity_Survival_Benefits_2011.pdf*
FCRPS 2006–07	Army Corps of Engineers, Bonneville Power Administration, and U.S. Bureau of Reclamation. 2008. 2006–07 FCRPS Annual Report. *https://www.salmonrecovery.gov/Files/2011 APR files/2006-2007_FCRPS_APR[1].pdf*
FCRPS 2007	Army Corps of Engineers, Bonneville Power Administration, and U.S. Bureau of Reclamation. 2007. Biological Assessment for Effects of Federal Columbia River Power System and Mainstem Effects of Other Tributary Actions on Anadromous Salmonid Species Listed Under the Endangered Species Act. *https://www.salmonrecovery.gov/Files/2011 APR files/2007_FCRPS_BA_MAIN[1].pdf*
FCRPS 2008	Army Corps of Engineers, Bonneville Power Administration, and U.S. Bureau of Reclamation. 2009. FCRPS 2008 Annual ESA Progress Report. *https://www.salmonrecovery.gov/Files/2011 APR files/Corrections/2008_FCRPS_APR.pdf*

In Text	Complete Title
FCRPS 2009	Federal Columbia River Power System. 2010. FCRPS 2009 Annual ESA Progress Report. *https://www.salmonrecovery.gov/Files/2011 APR files/Corrections/2009_FCRPS_APR.pdf*
FCRPS 2010	Army Corps of Engineers, Bonneville Power Administration, and U.S. Bureau of Reclamation. 2010. FCRPS 2010-2013 Implementation Plan. *https://www.salmonrecovery.gov/Files/2011 APR files/2010-2013_FCRPS_BiOp_Implementation_Plan_6.10.pdf*
FCRPS 2010	Federal Columbia River Power System. 2011. FCRPS 2010 Annual ESA Progress Report. *https://www.salmonrecovery.gov/Files/2011 APR files/Corrections/2010_FCRPS_APR.pdf*
Ham et al. 2012	Ham, K.D., P.S. Titzler, R.P. Mueller, and D. Trott. 2012. Hydroacoustic Evaluation of Adult Steelhead Fallback and Kelt Passage at McNary Dam, Winter 2010–11. Prepared for the U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington, under biological services Contract W912EF-08-D-0004, delivery order 0002, March 2012. Battelle, Pacific Northwest Division, Richland, WA 99352. *https://www.salmonrecovery.gov/Files/2011 APR files/New Folder 3/Ham_et_al_2012_-_Steelhead_Fallback_and_Kelt_Passage_McNary.pdf*
Hankin and Richards 2000	Hankin, D.G., and J. Richards. 2000. The Northern Pikeminnow Management Program, An Independent Review of Program Justification, Performance, and Cost-Effectiveness. Humboldt State University, Arcata, CA, and Portland State University, Portland, OR. *https://www.salmonrecovery.gov/Files/2011 APR files/New Folder 3/Hankin_2000_NPMP.pdf*
ISEMP 2011	ISEMP Lessons Learned Synthesis Report 2003–11. 2011. Prepared for the Bonneville Power Administration Project 2003-017-00. Published by Terraqua, Inc., Wauconda, WA. *https://www.salmonrecovery.gov/Files/2011 APR files/Corrections/ISEMP_2011_synthesis_report.pdf*
ISRP 2010	Independent Scientific Review Panel for the Northwest Power & Conservation Council. December 16, 2010. Final RME and Artificial Production Categorical Review Report. Report ISRP 2010-44A. *https://www.salmonrecovery.gov/Libraries/burton_dam_doc_lib/ISRP_2010_1_1.sflb.ashx*
ISRP and ISAB 2011	Independent Scientific Review Panel and Independent Scientific Advisory Board. 2011. Comments on the Anadromous Salmonid Monitoring Strategy (Memorandum ISRP/ISAB 2011-1). *https://www.salmonrecovery.gov/Files/2011 APR files/New Folder 3/ISRP_ISAB_2011-1.pdf*
Jacobson et al. 2012	Jacobson, K., B. Peterson, M. Trudel, J. Ferguson, C. Morgan, D. Welch, A. Baptista, B. Beckman, R. Brodeur, E. Casillas, R. Emmett, J. Miller, D. Teel, T. Wainwright, L. Weitkamp, J. Zamon and K. Fresh. 2012. The Marine Ecology of Juvenile Columbia River Basin Salmonids: A Synthesis of Research, 1998-2011. Report of the U.S. National Marine Fisheries Service, National Oceanic and Atmospheric Administration Fisheries and Oceans Canada Kintama Research Services, Ltd. and Oregon State University to Northwest Power and Conservation Council. *https://www.salmonrecovery.gov/Files/2011 APR files/New Folder 3/Jacobson_et_al_2012_Marine_Ecology_Synthesis_Research.pdf*

In Text	Complete Title
Johnson et al 2011	Johnson G.E., A. Storch, J.R. Skalski, A.J. Bryson, C. Mallette, A.B. Borde, E. Van Dyke, K.L. Sobocinski, N.K. Sather, D. Teel, E.M. Dawley, G.R. Ploskey, T.A. Jones, S.A. Zimmerman, and D.R. Kuligowski. 2011. Ecology of Juvenile Salmon in Shallow Tidal Freshwater Habitats of the Lower Columbia River, 2007-2010. PNNL-20083, Pacific Northwest National Laboratory, Richland, WA.*https://www.salmonrecovery.gov/Files/2011 APR files/New Folder 3/Johnson_et_al_2011_Ecology_Juvenile_Salmon_Shallow_Freshwater_Final.pdf*
Johnson and Whitesel 2012	Johnson, J., and T.A. Whitesel. 2012. Julia Butler Hansen National Wildlife Refuge: Post-Construction Assessment of Fishes, Habitats, and Tide Gates in Sloughs on the Mainland, 2011 Annual Report. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, Vancouver WA. Prepared for the U.S. Army Corps of Engineers, Portland District. *https://www.salmonrecovery.gov/Files/2011 APR files/New Folder 3/Johnson_and_Whitesel_2012_JBH_NWR_2011Monitoring.pdf*
Katz et al. 2006	Katz, S.L., K. Barnas, and S. Toshach. 2006. Data Management Needs for Regional Project Tracking to Support Implementation and Effectiveness Monitoring. NOAA Fisheries, Northwest Fisheries Science Center. *https://www.salmonrecovery.gov/Files/2011 APR files/New Folder 3/Katz_et_al_2006_Data_Mgmt_for_Project_Tracking.pdf*
Lyons et al. 2011	Lyons, D.E., D.D. Roby, A.F. Evans, N.J. Hostetter, and K. Collis. 2011. Benefits to Columbia River anadromous salmonids from potential reductions in avian predation on the Columbia Plateau. Report submitted to the U.S. Army Corps of Engineers, Walla Walla District. Bird Research Northwest. *https://www.salmonrecovery.gov/Files/2011 APR files/New Folder 3/Lyons_et_al_2011_Benefits_to_CR_Salmon_from_Reduc_Av_Pred (1).pdf*
McClure et al. 2011	McClure, M., J. Anderson, G. Pess, T. Cooney, R. Carmichael, C. Baldwin, Recovery Implementation Science Team, L. Weitkamp, D. Holzer, M. Sheer, S. Lindley. 2011. Anadromous Salmonid Reintroductions: General Planning Principles for Long-term Viability and Recovery. Final Review draft. *https://www.salmonrecovery.gov/Files/2011 APR files/New Folder 3/McClure_et_al_2011_Reintro_gnrl_prncpls_v5_final_review_draft_100411.pdf*
NOAA Fisheries 2010	U.S. Army Corps of Engineers. Bonneville Power Administration, U.S. Bureau of Reclamation, and National Marine Fisheries Service. 2010. Endangered Species Act, Section 7(a)(2) Consultation, Supplemental Biological Opinion — Supplemental Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin, and ESA Section 10(a)(I)(A) Permit for Juvenile Fish Transportation Program. *https://pcts.nmfs.noaa.gov/pls/pcts-pub/pcts_upload.summary_list_biop?p_id=124302*
NOAA Fisheries 2011	NOAA Fisheries. 2011. Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead. Northwest Region.*https://www.salmonrecovery.gov/Files/2011 APR files/New Folder 3/NOAA_2011_CR_Estuary_Recov_Plan_Mod.pdf*
Normandeau Associates 2011	Normandeau Associates. 2011. Estimate of Direct Effects of Steelhead Kelt Passage Through The First Powerhouse Ice-Trash-Sluice and Second Powerhouse Corner Collector at Bonneville Dam. Annual Report of Research by Normandeau Associates, Inc., to the U.S. Army Corps of Engineers Portland District. Contract No W912EF-08-D-0005 Task Order DT02. *https://www.salmonrecovery.gov/Files/2011 APR files/New Folder 3/Normandeau_2011_Bonneville_Kelt_Study_Final.pdf*

In Text	Complete Title
NWFSC et al. 2011	Northwest Fisheries Science Center, Oregon State University Cooperative Institute for Marine Resources Studies, and Oregon Health Sciences University OGI School of Science & Engineering. 2011. Annual Report to the Bonneville Power Administration, Reporting Period: April 2010- April 2011. *https://www.salmonrecovery.gov/Files/2011 APR files/New Folder 3/NWFSC_et_al_2011_Annual_Report_to_BPA.pdf*
Ploskey 2012	Ploskey G.R., M.A. Weiland, and T.J. Carlson. 2012. Summary of Route-Specific Passage Proportions and Survival Rates for Fish Passing through John Day Dam, The Dalles Dam, and Bonneville Dam in 2010 and 2011. PNNL-21442, Interim Report, Pacific Northwest National Laboratory, Richland, Washington.*https://www.salmonrecovery.gov/Files/2011 APR files/New Folder 3/Ploskey_et_al_2012_Route_Specific_Passage_2011.pdf*
Reclamation 2012	Reclamation Technical Service Center. 2012. Winthrop National Fish Hatchery Steelhead Management – RPA 40 Implementation Proposals: Project Alternatives Solution Study (PASS) Report. Pacific Northwest Regional Office, Boise, ID. *https://www.salmonrecovery.gov/Files/2011 APR files/Corrections/Reclamation_2012_Winthrop_PASS_Rpt_Fnl.pdf*
Rieman and Beamesderfer 1990	Rieman, B.E., and R.C. Beamesderfer. 1990. "Dynamics of a northern squawfish population and the potential to reduce predation on juvenile salmonids in a Columbia River Reservoir" in North American Journal of Fisheries Management 10:228-241. *https://www.salmonrecovery.gov/Files/2011 APR files/New Folder 3/Rieman_and_Beamesderfer_1990_Dynamics_N_squawfish_pop_NAJFM_10_228-41.pdf*
Roby et al. 2011	Roby, D.D., K. Collis, D. Lyon, J. Adkins, P. Loschl, Y. Suzuki, T. Marcella, L. Kerr, A. Evans, B. Cramer, N. Hostetter, B. Sanford, R.D. Ledgerwood, D.R. Kuligowski, and S. Sebring. 2011. Impacts of Avian Predation on Salmonid Smolts from the Columbia and Snake Rivers: 2004–2009 Synthesis Report. Prepared for U.S. Army Corps of Engineers – Walla Walla District. *https://www.salmonrecovery.gov/Files/2011 APR files/New Folder 3/Roby_ed_2011_Impacts_of_Avian_Predation_on_Salmonid_Smolts.pdf*
Sagar et al. 2011	Sagar, J.P., K.E. Marcoe, C.A. Simenstad, M.F. Ramirez, J.L. Burke, J.E. O'Connor, T.D. Counihan, I.R. Waite, A.B. Borde, S.A. Zimmerman, N.K. Sather, R.M. Thom, J.L. Morace, L.L. Johnson, P.M. Chittaro, K.H. Macneale, O.P. Olson, S.Y. Sol, D.J. Teal, G.M. Ylitalo, and L.K. Johnson. 2011. Lower Columbia River Ecosystem Monitoring Project Annual Report for Year 6 (September 2009 to November 2010). Prepared by the Lower Columbia River Estuary Partnership for the Bonneville Power Administration. *https://www.salmonrecovery.gov/Files/2011 APR files/New Folder 3/Sagar_et_al_2011_Ecosystem_Monitoring_Report.pdf*
Sagar et al. 2012	Sagar, J.P. [and 24 others]. 2012. Lower Columbia River Ecosystem Monitoring Program Annual Report for Year 7 (September 1, 2010 to December 31, 2011). Prepared by the Lower Columbia Estuary Partnership for the Bonneville Power Administration. *https://www.salmonrecovery.gov/Files/2011 APR files/New folder (2)/Sagar_et_al_2012_Ecosystem_Monitoring_Program_Yr7.pdf*

In Text	Complete Title
Sather et al. 2009	Sather N.K., G.E. Johnson, A. Storch, D. Teel, J.R. Skalski, T.A. Jones, E.M. Dawley, S.A. Zimmerman, A.B. Borde, C. Mallette, and R. Farr. 2009. Ecology of Juvenile Salmon in Shallow Tidal Freshwater Habitats in the Vicinity of the Sandy River Delta, Lower Columbia River, 2008. PNNL-18450, Pacific Northwest National Laboratory, Richland, WA. *https://www.salmonrecovery.gov/Files/2011 APR files/New folder (2)/Sather_et_al_2009_Ecology_SRD_2008.pdf*
Sather et al. 2012	Sather N.K., A.J. Storch, G.E. Johnson, D.J. Teel, J.R. Skalski, A.J. Bryson, R.M. Kaufmann, J. Blaine, D.L. Woodruff, D.R. Kuligowski, R.K. Kropp, and E.M. Dawley. 2012. Multi-Scale Action Effectiveness Research in the Lower Columbia River and Estuary, 2011. Pacific Northwest National Laboratory, Report PNNL-21194. Prepared for U.S. Army Corps of Engineers, Portland District, under Contract DE-AC05-76RL01830. *https://www.salmonrecovery.gov/Files/2011 APR files/New folder (2)/Sagar_et_al_2012_Ecosystem_Monitoring_Program_Yr7.pdf*
Simenstad et al. 2011	Simenstad, C.A., J.L Burke, J.E. O'Connor, C. Cannon, D.W. Heatwole, M.F. Ramirez, I.R. Waite, T.D. Counihan, and K.L Jones. 2011. Columbia River Estuary Ecosystem Classification—Concept and Application: U.S. Geological Survey Open-File Report 2011-1228. *https://www.salmonrecovery.gov/Files/2011 APR files/New folder (2)/Simenstad_et_al_2011_Estuary_Ecosystem_Classification.pdf*
Skalski et al. 2012a	Skalski, J.R., R.L. Townsend, A.G. Seaburg, G.R. Ploskey, and T.J. Carlson. 2012. Compliance monitoring of juvenile yearling Chinook salmon and juvenile steelhead survival and passage at Bonneville Dam, Spring, 2011. Annual report of research prepared by the Pacific Northwest National Laboratory and University of Washington for the Corps Portland District. *https://www.salmonrecovery.gov/Files/2011 APR files/New folder (2)/Skalski_et_al_2012_BON_PNNL_21175Rev1.pdf*
Skalski et al. 2012b	Skalski, J.R., R.L. Townsend, G.E. Johnson, and T.J. Carlson. 2012. Compliance monitoring of juvenile yearling Chinook salmon and steelhead survival and passage at The Dalles Dam, Spring 2011. Annual report of research prepared by the Pacific Northwest National Laboratory and University of Washington for the Corps Portland District. *https://www.salmonrecovery.gov/Files/2011 APR files/New folder (2)/Skalski_et_al_2012_DALLES_PNNL_21124Rev1.pdf*
Skalski et al. 2012c	Skalski, J.R., R.L. Townsend, A.G. Seaburg, M.A. Weiland, C.M. Woodley, J.S. Hughes, and T.J. Carlson. 2012. Compliance monitoring of yearling Chinook salmon and juvenile steelhead survival and passage at John Day Dam, Spring 2011. Annual report of research prepared by the Pacific Northwest National Laboratory and University of Washington for the Corps Portland District. *https://www.salmonrecovery.gov/Files/2011 APR files/New folder (2)/Skalski_etal_2012_JDA.pdf*
Snow et al. 2012	Snow, C., B. Goodman, T. Seamons, C. Frady, and A. Murdoch. 2012. Monitoring the Reproductive Success of Naturally Spawning Hatchery- and Natural-Origin Steelhead in a Tributary of the Methow River, Annual Progress Report for the Period: 1 August 2010–31 July 2011. Washington Department of Fish and Wildlife, Olympia, WA. *https://www.salmonrecovery.gov/Files/2011 APR files/New folder (2)/Snow_et_al_2012_Monitor_Repro_Success_Steelhead_Methow.pdf*

In Text	Complete Title
Stansell et al. 2011	Stansell, R.J., K.M. Gibbons, and W.T. Nagy. 2011. Evaluation of Pinniped Predation on Adult Salmonids and Other Fish in the Bonneville Dam Tailrace, 2011. U.S. Army Corps of Engineers, Fisheries Field Unit, Bonneville Lock and Dam, Cascade Locks, Oregon. *https://www.salmonrecovery.gov/Files/2011 APR files/New folder (2)/Stansell_et_al_2011_pinniped_field_report.pdf*
Tackley and Clugston 2011	Tackley, S. and D. Clugston. 2011. Estimated benefits of operating the Ice and Trash Sluiceway (ITS) at The Dalles Dam from December 1-15 and March 1-April 10 for overwintering steelhead and out-migrating steelhead kelts. Portland, OR. U.S. Army Corps of Engineers, Portland District. Memorandum for the Record. *https://www.salmonrecovery.gov/Files/2011 APR files/New folder (2)/Tackley_and_Clugston_2011_Justification_for_TDA_sluiceway_operation_FEB2011.pdf*
TMT 2011	Columbia River Regional Forum, Technical Management Team. December 7, 2011. 2011 Year End Review Session.
Ward et al. 2012	Ward, M.B., P. Nelle and S.M. Walker. (editors). 2011. CHaMP: 2011 Pilot Year Lessons Learned Project Synthesis Report. Prepared for the Bonneville Power Administration by CHaMP. Published by Bonneville Power Administration, Portland, OR. *https://www.salmonrecovery.gov/Files/2011 APR files/New folder (2)/Ward_et_al_2011_2011_CHaMP_Rpt.pdf*

Acronyms, Abbreviations, and Glossary

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
ATIIM	area time inundation index model
ASMS	Anadromous Salmonid Monitoring Strategy
AWS	auxiliary water supply
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
CE-QUAL-W2	two dimensional, longitudinal/vertical, hydrodynamic, and water quality model
CHaMP	Columbia Habitat Monitoring Program
CI	confidence interval
COAST	Coastal Ocean Acoustic Salmon Tracking Project
COMPASS	COMprehensive Fish PASSage Model (developed by NMFS)
COP	Configuration and Operational Plan
Corps	U.S. Army Corps of Engineers
Council	Alternative designation for NPCC
CRFG	Columbia River Forecast Group, formed by the Action Agencies and Fish Accord partners
CRHEET	Columbia River Hatchery Effects Evaluation Team
CRiSP	Columbia River Salmon Passage model
CRITFC	Columbia River Inter-tribal Fish Commission
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
D	differential delayed mortality
DIDSON	dual frequency identification sonar
DMLT	Data Management Leadership Team
DPS	distinct population segment
ELHD	early life history diversity
ERDC	Corps’ Engineer Research and Development Center
ERTG	Expert Regional Technical Group
ESA	Endangered Species Act
ESP	Ensemble Streamflow Predication
Estuary MOA	Washington Estuary Memorandum of Agreement
ESU	evolutionarily significant unit
FCRPS	Federal Columbia River Power System
FFDRWG	Fish Facility Design Review Workgroup
FFU	Corps’ Fish Field Unit
FGE	fish guidance efficiency
FOP	Fish Operations Plan
FPC	Fish Passage Center
FPE	fish passage efficiency

FPOM	Fish Passage Operations and Maintenance Workgroup
FPP	Fish Passage Plan
GIS	geographic information system
GPS	global positioning system
GSI	genetic stock identification
HGMP	Hatchery and Genetic Management Plan
IDFG	Idaho Department of Fish and Game
IMW	intensively monitored watershed
INPMEP	Idaho Natural Production Monitoring and Evaluation Project
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
JBS	juvenile bypass system
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
LiDAR	light detection and ranging
LSRCP	Lower Snake River Compensation Plan
LRR	lower river reach
M&E	monitoring and evaluation
maf	million acre-feet
mm	millimeter
MOP	minimum operating pool
MPG	major population group
NED	Northwest Environmental Data
NFH	National Fish Hatchery
NMFS	NOAA's National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOAA Fisheries	Alternative designation for NMFS
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
O&M	operations and maintenance
OBMEP	Okanogan Basin Monitoring and Evaluation Program
ODFW	Oregon Department of Fish and Wildlife
PCSRF	Pacific Coastal Salmon Recovery Fund
PH1	First Powerhouse (Bonneville Dam)
PH2	Second Powerhouse (Bonneville Dam)
PIT	Passive Integrated Transponder
PNAMP	Pacific Northwest Aquatic Monitoring Partnership
PNSHP	Pacific Northwest Salmon Habitat Restoration Project Tracking
POST	Pacific Ocean Survival Tracking Project
PTAGIS	PIT Tag Information System
Reclamation	U.S. Bureau of Reclamation

RIOG	Regional Implementation Oversight Group
rkm	river kilometer
RME *or* RM&E	research, monitoring, and evaluation
RMJOC	River Management Joint Operating Committee
ROSTER	River-Ocean Survival and Transportation Effects Routine
RPA	Reasonable and Prudent Alternative
RRS	relative reproductive success
RSW	removable spillway weir
SAR	smolt-to-adult return
SATURN	Science and Technology University Research Network
SBT	Shoshone-Bannock Tribe
sd	standard deviation
SLAM	Species Lifecycle Analysis Modules
SLED	sea lion exclusion device
SNP	single nucleotide polymorphism
SOR	System Operational Request
SR	Snake River
SRD	Sandy River Delta
SRFC	Snake River fall Chinook
SRWG	Studies Review Workgroup
SYSTDG	System Total Dissolved Gas
TDG	total dissolved gas
T:B	ratio of smolt-to-adult return of transported to bypassed migrating fish
T:M	ratio of smolt-to-adult return of transported to in-river migrating fish
TMT	Technical Management Team
UCR	Upper Columbia River
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USGS-CRRL	U.S. Geological Survey - Columbia River Research Laboratory
VARQ	variable outflow flood control procedures
VSP	viable salmonid population
WDFW	Washington Department of Fish and Wildlife
WMP	Water Management Plan
WSF	Water Supply Forecast
YN	Yakama Nation

Page is intentionally blank.

Appendix A – Literature Review for 2011 Citations for BiOp: Biological Effects of Climate Change

Page is intentionally blank.

Literature review for 2011 citations for BIOP: Biological effects of climate change

Prepared by Lisa Crozier
Northwest Fisheries Science Center, NOAA-Fisheries
July, 2012

Table of Contents

1 Executive summary

In 2011, the accumulation of more “fingerprints” of global warming continues (Blunden and Arndt 2012). CO_2 concentrations in the atmosphere broke new records, driving radiative forcing to 30% above 1990 levels. Rapid warming in high latitudes produced record losses of snow and ice from ice sheets and sea ice. Average summer temperatures throughout the U.S. were the second warmest on record, and despite the typically cool La Niña, 2011 was one of the 15 warmest years on record in the US, contributing to a very active wildfire season. The rise in 30-year average daily temperatures, reflected in the U.S. “Normals” for 1981-2010, was several degrees above that for the 1971-2000 period, reflecting the longer trends (Arguez et al. 2012). The frequency of extreme precipitation events (1-day and 5-day events) has increased over much of the Northern Hemisphere, despite natural forcing toward a decrease, thus presenting another “fingerprint” of the effects of anthropogenic forcing (Min et al. 2011).

In the PNW, hydrological impacts of warming have been strongest in rain-snow transient watersheds, where discharge has increased in the winter and decreased in the summer, producing earlier peak flows and lower low flows since 1962 (Jefferson 2011). New projections of hydrological responses in the PNW are consistent with the observed historical trends in hydrology (Cuo et al. 2011) and fire frequency and severity (Rogers et al. 2011), and emphasize the additional sensitivity in our region to higher projected rates of summer warming compared with winter warming for total annual discharge (Das et al. 2011). A statistically significant rise in summer sea level over the past century reflects larger patterns of sea level rise, while controlling for the effects of El Niño in winter (Komar et al. 2011). Similarly, summer upwelling intensity at 39º-42ºN has increased (Black et al. 2011), and upwelling has advanced earlier in the year, with a shorter upwelling period off British Columbia (Foreman et al. 2011). Hypoxia in the Columbia River estuary has been linked to upwelling events (Roegner et al. 2011b), and frequently reaches stressful levels for fish (2mg/L, Roegner et al. 2011a). Although some models project that hypoxic water from upwelling will decrease with climate change (Glessmer et al. 2011), sensitivity to hypoxia is much greater in warmer water, so it continues to present a serious risk (Vaquer-Sunyer and Duarte 2011). Numerous papers explore the hydrodynamics of the Columbia River, including sediment transport which might affect salmon survival (Jay et al. 2011; Jay and Naik 2011; Naik and Jay 2011b; Naik and Jay 2011a). Ecological fingerprints of climate change include a strong signal of long-term trends and regime shifts in marine ecosystems, described in a recent review of 300 time series in waters around the UK (Spencer et al. 2011).

A major concern is the extent to which natural responses to climate change must include range shifts or range contractions, because the current habitat will become unsuitable. The rate of range shifts and phenological shifts necessary to track climate change might be significantly larger in the ocean than on land, despite the slower absolute rate of warming in the ocean, due to shallower spatial and temporal gradients in temperature (Burrows et al. 2011). Abdul-Aziz et al (2011) illustrate this point dramatically for PNW salmon by showing that climate scenarios imply an enormous contraction (30-50% by the 2080s) of the summer thermal range suitable for chum, pink, coho, sockeye and steelhead in the marine environment, with an especially large contraction (86-88%) of Chinook salmon summer range (A1B and A2 scenarios). Previous analyses focusing on sockeye salmon (Welch et al.

1998) came to similar conclusions, but updated climate change projections and the multi-species perspective make this a particularly relevant paper.

Most of the other impacts of climate change on salmon reported in 2011 are consistent with the direction of previous studies. Copeland and Meyer (2011) found a positive effect of flow on juvenile Chinook density in the Salmon River Basin. Although demonstrated in Atlantic salmon (Marschall et al. 2011), observations that very long delays at dams can lead to exposure to extremely high river temperatures during smolting also could apply to the Columbia River. Bi et al (Bi et al. 2011a; Bi et al. 2011b) found strong correlations between marine distribution and growth and cold-water flow from the north, which presumably will decline with rising SST.

Numerous papers on adult migration demonstrate that migration timing is both genetically and plastically determined, and that changes in timing have already occurred (e.g., an evolutionary response in Columbia River sockeye, Crozier et al. 2011) and will continue with climate change. Projections of warming in the Fraser River produced much lower estimates of migration survival than occur now (Hague et al. 2011; Martins et al. 2011), although they aren't expected to drive the populations extinct on their own (i.e., acting on this life stage alone, Reed et al. 2011). Much of the current mortality might be due to diseases as yet unidentified (Miller et al. 2011a).

Several papers emphasize that focusing exclusively on effects of individual life stages gravely unrepresents the cumulative impacts of climate change on salmon (Healey 2011; Pankhurst and Munday 2011). Analyses of the factors correlated with salmon extinctions in California (Zeug et al. 2011) and Japan (Fukushima et al. 2011) point to changes in flow regimes and rising air temperatures.

The risk of diseases throughout the life cycle is probably one of the least well quantified areas of concern (e.g., little is known about virus responses to climate change, Danovaro et al. 2011). The best way to protect salmon from disease risk is to maintain large population sizes with high genetic diversity (de Eyto et al. 2011). Species interactions are also poorly predicted, although recent work shows that competition among trout species can significantly alter predicted effects of climate change (Wenger et al. 2011).

On the positive side, some papers found less negative impacts of rising temperatures than expected (e.g., high tolerance of Snake River fall Chinook for 23ºC, Geist et al. 2011), and substantial genetic variation (and thus theoretically, the potential for evolution) in growth parameters, smolt behavior, migration timing, cardiac performance and heat tolerance. However, the existence of genetic variation and local adaptation in physiological traits does not support much optimism that evolution is likely to rescue Chinook salmon from risk of lowered survival due to climate change (unlike migration timing, as mentioned above). Typically, evolution relies on large population sizes and plenty of time. This is especially true if fisheries selection, e.g., on age at return, opposes adaptive responses to climate change or enhances population variability in response to environmental forcing (Botsford et al. 2011; Rouyer et al. 2011).

Adaptation plans for responding to climate change in the Pacific Northwest are being developed (e.g., review in National Wildlife Federation 2011). However, several papers emphasize that institutional barriers are a serious impediment to proactive climate change adaptation in water management (Farley et al. 2011b; Hamlet 2011; Safford and Norman 2011).

In conclusion, new information from 2011 publications was generally consistent with previous analyses in reporting ongoing trends in climate consistent with climate change projections and negative implications for salmon. A few studies focused on areas that did not receive much attention in our previous report, and thus provide new information. These areas include the expected loss of significant portions of the marine distribution, albeit it mainly in the second half of this century, the current risk of hypoxia in the Columbia River estuary, as well as documented and projected rates of evolutionary changes in migration timing. Disease impacts on migration survival documented in Fraser River sockeye warn of the potential for a very rapid decline in survival, unlike the linear projections generally forecasted, with little managerial recourse. Several papers demonstrated how cumulative effects of climate change over the entire life cycle are likely to be much higher than previously predicted from effects on individual life stages. Finally, new adaptation plans for the PNW are being developed but institutional barriers to climate change adaptation for some agencies and water use sectors create challenges for effective response.

Table of acronyms

A1B, A2, B1	Carbon emission scenarios from IPCC Fourth Assessment Report
AOGCM	Coupled Atmosphere-Ocean General Circulation Model
ENSO	El Niño-Southern Oscillation
GCM	General Circulation Model
IPCC	Intergovernmental Panel on Climate Change
PDO	Pacific Decadal Oscillation
PNW	Pacific Northwest
SST	Sea surface temperature

2 Goals and methods of this review

The goal of this review was to identify the literature published in 2011 that is most relevant to predicting impacts of climate change on Columbia River salmon listed under the Endangered Species Act. A large amount of literature related to this topic is not included, because almost anything that affects salmon at all relates to or is altered in some way by changes in temperature, stream flow or marine conditions. We have tried to identify the most directly related papers by combining climatic and salmonid terms in search criteria. Thus many general principles demonstrated in other taxa or with more general contexts in mind have been omitted. This review also does not include potentially relevant gray literature, because the search engine used only includes the major peer-reviewed scientific journals. In total, the methods employed involved review of over 500 papers. Of these, 135 are included in this summary.

This search was conducted in ISI Web of Science in July, 2012. Each set of search criteria involved a new search, and results were compared with previous searches to identify missing topics. The specific search criteria all included PY=2011, plus:

1) TS=(climat* OR temperature OR streamflow OR flow OR snowpack OR precipitation OR PDO) AND TS=(salmon OR Oncorhynchus OR steelhead);

2) TS=(climat* OR Temperature OR Precipitation OR streamflow OR flow) AND TS="Pacific Northwest";

3) TS=(marine OR sea level OR hyporheic OR groundwater) AND TS=climat* AND TS=(salmon OR Oncorhynchus OR steelhead);

4) TS=(upwelling OR estuary) AND TS=climat* AND TS=Pacific;

5) FT=("ocean acidification" OR "California current" OR "Columbia River")

6) TS="prespawn mortality"

The review is organized by first considering physical environmental conditions (historical trends and relationships) and then predictions of future climate, snowpack, stream flow, temperature, ocean conditions, etc. A summary follows of the literature on salmonid responses to these environmental conditions, progressing through the life cycle.

3 Climate

3.1 *Global, national, regional climate*

3.1.1 1981-2010 U.S. "Normals"

NOAA released a new set of "Normal" temperatures, i.e., 30-year average temperatures for the U.S for the 1981-2010 period (Arguez et al. 2012). The new normals include some methodological and station changes, and thus are not recommended for describing long-term trends in climate. Nonetheless, there is a striking increase in most of the indices. January minimum temperature has risen 2-4ºF throughout the north-central US, with nearly the entire central US seeing at least 1ºF increases compared with 1971-2000 normals. July maximum temperatures have increased at least 0.5ºF in the entire West.

3.1.2 State of the Climate 2011

Despite the cooling effect of La Niña, 2011 was still one of the 15 warmest years on record and above the 1981-2010 average (Blunden and Arndt 2012). Global sea surface temperature (SST) was 0.1ºC cooler than El Niño-driven 2010, but the global upper ocean heat content was still higher than for all prior years. Atmospheric CO_2 concentrations increased by 2.1ppm in 2011, exceeding 390ppm for the first time since instrumental records began. Together with increases in other greenhouse gases, radiative forcing is now 30% higher than in 1990. Ocean uptake of CO_2 was 12% below the long-term average. The Arctic continued to warm at twice the rate of lower latitudes, continuing extreme surface warming and net snow and ice loss on the Greenland ice sheet and the greatest loss in the Canadian Arctic since Gravity Recovery and Climate Experiment satellite measurements began. Arctic sea ice extent in September 2011 was the second-lowest on record, and 4-5yr old ice set a new record minimum of 19% of normal. Similar records were set in Antarctica.

The nationally-averaged summer temperature was the second warmest on record, but the Pacific Northwest (PNW) was cooler than average. The tornado season was one of the most destructive and deadly recorded, and historic flooding soaked much of the central US, surpassing the great floods of the 1920s and 1930s. The US also had a very active wildfire year (Blunden and Arndt 2012).

Observations of weather over the past 60 years (shifts in the position of warm and cold fronts across US) are consistent with projections of climate change associated with elevated greenhouse gas concentrations. The overall shift toward cold fronts and away from warm fronts across the northern US arises from a combination of an enhanced ridge over western North America and a northward shift of storm tracks throughout the mid-latitudes (Hondula and Davis 2011).

3.1.3 Extreme events

General circulation models (GCM) predict that anthropogenic forcing will increase the frequency of extreme events, such as heavy precipitation events, that cause massive flooding in the PNW. Min et al (2011) identified positive trends in extreme precipitation events in GCM projections. These trends were most consistent in the anthropogenic-forcing experiment only (without natural forcing), because natural forcing over the 20th century would have led to decreases in extreme precipitation events in many areas, thus producing a weaker observed signal of the anthropogenic fingerprint (i.e., without correction for natural forcing). Statistical comparisons of model representations and observed data show that coarse-resolution models are not capable of capturing the frequency of extreme events, but regional climate models nested within them greatly improve the dynamics (Duliere et al. 2011). Note that in 2012 the Intergovernmental Panel on Climate Change (IPCC) released a thorough analysis of changes in the frequency of extreme events, which will be included in the 2012 literature review.

3.1.4 El Niño analysis and modelling

The 2009-2010 El Niño differed from classical El Niño because it exhibited a "Modoki phenomenon", or a "warm-pool" El Niño, with most warming in the central Pacific but a rapid transition to La Niña in 2011. Kim et al (2011) postulate the "fast phase transition" is due to a very warm Indian ocean and record-high SST in the central Pacific (see also Barnard et al. 2011).

Much work has been dedicated to improving the oceanographic data going into climate models, e.g., from autonomous gliders (Todd et al. 2011), and the spatial resolution of coupled atmosphere-ocean general circulation models (AOGCM) (Dawson et al. 2011), so that the next round of the IPCC's Fifth Assessment Report models should have better representation of El Nino-Southern Oscillation (ENSO).

The importance of El Niño modeling has been emphasized in many papers, particularly for the PNW. Paleological data indicates that the recent century has been unusually wet in the perspective of much longer time-series. Long-term droughts have occurred throughout the last 6000 years, especially during the last 1000 years. Shifts in the severity of both wet and dry multidecadal events appear to be driven by changes in the ENSO pattern, and its effect on the Pacific Decadal Oscillation (PDO) (Nelson et al. 2011).

3.2 Terrestrial

3.2.1 Historical trends in streamflow in PNW

Like previous studies, new analyses of historical trends in streamflow in the PNW emphasize the sensitivity of transitional watersheds (i.e., where precipitation falls as both snow and rain) and transitional elevations within watersheds to recent (and projected) warming. Specifically, in an analysis of 29 watersheds in the PNW (Jefferson 2011), transitional areas demonstrate the most significant historical trends (i.e., greater winter and lower summer discharge). Snow-dominated watersheds showed changes in the timing of runoff (22-27 days earlier) and lower low flows (5-9% lower) currently than in 1962. Peak flows increased in the more heavily snow-dominated watersheds exposed to more frequent rain-on-snow events at higher elevations, but there was no trend in most of the transient or rain-dominated watersheds.

A series of papers on the impact of climate, dams, water withdrawal, and other human impacts on the Columbia and Willamette Rivers demonstrate that 1) human factors dominate the change in outflow of the Columbia River over the 20th century (Jay and Naik 2011; Naik and Jay 2011a), 2) climate factors, especially ENSO and the PDO, but also more fine-scale details about the timing of winter storms and spring warming rates also drive significant changes in the annual flow, as well as the detailed flow profile and winter and spring freshets (Naik and Jay 2011a) , 3) sediment loads have been strongly reduced due mostly to flow management and withdrawals, but climate-driven flow reductions also lower sediment transport, which has negative impacts on juvenile salmon survival (Jay and Naik 2011; Naik and Jay 2011a).

Many papers explore how habitat generally and flow in particular are related to juvenile salmonid density or growth. We focus here only on those in the Columbia River Basin.

In the lower Columbia, low flows in summer and fall through a tidal channel in the lower Columbia River (from Portland, OR to Vancouver, WA) have gotten lower and tidal range has increased due to both tidal changes and river flow and harbor modifications (Jay et al. 2011).

In Idaho, water diversion patterns vary with water availability in the Snake River Plain over the past 35 years from 1971 to 2005 (Hoekema and Sridhar 2011). Overall trends of declining mid- and late-season diversion is due to lack of water supply due to lower summer flows. Diversions have increased in April in response to unusually wet springs.

In a study of temporal variability in stream habitat characteristics over nine years in 47 headwater streams, Al-Chokhachy et al (2011) used landscape, climate, and disturbance attributes as explanatory factors. Although the factors were significant, most of the variability was difficult to explain.

A high proportion of groundwater input to a basin significantly affects the flow regime. Streams in the Klamath Basin with major groundwater inflow have a smoother and delayed response to snowmelt. However, July to September baseflows decrease under climate change scenarios much faster than mostly surface-input streams (Mayer and Naman 2011).

3.2.2 Projected changes in stream flow and ice-cover

An analysis of how land-cover and climate change in the Puget Sound basin will drive hydrological change (Cuo et al. 2011) showed that land use, leading to younger vegetation and urbanization will likely have more impact at lower elevations than climate change alone. In the rain-snow transition zone, increased winter precipitation and less snow led to earlier winter and spring runoff, with increases in these seasons due to projected increases in precipitation. Reductions in late spring and summer runoff followed, but the net change was a slight increase in annual runoff. Land-cover change had greater impact on the total runoff, especially at lower elevations, due to an increase in impervious surfaces and loss of mature vegetation in forested areas.

Das et al (2011) explore the sensitivty of streamflow across the Columbia Basin (and three other basins) to the seasonality of warming. They find that annual streamflow is much more sensitive to warming in the summer than in the winter. This is because winter warming causes an initial increase in streamflow that partly compensates for the later low flows in the summer. Summer warming dries out soil immediately through greater evapotranspiration rates with no compensation during the next rainy season. Because the A2 scenario predicts greater summer warming (5ºC) than winter warming (3ºC), this has a greater impact than uniform warming or a bias in the other direction would have. Application of a 2ºC cool season warming and 4ºC warm season warming produced a decline in annual streamfow of 9.8% in the Columbia Basin (Das et al. 2011). Work continues (Bohn, Sonessa et al. 2010) on the Variable Infiltration Model hydrology model, downscaling bias correction, and understanding how best to use multi-model ensembles compared with best-fitting individual models.

Scenarios of climate change in the Willamette Basin predicted increases in flows in winter (September through February), and decreases in summer (March through August, Jung and Chang 2011). The spring freshet is expected to advance seasonally, the 7-day low flows decrease, and peak flows increase due to winter flooding, especially at higher elevations.

Similar to watersheds and elevations in the rain-snow transition zone, lakes where winter ice cover is short with winter minimum temperatures closer to 0ºC are most sensitive to warming. Weyhenmeyer et al (2011) predict that “3.7% of the world's lakes larger than 0.1 km^2 are at high risk of becoming open-water systems in the near future.”

In an analysis of uncertainty around flooding in urban areas, Jung et al (2011) explicitly focus on the uncertainty at all levels of modeling, from GCM model and emissions scenarios to land use change to hydrological model parameters and natural variability in climate. The development versus conservation land use scenarios in watersheds around Portland, OR made little difference to the overall projections, especially in the more developed watershed. In that watershed, hydrological parameters drove much more uncertainty than in the more pristine watershed. Uncertainty from GCM model structure (i.e., different GCMs) was larger than hydrological model uncertainty, and natural varibility was larger still, especially at long flood frequencies. Overall, flood frequencies are expected to increase by the 2050s.

3.2.3 Fire

Simulations of PNW fire frequency in future climates predict large increases in the area burned (76%-310%) and burn severities (29%-41%) by the end of the twenty-first century (Rogers et al. 2011). The changing fire regime lowers carbon storage west of the Cascades in the absence of fire suppression, but raises it in the dry eastern PNW.
Fire frequency is expected to increase in most areas of the PNW. Fire has a profound effect on steam temperature and nutrient input. An analysis of historical stream changes and trout response in burned and unburned areas of Montana showed stream temperatures increased 2-6ºC right after the fire, but recovery by fish was generally swift (Sestrich et al. 2011).

3.3 Marine

3.3.1 ENSO

State of the California Current System 2010-2011: The 2009-2010 El Niño was relatively weak and short-lived, and it was quickly followed by La Niña. La Niña produced some record-breaking cool conditions throughout the California Current system, with anomalously strong upwelling in summer 2010. Impacts of both El Niño and La Niña were weaker and the transition between them was less abrupt off southern California compared with off Washington and Oregon. Productivity in the pelagic ecosystem enhanced with La Niña off central and southern California, but El Niño-condition copepod assemblies persisted later in the northern California Current system (Bjorkstedt et al. 2011).

Heinemann et al (2011) developed a simplified ENSO and ecosystem (nutrient-phytoplankton-zooplankton) model that demonstrates how the ecosystem itself could moderate ENSO variability by the effect of phytoplankton on the absorption of shortwave radiation in the water column. This biological feedback to the climate system leads to (1) warming of the tropical Pacific, (2) reduction of the ENSO amplitude, and (3) prolonging the ENSO period. In a somewhat similar analysis, Lin et al (2011) showed that the spatial distribution of chlorophyll-a actually influences the mean state of the ocean in the tropical Pacific. Because chlorophyll-a blocks solar radiation to some extent, a shallow thermocline and stronger currents lead to decreased annual mean SST in the eastern equatorial Pacific. They conclude that the seasonal cycle of chlorophyll-a can dramatically change the ENSO period in the coupled model.

3.3.2 Sea Level Rise, wind speed and wave height

Sea level varies seasonally and with significant ocean phenomena, such as El Niño events. Determining whether there has been a significant rise in sea level must first, therefore, account for this effect. Komar et al (2011) separated out the seasonal trends in sea level in the PNW. Strong El Niño events dominate the winter record, but the more stable summer sea levels show statistically significant trends toward higher sea level.

Using satellite data, Young et al (2011) documented increasing oceanic wind speeds and wave height over 23 years globally, with a higher rate of increase in extreme events.

3.3.3 Upwelling

Most analyses published in 2011 found that upwelling has become more intense over the past century. The California Current System demonstrates two seasonal upwelling “modes” (Black et al. 2011). Summer upwelling shows longer frequency variation, reflecting multi-decadal processes. Significant linear trends over 64 years show the intensity of summer upwelling has increased at 39ºN to 42ºN. Winter upwelling reflects North Pacific Index and ENSO cycles. Chinook salmon growth-increment chronology correlated significantly with the summer upwelling mode (Black et al. 2011). Similarly, upwelling off British Columbia (Foreman et al. 2011) starts later and ends earlier, based on trends over the past 50 years. Nonetheless, cumulative upwelling and downwelling has significantly increased, because of the increase in intensity. The intensity of coastal upwelling off California, however, has not increased over the past 60 years (Pardo et al. 2011), based on SST and the upwelling index from the National Centers for Environmental Prediction/ National Center for Atmospheric Research reanalysis project database.

The effects of upwelling off the coast extend into the Columbia River estuary. Roegner et al (2011b) investigated whether the source of chorophyll in the estuary was freshwater or marine. High flows in spring brought freshwater chlorophyll into the estuary, although production was relatively low. In the summer, upwelling winds transported chlorophyll from the ocean. Tidal cycles determined stratification, which was higher during neap tides than spring tides.

3.3.4 Oxygen mimium zones and O_2 sensitivity

Oxygen minimum zones (OMZs), have been expanding over the 20th century. Studies of a 2.4-4.5ºC warming event in the Miocene indicates that similar low oxygen conditions occurred at that time as have recently been observed (Belanger 2011). An analysis of anchovy and sardine oscillations indicates that oxygen levels, rather than temperature or food availability could be the primary factor driving anchovy/sardine oscillations in the Peruvian upwelling region (Bertrand et al. 2011).

The Columbia River estuary experiences low oxygen conditions (2mg/L) when strong upwelling combines with neap tides (Roegner et al. 2011a). Mortality caused by low oxygen is significantly increased by warmer water. In a meta-analysis, Vaquer-Sunyer and Duarte (2011) found that increasing temperature reduced marine benthic macrofauna survival times and increased minimum oxygen thresholds for survival by 74%, and 16%, respectively, on average. They project that 4ºC ocean warming will lower survival times by 35.6% and raise minimum oxygen concentrations by 25.5%, potentially causing many more die-offs in the future.

A separate model of upwelling in an AOGCM predicts a reduction in the impact of OMZs from upwelling. Glessmer et al Glessmer, Park et al. 2011) found that 25% less low oxygen water reached the surface in their double CO_2 scenario, compared with the current climate.

3.3.5 Ocean acidification

Ocean pH is often thought of as being fairly static, but Hofmann et al (2011) demonstrate very high spatial and temporal variability in diverse marine habitats. Others (Joint et al. 2011) similiarly argue that natural variability is very high, pointing out that pH can change much more in freshwater lakes. Models of future pH and biological responses and feedbacks are still challenging (Tagliabue et al. 2011).

Much work has continued on the sensitivity of different organisms and life stages to ocean acidification. Gruber (2011) published an overview of the combined threats of ocean acidification, rising temperatures, and lowered oxygen levels. Many species have been studied in 2011, including herring (Franke and Clemmesen 2011), coral reef fishes (Munday et al. 2011a), clownfish (Munday et al. 2011b), an intact invertebrate community (Hale et al. 2011), crustaceans (Whiteley 2011) plus many studies on pteropods (Lischka et al. 2011) and phytoplankton (Low-DÉCarie et al. 2011). The results are mixed, but many stages and species are not especially sensitive. Pteropods are a concern for salmon because they are a prey item and have an aragonitic shell. They are sensitive to temperature increases in addition to rising acidity (Lischka et al. 2011).

3.3.6 Ecosystem effects

Large-scale climate factors and ocean chemistry drive the distribution and productivity of the entire marine biota. Factors such as the PDO, ENSO, and Northern Oscillation Index are strong predictors of larval fish concentration and diversity in the northern California Current (Auth et al. 2011). Upwelling indices are a significant predictor of herring and surf smelt catches in the Skagit River estuary (Reum et al. 2011). The Aleutian Low Pressure Index is correlated with seabird productivity and timing (Bond et al. 2011). Long-term trends in community composition this past century have been documented in a majority of time series of marine ecosystems. In a study of 300 biological time series from seven marine regions off western Europe, Spencer et al (Spencer et al. 2011) found most regions showed both long-term trends and regime shifts. Pollock, for example, changed its role in the food web during warm periods (Coyle et al. 2011). Regime shifts (i.e., a step in some measure of biological response over a short temporal interval or in response to a small physical change) are also widespread, although they might be overestimated by failure to account for temporal trends (Spencer et al. 2011).

Predicting how ecosystems will change with the climate typically relies on environmental correlates of organism distribution. Lenoir et al (2011) developed a model that explains observed shifts in the distribution of eight exploited fish in the North Atlantic, and projects that these species should continue to move northward, but some might be hindered by barriers and rate limitations. Finally, mesocosm experiments show how warming accelerates the phytoplankton bloom timing by about 1 day/ºC, and decreases biomass (Sommer and Lewandowska 2011).

Using NOAA's Geophysical Fluid Dynamics Laboratory Earth System Model, Polovina et al (2011) project shifts in large marine ecosystems. They use modeled phytoplankton density to distinguish 3 biomes in the North Pacific. Under the A2 emissions scenario, the model predicts that temperate and equatorial upwelling biomes will occupy 34 and 28% less area by 2100. The subtropical biome, on the other hand, expands. Extending this change in area to primary productivity and fisheries catches, they expect a 38% decrease in the temperate biome, and a 26% increase in the subtropical biome catch.

An additional concern throughout the ecosystem is the increasing prevalence of persistent organic pollutants, especially polycyclic aromatic hydrocarbons from fossil fuel burning (De Laender et al. 2011). This direct source of pollution is a major concern for salmon, especially coho, in urban areas, but might become a more widespread marine phenomenon.

Jones (2011) discusses the potential for increasing marine productivity by enriching the oceans artificially with macronutrients (the Haber-Bosch process). He argues that phosphorus appears to limit the carbon storage capacity of nitrogen and hence additional new primary production.

3.3.7 Viruses

A typically overlooked consequence of global change is a potential increase in the impacts from viruses. Danovario et al (2011) review the very large impacts viruses have on phytoplankton, especially, but also throughout the ecosystem. They point out many positive correlations between temperature (and other expected changes in ocean chemistry) and viral abundance, but the relationships are complicated and more work is needed.

3.4 Comparing rates of climate change in marine and terrestrial environments

Burrows et al (2011) compared the rates of historical climate change in marine and terrestrial environments. Focusing on the rates of temperature change that organisms might be expected to track through either range shifts or phenological change, they calculated the velocity of temperature change in terms of the latitudinal distance an isotherm has shifted (km/year), and the seasonal shift in spring and fall temperatures (days per year). These two quantities are ratios of the long-term temperature trend and either the spatial or temporal gradients across the landscape. Using these metrics, they found that although the absolute rate is a little slower in the ocean, because the spatial and seasonal gradients in temperature are shallower, the overall velocity and seasonal rates of change are faster for marine than terrestrial ecosystems, implying faster range shifts will be needed to track cliamte change. The ocean also differs from land because many ocean areas are cooling, especially in areas where upwelling has intensified, generating a bimodal distribution of rates of temperature change.

4 Salmon life-stage effects

4.1 Freshwater stages

4.1.1 Juvenile behavior and survival

Copeland and Meyer (2011) studied the correlations in juvenile salmonid density since 1985 in the Salmon and Clearwater River Basins. Densities in all six species were positively correlated, and flow and Chinook salmon redds were correlated with densities overall. For Chinook salmon, models with spawner density combined with either annual mean discharge or drought (Palmer Drought Severity Index) had similar Akaike information criterion (AIC) weights, and explained 52% of the variation.

Hypoxia limits the suitability of many nesting sites, and is often affected by changes in flow via deposition rate of fine sediments or flushing and groundwater infiltration. Malcolm et al (2011) found that interstitial velocity is not a good predictor of hyporheic dissolved oxygen. Miller et al (2011b) explore how rainbow trout compensate for low oxygen by altering their cardiac ontogenic program.

Heat tolerance varies by life stage in salmon. Breau et al (2011) show that differences in thermal-refuge-seeking behavior between age 0+ and age 1+ and 2+ Atlantic salmon stems from higher tolerance in respiration and cardiac performance in younger fish.

Given the dramatic changes in winter temperature expected throughout the PNW, it is a concern that winter ecology is not well understood. Stream environments create complicated ice dynamics that are very sensitive to fine scale variation in temperature and flow (Brown et al. 2011). Fish responses to thermally elevated areas overwinter (e.g., near nuclear power plants) sometimes have negative consequences for reproduction, but likely responses to long-term, gradual changes throughout the stream are not clear. Undercut banks are critical winter habitat for brook trout in small mountain stream, affected only slightly by winter flow reductions (Krimmer et al. 2011).

4.1.2 Juvenile growth

Salmon growth rates depend on temperature both directly because of temperature-governed chemical reaction rates, and indirectly because of elevated energetic demands of higher metabolic rates. Increased consumption can sometimes compensate for higher metabolic rates, leading to an interaction between ration and temperature effects. Geist et al (2011) tested the growth rate of Snake River fall Chinook below Hells Canyon Dam, and found high tolerance to short periods of high temperature (23ºC) even at relatively low rations (down to 4% of body weight). However, at 1% ration, fish grew better at constant cool temperatures, suggesting that this low consumption rate was insufficient to cover metabolic costs of high temperatures. Natural consumption rates at this location are unknown. Steelhead in Los Angeles County grow year-round and produce large smolts, despite spending a week each year at mean temperatures over 22ºC (Bell et al. 2011). It is important to note that although growth is sensitive to temperature, other factors, such as negative effects of fish density, can be more limiting (Bal et al. 2011).

Bioenergetic models are a primary means of analyzing changes in stream quality on growth. A crucial element of these models is the interaction between metabolic rate and energy supply through food consumption. Individual variation in bioenergetic parameters is generally ignored, but Armstrong et al (2011) show through a modelling exercise that this variation can significantly affect the impact of flow and food variability on growth.

Energetic rates were measured in rainbow trout exposed to various flows in a natural environment. The crucial difference between their environment and a typical laboratory set up was the existence of refuges from high flows, which allowed swim speed to decline at peak flows (Cocherell et al. 2011). Taguchi and Liao (2011) also explored how microhabitat utilization can be very energetically efficient.

By coupling a bioenergetic model with a simplified stream temperature model, Beer and Anderson (2011) demonstrate potential changes in Chinook and steelhead growth rates as a sensitivity analysis of change in mean air temperature and change in snowpack. They describe 4 characteristic stream types in the PNW -- warm winter and cool summer (North Santium); cold stream with high snowpack (Clearwater); warm summer with high snowpack (Salmon River) and warm summer with low snowpack (Snake River). They found that in the streams with cooler summers, warming and loss of snow increased growth rates, but in the warmer-summer streams, growth decreased.

4.1.3 Smolt behavior and survival

Bjornsson et al (2011) review physiological characteristics of smolting and environmental drivers. Acidification, as well as endocrine disruptors and other contaminants could lower survival through interferring with this carefully controlled process. Perkins and Jager (2011) created a development model for Snake River fall Chinook salmon that proposes a mechanism by which delayed growth leads to a yearling smolt behavior.This type of behavioral switch could make a big difference in population responses to climate change, but is hard to predict ahead of time. Other studies (Hayes et al. 2011) of California steelhead document different hormone levels between fish that smolt at different times over the season, and some fish that return upstream before smolting the following year. This rich variety of behavior will be crucial to effective responses to climate change.

Many anthropogenic habitat modifications have the potential to exacerbate effects of climate change on stream temperature. Smolt survival is often reduced at high temperatures, and due to direct and indirect effects of dam passage. Marschall et al (2011) explicitly modeled the interaction between delays at dams and exposure to high temperatures during smolt migration. Assuming that a threshold temperature causes fish to initiate migration in spring, they explore the range of initiation temperatures likely to ensure a successful migration with and without delays caused by dams. They find that even short delays at dams greatly reduce this window of opportunity. Particularly dangerous were irregular warm river sections that occurred downstream, and caused high delayed mortality (i.e., after successful passage through a dam) in late migrants. Their model is based on temperatures, flows, and migration distances measured in the Connecticut River for Atlantic salmon, but bears high relevance to Columbia River salmonids. Finally, conditions during smolting can affect maturation age. Exposure to elevated temp (16ºC) and continuous light can trigger early maturation in male Atlantic salmon (Fjelldal et al. 2011).

4.1.4 Adult migration

The return to freshwater to spawn is a delicately timed behavior. Each population has adapted the timing of return to minimize mortality in freshwater prior to spawning, and to maximize fecundity which depends on marine growth and energetic expenditure during the migration, among other things. Migration mortality is closely tied to environmental conditions, especially temperature, experienced during the migration. Many papers published in 2011 explore the genetic and behavioral controls on timing and resulting morality.

Adult migration timing in sockeye has been progressing earlier in the year in the Columbia River over the 20th century. Crozier et al (2011) explore how changes in river temperature and flow, as well as ocean conditions might be driving this advance. They found evidence that this trait evolved genetically due to mortality of late migrants exposed to higher Columbia River temperatures during the historical migration period. The fish also show a strong annual response to river flow, such that they migrate earlier in low-flow years. These two processes combined suggest both plastic and evolutionary responses are involved in an adaptive shift likely to continue in response to climate change. Genetic studies have identified candidate genetic markers in Columbia River adult Chinook salmon associated with run-timing (Hess and Narum 2011). Liedvogel et al (2011) review the genetics of migration more broadly.

Early migration in Adams and Weaver Creek sockeye in the Fraser River has a very different explanation and result, however. Early migrants in the Fraser experience very high temperatures and have high mortality, so the sudden change in behavior that began in 1995 has been hard to explain. Thomson and Hourston (2011) correlated early entry timing with weaker wind stress for Adams River stocks, and with lower surface salinity for Weaver Creek stocks. They postulate that both factors lead physiologically to earlier entry because the former entails easier swimming against weaker currents and the latter entails earlier osmoregulatory adaptation to freshwater, noting that early migrants were exposed to relatively fresh water earlier in the year.

Several genetic studies of Fraser River sockeye have found that gene expression varies systematically over the course of the migration (Evans et al. 2011), and that certain gene expression patterns were strongly correlated with mortality during the migration (Miller et al. 2011a). The genes that were upregulated are associated with the immune defense system, and the authors propose that viral infection might be to blame for the low survival. Other papers developed statistical correlates of migration survival for in-season fisheries management, in which temperature and flow were strong predictors of survival for some stocks, especially those exposed to harsher conditions (Cummings et al. 2011). Warmer water lowers catch-and-release survival (Gale et al. 2011), and might be important in interpreting tagging studies. A comparison of migration survival of fish tagged at sea versus those tagged in freshwater (which is much warmer) found that those tagged at sea had much higher survival (Martins et al. 2011).

The timing of the adult migration among Yukon River Chinook salmon is correlated with SST, air temperature and sea ice cover. As these factors change with climate change, migration is expected to occur earlier (Mundy and Evenson 2011).

Projected adult migrant survival

Several papers used observed survival of migrating Fraser River sockeye to project survival under future climate scenarios. Martins et al (2011) modeled 9-16% declines by the end of the century. Hague et al (2011) quantified the number of day per year that migrating fish will experience less optimal temperatures. They found that the number of days over 19ºC tripled, reducing their aerobic scope to zero in some cases. They found that exposure varied within each run, such that there is potential for shifts in run-timing to drive adaptive responses to rising temperature. An individual-based simulation model of the evolutionary response to rising river temperatures with climate change showed that Fraser River sockeye with a reasonable heritability (0.5) would theoretically shift their migration 10 days earlier in response to 2ºC warming. Nonetheless, this study did not generally predict extinction of these populations even if they did not respond to selection (Reed et al. 2011). But evolution in run timing has clearly occurred in Chinook salmon introduced to New Zealand, where populations from a common ancestry have diverged 18 days in their spawning-migration (Quinn et al. 2011).

Local adaptation and acclimation in heat tolerance

Evolution in response to rising temperatures could occur in adult migration timing, as discussed above, or in heat tolerance. Eliason et al (2011) studied variation in cardiac tissue. Local adaptation in thermal optima for aerobic, cardiac tissue and performance among populations migrating at different times through the Fraser River. They argue that the heart has adapted to population-specific migration temperatures, in addition to the length of migration. This is consistent with interspecific differences. Pink salmon have higher heat tolerance during migratory stages than sockeye (Clark et al. 2011). Similar differences can also reflect acclimation. Studies of cardiac tissue in rainbow trout identified very distinct morphology and tissue composition in distinct cold-acclimated and warm-acclimated fish (Klaiman et al. 2011).

4.2 Marine stage

4.2.1 Marine survival

Because ocean survival is the strongest correlate of population growth rate for most populations, understanding the factors that drive marine survival has been a high priority for decades.

The primary factors thought to govern survival are growing conditions, which are generally correlated with overall ocean productivity. In a new paper confirming and refining previously recognized patterns for PNW salmon, Bi et al (2011b) explore the relationship between coho early marine survival, copepod species composition, water transport in the California Current, and larger climatic indices (the PDO). Cold copepod biomass correlates with coho survival. Seasonally, they found that lipid-rich copepods associated with cool water are less abundant in the winter, when the current is coming predominantly from the south ("positive alongshore current") and more abundant in summer, when current is coming from the north ("negative alongshore current"). At the annual and decadal scale, when the PDO is positive, more water comes from the south in winter; when PDO is negative, more water comes from north during summer. In a separate paper, Bi et al. (2011a) confirmed the spatial relationships between yearling Chinook and coho distributions and copepod assemblages. Both species are strongly positively correlated with the cold copepod assemblage and chlorophyll a concentration. Yearling coho had similar relationships, but also positively correlated with temperature. Nonetheless, the adult migration does not necessarily track annual varation in zooplankton location. Bristol Bay sockeye do not seem to vary their migration route among years in response to variation in marine productivity and temperature (Seeb et al. 2011).

Salmon growth and survival often correlates with SST (e.g., Norwegian Atlantic salmon growth at sea is positively correlated with SST in the Barents and Norwegian Seas (Jensen et al. 2011), and Japanese chum salmon growth is positively correlated with summer/fall SST in coastal areas while fish stay near shore, and off-shore temperatures later in the year (Saito et al. 2011). Much of the mortality is size-selective, with smaller fish having higher mortality rates. Size-selective mortality could stem from either an energetic constraint (insufficient resources to survive harsh conditions) or size-selective predation. In Alaskan sockeye, Farley et al (2011a) found that the energetic status of juvenile sockeye was adequate to survive winter, and suggest predation-avoidance behavior as a better explanation for size-selective mortality and ongoing energy loss. They suggest that higher temperatures in climate projections might lead to declines in age-0 pollock, a high quality prey for salmon, and lead to lower winter survival.

Marine survival is tightly linked to ocean conditions at the time of smolting. The Rivers Inlet sockeye population in British Columbia has been depressed since the 1990s. High flows in this river decrease marine productivity because the river is nutrient-poor. Thus the negative correlation between high river flow and marine survival appears to result from the impact of low nutrient, brackish water depressing marine plankton growth (Ainsworth et al. 2011b). This system-specific impact on marine productivity explains the difference between a positive correlation for high-nutrient rivers, like the Columbia, and low-nutrient rivers like Rivers Inlet.

More broadly, salmon survival is often correlated with broader indicators of ecosystem productivity. Lower trophic level productivity generally supports better growth and survival all the way up the food chain. Borstad et al (2011) found that regional chlorophyll abundance in April, timing of spring wind transition and phytoplankton bloom are important for survival of Canadian Triangle Island sockeye salmon, sandlance and rhinoceros auklets.

4.2.2 Projected future marine habitat availability

In an important paper, Abdul-Aziz et al (2011) constructed maps of potential salmon marine distributions under climate change scenarios. They developed thermal niche models for summer and winter separately for five Pacific salmon species and steelhead based on high-seas catch records over the last 50 years. These are not mechanistically-determined range limits, e.g. through physiological constraints, and thus might not correlate with future distributions exactly the way they do now. It is likely that changes in the distribution of food availability will play a very large role in future distributions, which might depend on many factors. However, they do indicate how projected changes in SST translate into one characterization of potential salmon habitat. Historical analysis showed that salmon thermal habitat, using observed temperature ranges, changed very little over the 20^{th} century. However, under the A1B and A2 emissions scenarios, the multi-model ensemble average SST imply a reduction in summer habitat for coho 5-32%, where the range goes from the 2020s to the 2080s, Chinook habitat declines 24-88%, and Steelhead habitat area declines 8-43%. Winter habitat area shows much less effect in these species, ranging from 0 to 10% for the 3 species and three future time periods. Sockeye had much greater sensitivity in their winter range, reducing from 6-41%. The B1 scenario had a similar result for 2020s and 2040s, but was less severe by 2080 (-66% for Chinook summer habitat, -21 to -24% for coho and steelhead summer, and 0 to -7% for all three species in winter). One reason for the high percentage reduction in Chinook summer habitat was that their historical absolute area was estimated to be much smaller in summer than the other species (7 million km^2 compared with 10-11 million km^2). But the projection is for a complete loss of Gulf of Alaska habitat by the 2040s, and complete loss of Okhotsk Sea and Subarctic subdomains, and most of the Bering Sea habitat. There is a small extension into the Arctic Ocean that is not currently occupied, but net reductions vastly outweighed this potential expansion.

4.2.3 Ocean acidification

Two recent modeling papers explored the ecological impacts of ocean acidification and other aspects of climate change. Ainsworth et al. (2011a) predicted that ocean acidification may cause salmon landings to decrease in Southeast Alaska and Prince Williams Sound food webs and increase in Northern British Columbia and Northern California Current food webs. However, when the authors applied five impacts of global change to these food webs simultaneously (primary productivity, species range shifts, zooplankton community size structure, ocean acidification, and ocean deoxygenation), projected salmon landings decreased in all locales (Ainsworth et al. 2011a). Incorporating ocean acidification and ocean deoxygenation into bioclimatic envelope models for harvested fishes in the Northeast Atlantic caused 20-30% declines in projected future harvest, likely due to reduced growth performance and faster range shifts (Cheung et al. 2011).

5 Higher-level processes

5.1 Population-level effects

Warming temperatures in Alaska have opened up potential habitat for colonization. Pink salmon and Dolly Varden were among the first fish to colonize one such stream in Glacier Bay (Milner et al. 2011). The stream community has developed over the past 30 years. Having robust populations at the edge of the current range to provide colonists faciliates range expansion.

5.2 Diseases

The negative impact of multiple stressors, such as UV-B exposure and high temperatures, on immune function, together with predicted increases in pathogen load in warmer waters resulting from global climate change, suggest an increased risk of diseases in fishes (Jokinen et al. 2011). De Eyto et al (2011) show that selection on immunological adaptation at the major histocompatibility genes in Atlantic salmon varied with life stage and were strongly correlated with juvenile survival. They emphasize the importance of maintaining genetic diversity to evolve in response to novel disease pressures expected to result from climate change.

Many diseases are more prevalent or virulent at warmer temperatures. Salmonid parasites often require intermediate hosts, and parasite risk to fish can be lower in areas unsuitable for the other host. *Tubifex tubifex*, the host of whirling disease, cannot tolerate very hot streams affected by geothermal processes in Yellowstone National Park, thus reducing infection of rainbow trout in these reaches (Alexander et al. 2011). However, some expected negative effects of rising temperatures have not been detected. In an Alaskan stream summer water temperature has increased 1.9ºC over the past 46 years. However, the presumed increase in consumption rates in sockeye has not led to an increase in tapeworm load (Bentley and Burgner 2011). Algal blooms are affected by environmental conditions, and can kill large numbers of fish. When an algal bloom moved through a fish farm in New Zealand, a large fish kill occurred (MacKenzie et al. 2011). The extent to which wild fish could have avoided the bloom is unknown.

5.3 Population declines and variability attributed to climatic factors

A fairly rare but important element of evaluating the importance of environmental effects is a comparison between environmental and anthropogenic or a variety of alternative hypotheses. Most studies look at only a single type of explanation – i.e., they just compare environmental effects. But Otero et al (2011) conducted a comprehensive analysis of the catch of Atlantic grilse over the whole length of the Norwegian coast as a function of environmental effects during the smolt stage and the return migration, marine, and anthropogenic (fish farms, fishery, dams) potential driving factors. They find water temperature and flow interact with dams to shape catches, and aquaculture and fisheries have negative effects.

Many spring and fall run Chinook salmon populations have been extirpated from the Central Valley of California. Migration barriers completely explain Central Valley California fall Chinook extirpation, but for spring Chinook, habitat loss and altered flow regimes, especially enhanced summer flows, predicted extirpation (Zeug et al. 2011). An analysis of population extinction of Sakhalin taimen (*Parahucho perryi*) in Japan showed that in comparing populations that ranged from extinct to endangered to extant, lower air temperatures and minimal agricultural development set extant populations apart. Lagoons also provided refugia (Fukushima et al. 2011).

When fisheries alter the age structure of a population, it can lose some of its resiliency to environmental variation. Long-term shifts toward a shorter generation time, and reduced age overlap within the population adds variability to population growth rates. Environmental conditions driving that variability thus become more important. Cod show increasing sensitivity to environmental fluctuations, which could ultimately make climate impacts more severe (Rouyer et al. 2011). Age structure can also be important if generation time coincides with the periodicity of a key environmental driving factor. Age-structured models with periodic environmental forcing and fishing pressure generate the cohort resonance effect, which can drive much more variability in population abundance than predicted by an ecosystem or stage-structured model if the frequency of the forcing factor is close to the mean age of reproduction (Botsford et al. 2011).

5.4 Projected cumulative effects throughout the life cycle

A holistic perspective demonstrates that climate change will pose significant stress not just on one or two stages, but potentially on every life stage. Healy (2011) outlines adverse impacts throughout the life cycle, as well as pointing out how responses in one stage can carry over and affect survival or growth in a subsequent stage, and even suequent generations. Cumulatively, he argues they pose enormous risk for Fraser River sockeye. Healy also lists management and policy responses that would reduce these stresses by life stage.

Elevated tempeatures often inhibit reproduction. Pankhurst and Munday (2011) review the entire suite of known endocrine effects in salmonids, as well as the diverse sensitivities in juvenile stages as well. They emphasize that the ramifications of chemical, thermal and hydrological change will be complex and pervasive throughout the life cycle and geographic range of these fish.

5.5 Species interactions

Wenger et al (2011) used thermal criteria, flow frequency, and interaction strengths with other salmonids to predict habitat availability for all trout in the interior west under climate change scenarios. Under A1B scenarios, average habitat decline across all species is 47%. Brook trout loses the most habitat (77%) and rainbow trout the least (35%). Species interactions shaped the outcome negatively for some species and positively for others. It does demonstrate that considering species interactions could significantly alter predicted responses to climate change.

Temperature gradients cause variation in salmon behavior that can either enhance ecosystem productivity, or reduce it. The large spread in Alaskan sockeye salmon spawn timing due to thermal differences among streams supports most of the growth in rainbow trout, who eat salmon eggs over a relatively long temporal window in the fall (Ruff et al. 2011). On the other hand, a study of paleoecological and recent lake productivity in Tuya Lake, British Columbia revealed an interaction between salmon consumption and warming, such that salmon enhanced climate-induce nitrogen deficiencies (Selbie et al. 2011). They emphasize that ecosystem structure is very sensitive to temperature.

6 Human adaptation

Extensive work explores adaptation responses to climate change. This literature is mostly beyond the scope of this review, but we just highlight a few examples here. Several papers concentrate on human responses to climate change. A comprehensive review of marine and aquatic vulnerabilities, adaptation strategies, and existing adaptation plans in the PNW was drafted in 2011 (National Wildlife Federation 2011). This report identified common elements of adaptation plans in the PNW and elsewhere, including: remove other threats and reduce non-climate stressors that interact negatively with climate change or its effects; establish or increase habitat buffer zones and corridors; increase monitoring and facilitate management under uncertainty, including scenario-based planning and adaptive management. The report includes additional approaches from available literature in the broad areas of information gathering and capacity building; monitoring and planning; infrastructure and development; governance, policy, and law; and, conservation, restoration, protection and natural resource management. This information is intended to guide development of climate change adaptation strategies through the North Pacific Landscape Conservation Cooperative. At the national level, adaptation strategies have been proposed for ecosystems including coastal and aquatic systems affecting salmonids (USFWS et al. 2011). The draft inland aquatic ecosystems strategy focuses on protecting and restoring existing habitat; maintaining ecosystem functions that will continue to provide benefits in a changing climate; reducing impacts of non-climate stressors; and including climate considerations in resource management planning, monitoring, and outreach programs. A final national adaptation strategy is expected in 2012. Safford and Norman (2011) describe the institutional forces that shape the way recovery planning groups in Puget Sound develop plans to manage water to improve salmon survival. They found that asymmetrical roles (e.g., tribal veto power), coupled with lack of explicit support for tribal sovereignty (which might reduce the likelihood of tribal vetoes) contribute to institutional problems. Similarly, allowing technical planners to also contribute to citizen committees reduces the ability of the planning groups to achieve diverse social and technical objectives. The lack of broader participation has generally led to calls for increasing water supply for salmon, but there has been a lack of concrete recommendations for accomplishing this. Farley et al (2011b) describe capacity for institutional responses to climate change among four water sectors in Oregon’s McKenzie River basin and found that some sectors have more flexibility (e.g., fish habitat recovery and flood control) than others (e.g., municipal water and fishing guides) for responding to climate change. Hamlet (2011) also examines institutional capacity for water management adaptation, and finds that, although existing institutions have resources to deal with moderate changes, substantial obstacles to climate change adapation exist for large and complex systems such as the Columbia River basin. Lack of a centralized authority for water management decisions, layers of existing laws and regulations, and lack of specificity in some management plans contribute to this concern. He suggests that the most progress in large systems may be expected at smaller geographical scales such as subbasins. He does note that in the last several years, significant progress has been made in surmounting some of these obstacles, and the PNW region's water resources agencies at all levels of governance are making progress in addressing the fundamental challenges inherent in adapting to climate change. Thorpe and Stanley (2011) emphasize that restoration goals must focus on building resilient functioning ecosystems with the capacity to respond to climate change, rather than historical models. Two papers project stress on regional and urban water supplies (House-Peters and Chang 2011; Traynham et al. 2011). House-Peters and Change (2011) identify potential solutions through dense development in urban areas and tree planting. Koehn et al (2011) review the major impacts of climate change on fishes, and step through potential adaptation measures. Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment is a document produced by the NWF that provides an overview of species and ecosystem sensitivity, exposure, and vulnerability to climate change. They propose a systematic approach to evaluating risks and selecting conservation measures that most efficiently address those risks (Glick et al. 2011).

6.1 Human impact on stream temperature

A review paper (Hester and Doyle 2011) on human impacts on stream temperature describes the most common actions with thermal impacts and calculates the mean temperature change reported. The actions summarized are: loss of riparian shading, loss of upland forest, reductions of groundwater exchange, increased width-to-depth ratio, input of effluent discharges, diversion of tributary input, releases from below the thermocline of reservoirs, and global warming. Cold water reservoir releases in summer were the primary means of cooling streams, although diverting warm tributaries can also lower stream temperatures. Hester and Doyle (2011) also collected thermal performance curves for stream and river species. They summarized the amount of temperature change from the thermal optimum to 50% performance (growth, development, reproductive activity, or survival) both above and below the optimum. They found that most performance curves are asymetrical, and that most species are more sensitive to temperatures above the optimum (typical breadth from optimum to 50% for fish is about 4ºC above the optimum, and 6ºC below the optimum). Most human impacts shift temperature less than 5ºC, but reservoir releases, riparian shading and changes in groundwater exchange can change stream temperature up to 12-14ºC.

In a review of the impact of logging on stream temperature in the Oregon Coast Range, Groom et al (2011b) found that maximum, mean, minimum, and diel fluctuations in summer stream temperature increased with a reduction in shade, longer treatment reaches, and low gradient. Shade was best predicted by riparian basal area and tree height. In a separate paper, Groom et al (2011a) found that typical logging practices on private land generally caused streams to exceed water quality thresholds, but that recent management rules successfully lowered this probability greatly.

Some rivers have management options for lowering stream temperature over a short period of time, which can be crucial for preventing lethal temperatures for fish. For example, Lewiston Dam can release cold water into the Klamath; water can also be protected from withdrawals. These methods can be effective if they are timed precisely. A simulation study found short-term (7-10 day) water temperature forecasts prove useful for increasing fish production in the Klamath and John Day Rivers (Huang et al. 2011).

7 Literature cited

Abdul-Aziz, O. I., N. J. Mantua, and K. W. Myers. 2011. Potential climate change impacts on thermal habitats of Pacific salmon (Oncorhynchus spp.) in the North Pacific Ocean and adjacent seas. Canadian Journal of Fisheries and Aquatic Sciences 68:1660-1680.

Ainsworth, C. H., J. F. Samhouri, D. S. Busch, W. W. L. Chueng, J. Dunne, and T. A. Okey. 2011a. Potential impacts of climate change on Northeast Pacific marine fisheries and food webs. ICES Journal of Marine Science 68:1217-1229.

Ainsworth, L. M., R. Routledge, and J. Cao. 2011b. Functional Data Analysis in Ecosystem Research: The Decline of Oweekeno Lake Sockeye Salmon and Wannock River Flow. Journal of Agricultural Biological and Environmental Statistics 16:282-300.

Al-Chokhachy, R., B. B. Roper, E. K. Archer, and S. Miller. 2011. Quantifying the Extent of and Factors Associated with the Temporal Variability of Physical Stream Habitat in Headwater Streams in the Interior Columbia River Basin. Transactions of the American Fisheries Society 140:399-414.

Alexander, J. D., B. L. Kerans, T. M. Koel, and C. Rasmussen. 2011. Context-specific parasitism in Tubifex tubifex in geothermally influenced stream reaches in Yellowstone National Park. Journal of the North American Benthological Society 30:853-867.

Arguez, A., I. Durre, S. Applequist, R. S. Vose, M. F. Squires, X. Yin, R. R. Heim et al. 2012. NOAA s 1981–2010 U.S. Climate Normals: An Overview. Bulletin of the American Meteorological Society.

Armstrong, J. D., K. J. Millidine, and N. B. Metcalfe. 2011. Ecological consequences of variation in standard metabolism and dominance among salmon parr. Ecology of Freshwater Fish 20:371-376.

Auth, T. D., R. D. Brodeur, H. L. Soulen, L. Ciannelli, and W. T. Peterson. 2011. The response of fish larvae to decadal changes in environmental forcing factors off the Oregon coast. Fisheries Oceanography 20:314-328.

Bal, G., E. Rivot, E. Prevost, C. Piou, and J. L. Bagliniere. 2011. Effect of water temperature and density of juvenile salmonids on growth of young-of-the-year Atlantic salmon Salmo salar. Journal of Fish Biology 78:1002-1022.

Barnard, P. L., J. Allan, J. E. Hansen, G. M. Kaminsky, P. Ruggiero, and A. Doria. 2011. The impact of the 2009-10 El Nino Modoki on US West Coast beaches. Geophysical Research Letters 38.

Beer, W. N., and J. J. Anderson. 2011. SENSITIVITY OF JUVENILE SALMONID GROWTH TO FUTURE CLIMATE TRENDS. River Research and Applications 27:663-669.

Belanger, C. L. 2011. Coastal dysoxia accompanies Early Miocene warming based on benthic foraminiferal and sedimentary records from Oregon. Marine Micropaleontology 80:101-113.

Bell, E., S. M. Albers, J. M. Krug, and R. Dagit. 2011. Juvenile growth in a population of southern California steelhead (Oncorhynchus mykiss). California Fish and Game 97:25-35.
Bentley, K. T., and R. L. Burgner. 2011. An assessment of parasite infestation rates of juvenile sockeye salmon after 50 years of climate warming in southwest Alaska. Environmental Biology of Fishes 92:267-273.
Bertrand, A., A. Chaigneau, S. Peraltilla, J. Ledesma, M. Graco, F. Monetti, and F. P. Chavez. 2011. Oxygen: A Fundamental Property Regulating Pelagic Ecosystem Structure in the Coastal Southeastern Tropical Pacific. Plos One 6.
Bi, H. S., W. T. Peterson, J. Lamb, and E. Casillas. 2011a. Copepods and salmon: characterizing the spatial distribution of juvenile salmon along the Washington and Oregon coast, USA. Fisheries Oceanography 20:125-138.
Bi, H. S., W. T. Peterson, and P. T. Strub. 2011b. Transport and coastal zooplankton communities in the northern California Current system. Geophysical Research Letters 38.
Bjorkstedt, E. P., R. Goericke, S. McClatchie, E. Weber, W. Watson, N. Lo, B. Peterson et al. 2011. State of the California Current 2010-2011: Regionally variable responses to a strong (but fleeting?) La Nina. California Cooperative Oceanic Fisheries Investigations Reports 52:36-68.
Bjornsson, B. T., S. O. Stefansson, and S. D. McCormick. 2011. Environmental endocrinology of salmon smoltification. General and Comparative Endocrinology 170:290-298.
Black, B. A., I. D. Schroeder, W. J. Sydeman, S. J. Bograd, B. K. Wells, and F. B. Schwing. 2011. Winter and summer upwelling modes and their biological importance in the California Current Ecosystem. Global Change Biology 17:2536-2545.
Blunden, J., and D. S. Arndt. 2012. State of the Climate in 2011. Bulletin of the American Meteorological Society 93:S1-S282.
Bond, A. L., I. L. Jones, W. J. Sydeman, H. L. Major, S. Minobe, J. C. Williams, and G. V. Byrd. 2011. Reproductive success of planktivorous seabirds in the North Pacific is related to ocean climate on decadal scales. Marine Ecology-Progress Series 424:205-U218.
Borstad, G., W. Crawford, J. M. Hipfner, R. Thomson, and K. Hyatt. 2011. Environmental control of the breeding success of rhinoceros auklets at Triangle Island, British Columbia. Marine Ecology-Progress Series 424:285-302.
Botsford, L. W., M. D. Holland, J. F. Samhouri, J. W. White, and A. Hastings. 2011. Importance of age structure in models of the response of upper trophic levels to fishing and climate change. Ices Journal of Marine Science 68:1270-1283.
Breau, C., R. A. Cunjak, and S. J. Peake. 2011. Behaviour during elevated water temperatures: can physiology explain movement of juvenile Atlantic salmon to cool water? Journal of Animal Ecology 80:844-853.
Brown, R. S., W. A. Hubert, and S. F. Daly. 2011. A Primer on Winter, Ice, and Fish: What Fisheries Biologists Should Know about Winter Ice Processes and Stream-Dwelling Fish. Fisheries 36:8-26.

Burrows, M. T., D. S. Schoeman, L. B. Buckley, P. Moore, E. S. Poloczanska, K. M. Brander, C. Brown et al. 2011. The Pace of Shifting Climate in Marine and Terrestrial Ecosystems. Science 334:652-655.

Cheung, W. W. L., J. Dunne, J. L. Sarmiento, and D. Pauly. 2011. Integrating ecophysiology and plankton dynamics into projected maximum fisheries catch potential under climate change in the Northeast Atlantic. ICES Journal of Marine Science: Journal du Conseil 68:1008-1018.

Clark, T. D., K. M. Jeffries, S. G. Hinch, and A. P. Farrell. 2011. Exceptional aerobic scope and cardiovascular performance of pink salmon (Oncorhynchus gorbuscha) may underlie resilience in a warming climate. Journal of Experimental Biology 214:3074-3081.

Cocherell, S. A., D. E. Cocherell, G. J. Jones, J. B. Miranda, L. C. Thompson, J. J. Cech, and A. P. Klimley. 2011. Rainbow trout Oncorhynchus mykiss energetic responsesto pulsed flows in the American River, California, assessed by electromyogram telemetry. Environmental Biology of Fishes 90:29-41.

Copeland, T., and K. A. Meyer. 2011. Interspecies Synchrony in Salmonid Densities Associated with Large-Scale Bioclimatic Conditions in Central Idaho. Transactions of the American Fisheries Society 140:928-942.

Coyle, K. O., L. B. Eisner, F. J. Mueter, A. I. Pinchuk, M. A. Janout, K. D. Cieciel, E. V. Farley et al. 2011. Climate change in the southeastern Bering Sea: impacts on pollock stocks and implications for the oscillating control hypothesis. Fisheries Oceanography 20:139-156.

Crozier, L. G., M. D. Scheuerell, and R. W. Zabel. 2011. Using Time Series Analysis to Characterize Evolutionary and Plastic Responses to Environmental Change: A Case Study of a Shift toward Earlier Migration Date in Sockeye Salmon. American Naturalist 178:755-773.

Cummings, J. W., M. J. Hague, D. A. Patterson, and R. M. Peterman. 2011. The Impact of Different Performance Measures on Model Selection for Fraser River Sockeye Salmon. North American Journal of Fisheries Management 31:323-334.

Cuo, L., T. K. Beyene, N. Voisin, F. G. Su, D. P. Lettenmaier, M. Alberti, and J. E. Richey. 2011. Effects of mid-twenty-first century climate and land cover change on the hydrology of the Puget Sound basin, Washington. Hydrological Processes 25:1729-1753.

Danovaro, R., C. Corinaldesi, A. Dell'Anno, J. A. Fuhrman, J. J. Middelburg, R. T. Noble, and C. A. Suttle. 2011. Marine viruses and global climate change. Fems Microbiology Reviews 35:993-1034.

Das, T., D. W. Pierce, D. R. Cayan, J. A. Vano, and D. P. Lettenmaier. 2011. The importance of warm season warming to western US streamflow changes. Geophysical Research Letters 38.

Dawson, A., A. J. Matthews, and D. P. Stevens. 2011. Rossby wave dynamics of the North Pacific extra-tropical response to El Nino: importance of the basic state in coupled GCMs. Climate Dynamics 37:391-405.

de Eyto, E., P. McGinnity, J. Huisman, J. Coughlan, S. Consuegra, K. Farrell, C. O'Toole et al. 2011. Varying disease-mediated selection at different life-history stages of Atlantic salmon in fresh water. Evolutionary Applications 4:749-762.

De Laender, F., J. Hammer, A. J. Hendriks, K. Soetaert, and C. R. Janssen. 2011. Combining Monitoring Data and Modeling Identifies PAHs as Emerging Contaminants in the Arctic. Environmental Science & Technology 45:9024-9029.
Duliere, V., Y. X. Zhang, and E. P. Salathe. 2011. Extreme Precipitation and Temperature over the U.S. Pacific Northwest: A Comparison between Observations, Reanalysis Data, and Regional Models. Journal of Climate 24:1950-1964.
Eliason, E. J., T. D. Clark, M. J. Hague, L. M. Hanson, Z. S. Gallagher, K. M. Jeffries, M. K. Gale et al. 2011. Differences in Thermal Tolerance Among Sockeye Salmon Populations. Science 332:109-112.
Evans, T. G., E. Hammill, K. Kaukinen, A. D. Schulze, D. A. Patterson, K. K. English, J. M. R. Curtis et al. 2011. Transcriptomics of environmental acclimatization and survival in wild adult Pacific sockeye salmon (Oncorhynchus nerka) during spawning migration. Molecular Ecology 20:4472-4489.
Farley, E. V., A. Starovoytov, S. Naydenko, R. Heintz, M. Trudel, C. Guthrie, L. Eisner et al. 2011a. Implications of a warming eastern Bering Sea for Bristol Bay sockeye salmon. Ices Journal of Marine Science 68:1138-1146.
Farley, K. A., C. Tague, and G. E. Grant. 2011b. Vulnerability of water supply from the Oregon Cascades to changing climate: Linking science to users and policy. Global Environmental Change-Human and Policy Dimensions 21:110-122.
Fjelldal, P. G., T. Hansen, and T. S. Huang. 2011. Continuous light and elevated temperature can trigger maturation both during and immediately after smoltification in male Atlantic salmon (Salmo salar). Aquaculture 321:93-100.
Foreman, M. G. G., B. Pal, and W. J. Merryfield. 2011. Trends in upwelling and downwelling winds along the British Columbia shelf. Journal of Geophysical Research-Oceans 116.
Franke, A., and C. Clemmesen. 2011. Effect of ocean acidification on early life stages of Atlantic herring (Clupea harengus L.). Biogeosciences 8:3697-3707.
Fukushima, M., H. Shimazaki, P. S. Rand, and M. Kaeriyama. 2011. Reconstructing Sakhalin Taimen Parahucho perryi Historical Distribution and Identifying Causes for Local Extinctions. Transactions of the American Fisheries Society 140:1-13.
Gale, M. K., S. G. Hinch, E. J. Eliason, S. J. Cooke, and D. A. Patterson. 2011. Physiological impairment of adult sockeye salmon in fresh water after simulated capture-and-release across a range of temperatures. Fisheries Research 112:85-95.
Geist, D. R., Z. Q. Deng, R. P. Mueller, V. Cullinan, S. Brink, and J. A. Chandler. 2011. The Effect of Fluctuating Temperatures and Ration Levels on the Growth of Juvenile Snake River Fall Chinook Salmon. Transactions of the American Fisheries Society 140:190-200.
Glessmer, M. S., W. Park, and A. Oschlies. 2011. Simulated reduction in upwelling of tropical oxygen minimum waters in a warmer climate. Environmental Research Letters 6.
Glick, P., B. A. Stein, and N. A. Edelson. 2011. Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment. Washington, D.C., National Wildlife Federation.

Groom, J. D., L. Dent, and L. J. Madsen. 2011a. Stream temperature change detection for state and private forests in the Oregon Coast Range. Water Resources Research 47.

Groom, J. D., L. Dent, L. J. Madsen, and J. Fleuret. 2011b. Response of western Oregon (USA) stream temperatures to contemporary forest management. Forest Ecology and Management 262:1618-1629.

Gruber, N. 2011. Warming up, turning sour, losing breath: ocean biogeochemistry under global change. Philosophical Transactions of the Royal Society a-Mathematical Physical and Engineering Sciences 369:1980-1996.

Hague, M. J., M. R. Ferrari, J. R. Miller, D. A. Patterson, G. L. Russell, A. P. Farrell, and S. G. Hinch. 2011. Modelling the future hydroclimatology of the lower Fraser River and its impacts on the spawning migration survival of sockeye salmon. Global Change Biology 17:87-98.

Hale, R., P. Calosi, L. McNeill, N. Mieszkowska, and S. Widdicombe. 2011. Predicted levels of future ocean acidification and temperature rise could alter community structure and biodiversity in marine benthic communities. Oikos 120:661-674.

Hamlet, A. F. 2011. Assessing water resources adaptive capacity to climate change impacts in the Pacific Northwest Region of North America. Hydrology and Earth System Sciences 15:1427-1443.

Hayes, S. A., M. H. Bond, C. V. Hanson, A. W. Jones, A. J. Ammann, J. A. Harding, A. L. Collins et al. 2011. Down, up, down and "smolting" twice? Seasonal movement patterns by juvenile steelhead (Oncorhynchus mykiss) in a coastal watershed with a bar closing estuary. Canadian Journal of Fisheries and Aquatic Sciences 68:1341-1350.

Healey, M. 2011. The cumulative impacts of climate change on Fraser River sockeye salmon (Oncorhynchus nerka) and implications for management. Canadian Journal of Fisheries and Aquatic Sciences 68:718-737.

Heinemann, M., A. Timmermann, and U. Feudel. 2011. Interactions between marine biota and ENSO: a conceptual model analysis. Nonlinear Processes in Geophysics 18:29-40.

Hess, J. E., and S. R. Narum. 2011. Single-Nucleotide Polymorphism (SNP) Loci Correlated with Run Timing in Adult Chinook Salmon from the Columbia River Basin. Transactions of the American Fisheries Society 140:855-864.

Hester, E. T., and M. W. Doyle. 2011. Human Impacts to River Temperature and Their Effects on Biological Processes: A Quantitative Synthesis. Journal of the American Water Resources Association 47:571-587.

Hoekema, D. J., and V. Sridhar. 2011. Relating climatic attributes and water resources allocation: A study using surface water supply and soil moisture indices in the Snake River basin, Idaho. Water Resources Research 47.

Hofmann, G. E., J. E. Smith, K. S. Johnson, U. Send, L. A. Levin, F. Micheli, A. Paytan et al. 2011. High-Frequency Dynamics of Ocean pH: A Multi-Ecosystem Comparison. Plos One 6.

Hondula, D. M., and R. E. Davis. 2011. Climatology of winter transition days for the contiguous USA, 1951-2007. Theoretical and Applied Climatology 103:27-37.

House-Peters, L. A., and H. Chang. 2011. Modeling the impact of land use and climate change on neighborhood-scale evaporation and nighttime cooling: A surface energy balance approach. Landscape and Urban Planning 103:139-155.

Huang, B., C. Langpap, and R. M. Adams. 2011. Using instream water temperature forecasts for fisheries management: an application int he Pacific Northwest. Journal of the American Water Resources Association 47:861-876.

Jay, D. A., K. Leffler, and S. Degens. 2011. Long-Term Evolution of Columbia River Tides. Journal of Waterway Port Coastal and Ocean Engineering-Asce 137:182-191.

Jay, D. A., and P. K. Naik. 2011. Distinguishing human and climate influences on hydrological disturbance processes in the Columbia River, USA. Hydrological Sciences Journal-Journal Des Sciences Hydrologiques 56:1186-1209.

Jefferson, A. J. 2011. Seasonal versus transient snow and the elevation dependence of climate sensitivity in maritime mountainous regions. Geophysical Research Letters 38.

Jensen, A. J., P. Fiske, L. P. Hansen, B. O. Johnsen, K. A. Mork, and T. F. Naesje. 2011. Synchrony in marine growth among Atlantic salmon (Salmo salar) populations. Canadian Journal of Fisheries and Aquatic Sciences 68:444-457.

Joint, I., S. C. Doney, and D. M. Karl. 2011. Will ocean acidification affect marine microbes? Isme Journal 5:1-7.

Jokinen, I. E., H. M. Salo, E. Markkula, K. Rikalainen, M. T. Arts, and H. I. Browman. 2011. Additive effects of enhanced ambient ultraviolet B radiation and increased temperature on immune function, growth and physiological condition of juvenile (parr) Atlantic Salmon, Salmo salar. Fish & Shellfish Immunology 30:102-108.

Jones, I. S. F. 2011. Contrasting micro- and macro-nutrient nourishment of the ocean. Marine Ecology-Progress Series 425:281-296.

Jung, I. W., and H. J. Chang. 2011. Assessment of future runoff trends under multiple climate change scenarios in the Willamette River Basin, Oregon, USA. Hydrological Processes 25:258-277.

Kim, W., S. W. Yeh, J. H. Kim, J. S. Kug, and M. Kwon. 2011. The unique 2009-2010 El Nino event: A fast phase transition of warm pool El Nino to La Nina. Geophysical Research Letters 38.

Klaiman, J. M., A. J. Fenna, H. A. Shiels, J. Macri, and T. E. Gillis. 2011. Cardiac Remodeling in Fish: Strategies to Maintain Heart Function during Temperature Change. Plos One 6.

Koehn, J. D., A. J. Hobday, M. S. Pratchett, and B. M. Gillanders. 2011. Climate change and Australian marine and freshwater environments, fishes and fisheries: synthesis and options for adaptation. Marine and Freshwater Research 62:1148-1164.

Komar, P. D., J. C. Allan, and P. Ruggiero. 2011. Sea Level Variations along the U.S. Pacific Northwest Coast: Tectonic and Climate Controls. Journal of Coastal Research 27:808-823.

Krimmer, A. N., A. J. Paul, A. Hontela, and J. B. Rasmussen. 2011. Behavioural and physiological responses of brook trout Salvelinus fontinalis to midwinter flow

reduction in a small ice-free mountain stream. Journal of Fish Biology 79:707-725.
Lenoir, S., G. Beaugrand, and É. Lecuyer. 2011. Modelled spatial distribution of marine fish and projected modifications in the North Atlantic Ocean. Global Change Biology 17:115-129.
Liedvogel, M., S. Akesson, and S. Bensch. 2011. The genetics of migration on the move. Trends in Ecology & Evolution 26:561-569.
Lin, P. F., H. L. Liu, Y. Q. Yu, and X. H. Zhang. 2011. Response of Sea Surface Temperature to Chlorophyll-a Concentration in the Tropical Pacific: Annual Mean, Seasonal Cycle, and Interannual Variability. Advances in Atmospheric Sciences 28:492-510.
Lischka, S., J. Budenbender, T. Boxhammer, and U. Riebesell. 2011. Impact of ocean acidification and elevated temperatures on early juveniles of the polar shelled pteropod Limacina helicina: mortality, shell degradation, and shell growth. Biogeosciences 8:919-932.
Low-DÉCarie, E., G. F. Fussmann, and G. Bell. 2011. The effect of elevated CO2 on growth and competition in experimental phytoplankton communities. Global Change Biology 17:2525-2535.
MacKenzie, L. A., K. F. Smith, L. L. Rhodes, A. Brown, V. Langi, M. Edgar, G. Lovell et al. 2011. Mortalities of sea-cage salmon (Oncorhynchus tshawytscha) due to a bloom of Pseudochattonella verruculosa (Dictyochophyceae) in Queen Charlotte Sound, New Zealand. Harmful Algae 11:45-53.
Malcolm, I. A., A. F. Youngson, C. Soulsby, C. Imholt, and R. J. Fryer. 2011. Is Interstitial Velocity a Good Predictor of Salmonid Embryo Survival? Transactions of the American Fisheries Society 140:898-904.
Marschall, E. A., M. E. Mather, D. L. Parrish, G. W. Allison, and J. R. McMenemy. 2011. Migration delays caused by anthropogenic barriers: modeling dams, temperature, and success of migrating salmon smolts. Ecological Applications 21:3014-3031.
Martins, E. G., S. G. Hinch, D. A. Patterson, M. J. Hague, S. J. Cooke, K. M. Miller, M. F. Lapointe et al. 2011. Effects of river temperature and climate warming on stock-specific survival of adult migrating Fraser River sockeye salmon (Oncorhynchus nerka). Global Change Biology 17:99-114.
Mayer, T. D., and S. W. Naman. 2011. Streamflow response to climate as influences by geology and elevation. Journal of the American Water Resources Association 47:724-738.
Miller, K. M., S. R. Li, K. H. Kaukinen, N. Ginther, E. Hammill, J. M. R. Curtis, D. A. Patterson et al. 2011a. Genomic Signatures Predict Migration and Spawning Failure in Wild Canadian Salmon. Science 331:214-217.
Miller, S. C., T. E. Gillis, and P. A. Wright. 2011b. The ontogeny of regulatory control of the rainbow trout (Oncorhynchus mykiss) heart and how this is influenced by chronic hypoxia exposure. Journal of Experimental Biology 214:2065-2072.
Milner, A. M., A. L. Robertson, L. E. Brown, S. H. Sonderland, M. McDermott, and A. J. Veal. 2011. Evolution of a stream ecosystem in recently deglaciated terrain. Ecology 92:1924-1935.

Min, S. K., X. B. Zhang, F. W. Zwiers, and G. C. Hegerl. 2011. Human contribution to more-intense precipitation extremes. Nature 470:378-381.

Munday, P. L., M. Gagliano, J. M. Donelson, D. L. Dixson, and S. R. Thorrold. 2011a. Ocean acidification does not affect the early life history development of a tropical marine fish. Marine Ecology-Progress Series 423:211-221.

Munday, P. L., V. Hernaman, D. L. Dixson, and S. R. Thorrold. 2011b. Effect of ocean acidification on otolith development in larvae of a tropical marine fish. Biogeosciences 8:1631-1641.

Mundy, P. R., and D. F. Evenson. 2011. Environmental controls of phenology of high-latitude Chinook salmon populations of the Yukon River, North America, with application to fishery management. Ices Journal of Marine Science 68:1155-1164.

Naik, P. K., and D. A. Jay. 2011a. Distinguishing human and climate influences on the Columbia River: Changes in mean flow and sediment transport. Journal of Hydrology 404:259-277.

—. 2011b. Human and climate impacts on Columbia River hydrology and salmonids. River Research and Applications 27:1270-1276.

National Wildlife Federation. 2011. Climate Change Effects and Adaptation Approaches in Marine and Coastal Ecosystems of the North Pacific Landscape Conservation Cooperative Region: A Compilation of Scientific Literature. Phase 1 Draft Final Report. http://www.nwf.org/~/media/PDFs/Global-Warming/Reports/NPLCC%20Reports/NPLCC_Marine_Climate-Effects_Draft-Final_FullReport.ashx

Nelson, D. B., M. B. Abbott, B. Steinman, P. J. Polissar, N. D. Stansell, J. D. Ortiz, M. F. Rosenmeier et al. 2011. Drought variability in the Pacific Northwest from a 6,000-yr lake sediment record. Proceedings of the National Academy of Sciences of the United States of America 108:3870-3875.

Otero, J., A. J. Jensen, J. H. L'Abee-Lund, N. C. Stenseth, G. O. Storvik, and L. A. Vollestad. 2011. Quantifying the Ocean, Freshwater and Human Effects on Year-to-Year Variability of One-Sea-Winter Atlantic Salmon Angled in Multiple Norwegian Rivers. Plos One 6.

Pankhurst, N. W., and P. L. Munday. 2011. Effects of climate change on fish reproduction and early life history stages. Marine and Freshwater Research 62:1015-1026.

Pardo, P. C., X. A. Padin, M. Gilcoto, L. Farina-Busto, and F. F. Perez. 2011. Evolution of upwelling systems coupled to the long-term variability in sea surface temperature and Ekman transport. Climate Research 48:231-246.

Perkins, T. A., and H. I. Jager. 2011. Falling Behind: Delayed Growth Explains Life-History Variation in Snake River Fall Chinook Salmon. Transactions of the American Fisheries Society 140:959-972.

Polovina, J. J., J. P. Dunne, P. A. Woodworth, and E. A. Howell. 2011. Projected expansion of the subtropical biome and contraction of the temperate and equatorial upwelling biomes in the North Pacific under global warming. Ices Journal of Marine Science 68:986-995.

Quinn, T. P., M. J. Unwin, and M. T. Kinnison. 2011. Contemporary divergence in migratory timing of naturalized populations of chinook salmon, Oncorhynchus tshawytscha, in New Zealand. Evolutionary Ecology Research 13:45-54.

Reed, T. E., D. E. Schindler, M. J. Hague, D. A. Patterson, E. Meir, R. S. Waples, and S. G. Hinch. 2011. Time to Evolve? Potential Evolutionary Responses of Fraser River Sockeye Salmon to Climate Change and Effects on Persistence. Plos One 6.

Reum, J. C. P., T. E. Essington, C. M. Greene, C. A. Rice, and K. L. Fresh. 2011. Multiscale influence of climate on estuarine populations of forage fish: the role of coastal upwelling, freshwater flow and temperature. Marine Ecology-Progress Series 425:203-215.

Roegner, G. C., J. A. Needoba, and A. M. Baptista. 2011a. Coastal Upwelling Supplies Oxygen-Depleted Water to the Columbia River Estuary. PLoS ONE 6 e18672.

Roegner, G. C., C. Seaton, and A. M. Baptista. 2011b. Climatic and Tidal Forcing of Hydrography and Chlorophyll Concentrations in the Columbia River Estuary. Estuaries and Coasts 34:281-296.

Rogers, B. M., R. P. Neilson, R. Drapek, J. M. Lenihan, J. R. Wells, D. Bachelet, and B. E. Law. 2011. Impacts of climate change on fire regimes and carbon stocks of the U.S. Pacific Northwest. Journal of Geophysical Research-Biogeosciences 116.

Rouyer, T., G. Ottersen, J. M. Durant, M. Hidalgo, D. A. G. Ø. Hjermann, J. Persson, L. C. Stige et al. 2011. Shifting dynamic forces in fish stock fluctuations triggered by age truncation? Global Change Biology:no-no.

Ruff, C. P., D. E. Schindler, J. B. Armstrong, K. T. Bentley, G. T. Brooks, G. W. Holtgrieve, M. T. McGlauflin et al. 2011. Temperature-associated population diversity in salmon confers benefits to mobile consumers. Ecology 92:2073-2084.

Safford, T. G., and K. C. Norman. 2011. Water water everywhere, but not enough for salmon? Organizing integrated water and fisheries management in Puget Sound. Journal of Environmental Management 92:838-847.

Saito, T., T. Kaga, E. Hasegawa, and K. Nagasawa. 2011. Effects of juvenile size at release and early marine growth on adult return rates for Hokkaido chum salmon (Oncorhynchus keta) in relation to sea surface temperature. Fisheries Oceanography 20:278-293.

Seeb, L. W., J. E. Seeb, C. Habicht, E. V. Farley, and F. M. Utter. 2011. Single-Nucleotide Polymorphic Genotypes Reveal Patterns of Early Juvenile Migration of Sockeye Salmon in the Eastern Bering Sea. Transactions of the American Fisheries Society 140:734-748.

Selbie, D. T., J. N. Sweetman, P. Etherton, K. D. Hyatt, D. P. Rankin, B. P. Finney, and J. P. Smol. 2011. Climate change modulates structural and functional lake ecosystem responses to introduced anadromous salmon. Canadian Journal of Fisheries and Aquatic Sciences 68:675-692.

Sestrich, C. M., T. E. McMahon, and M. K. Young. 2011. Influence of Fire on Native and Nonnative Salmonid Populations and Habitat in a Western Montana Basin. Transactions of the American Fisheries Society 140:136-146.

Sommer, U., and A. Lewandowska. 2011. Climate change and the phytoplankton spring bloom: warming and overwintering zooplankton have similar effects on phytoplankton. Global Change Biology 17:154-162.

Spencer, M., S. N. R. Birchenough, N. Mieszkowska, L. A. Robinson, S. D. Simpson, M. T. Burrows, E. Capasso et al. 2011. Temporal change in UK marine communities: trends or regime shifts? Marine Ecology-an Evolutionary Perspective 32:10-24.
Tagliabue, A., L. Bopp, and M. Gehlen. 2011. The response of marine carbon and nutrient cycles to ocean acidification: Large uncertainties related to phytoplankton physiological assumptions. Global Biogeochemical Cycles 25.
Taguchi, M., and J. C. Liao. 2011. Rainbow trout consume less oxygen in turbulence: the energetics of swimming behaviors at different speeds. Journal of Experimental Biology 214:1428-1436.
Thomson, R. E., and R. A. S. Hourston. 2011. A matter of timing: the role of ocean conditions in the initiation of spawning migration by late-run Fraser River sockeye salmon (*Oncorhynchus nerka*). Fisheries Oceanography 20:47-65.
Thorpe, A. S., and A. G. Stanley. 2011. Determining appropriate goals for restoration of imperilled communities and species. Journal of Applied Ecology 48:275-279.
Todd, R. E., D. L. Rudnick, R. E. Davis, and M. D. Ohman. 2011. Underwater gliders reveal rapid arrival of El Nino effects off California's coast. Geophysical Research Letters 38.
Traynham, L., R. Palmer, and A. Polebitski. 2011. Impacts of Future Climate Conditions and Forecasted Population Growth on Water Supply Systems in the Puget Sound Region. Journal of Water Resources Planning and Management-Asce 137:318-326.
USFWS, NOAA-Fisheries Service, and Association of Fish and Wildlife Agencies. 2011. National Fish, Wildlife and Plants Climate Adaptation Strategy, Agency Review Draft, November 2011. http://www.wildlifeadaptationstrategy.gov:153
Vaquer-Sunyer, R., and C. M. Duarte. 2011. Temperature effects on oxygen thresholds for hypoxia in marine benthic organisms. Global Change Biology 17:1788-1797.
Welch, D. W., Y. Ishida, and K. Nagasawa. 1998. Thermal limits and ocean migrations of sockeye salmon (*Oncorhynchus nerka*): long-term consequences of global warming. Canadian Journal of Fisheries and Aquatic Sciences 55:937-948.
Wenger, S. J., D. J. Isaak, C. H. Luce, H. M. Neville, K. D. Fausch, J. B. Dunham, D. C. Dauwalter et al. 2011. Flow regime, temperature, and biotic interactions drive differential declines of trout species under climate change. Proceedings of the National Academy of Sciences of the United States of America 108:14175-14180.
Weyhenmeyer, G. A., D. M. Livingstone, M. Meili, O. Jensen, B. Benson, and J. J. Magnuson. 2011. Large geographical differences in the sensitivity of ice-covered lakes and rivers in the Northern Hemisphere to temperature changes. Global Change Biology 17:268-275.
Whiteley, N. M. 2011. Physiological and ecological responses of crustaceans to ocean acidification. Marine Ecology-Progress Series 430:257-271.
Young, I. R., S. Zieger, and A. V. Babanin. 2011. Global Trends in Wind Speed and Wave Height. Science 332:451-455.
Zeug, S. C., L. K. Albertson, H. Lenihan, J. Hardy, and B. Cardinale. 2011. Predictors of Chinook salmon extirpation in California's Central Valley. Fisheries Management and Ecology 18:61-71.

Page is intentionally blank.

Appendix B – FCRPS Biological Opinion 2011 Annual Progress Report Response to Regional Implementation Oversight Group (RIOG) Comments

Page is intentionally blank.

FCRPS Biological Opinion 2011 Annual Progress Report Response to Regional Implementation Oversight Group (RIOG) Comments September 2012			
A draft of the FCRPS Biological Opinion (BiOp) 2011 Annual Progress Report (APR) was provided to the Federal-State-Tribal RIOG on August 15, 2012 for comment. The Action Agencies presented an overview summary of the APR at the RIOG meeting held on August 22, 2012 and content of the APR was discussed. This table is a response to comments received[1], including details of how changes were incorporated into the document, if appropriate. The APR summarizes the Action Agencies' implementation in 2011 of the 10-year FCRPS BiOp (2008-2018) and is prepared pursuant to the 2010 Supplemental BiOp, RPA Action 2. The 2011 APR reports on the progress of implementing the RPA Actions from January 1, 2011 through December 31, 2011, while progress on multi-year activities and achievement of performance targets for the 10-year BiOp will be presented in the Comprehensive Evaluation in 2013 and 2016 (RPA Action 3). The APR is organized into three sections. Section 1 includes general information that is meant to provide context for a general reader and describes important implementation actions (highlights) and progress that occurred in 2011. This section also presents information in formats requested previously by the RIOG. Section 2 provides 2011 accomplishments on BiOp RPA implementation by action. Section 3 lists projects implemented during 2011 and includes habitat metrics completed. The APR informs future RPA action implementation and incorporates scientific information available during the time period covered by the report.			
From	**Section**	**Comment**	**Action**
OR	General Comment 1	The 2011 Progress Report only reports implementation of projects, without demonstrating any survival benefits to species listed under the Endangered Species Act (ESA). Numbers of projects implemented or dollars spent are not performance metrics. Instead, the Progress Report needs to explicitly demonstrate how the implemented projects are making progress toward ensuring the survival and recovery of ESA-listed fish species.	As called for in the FCRPS BiOp, RPA Action 2, the 2011 APR describes the status of implementing all actions as of the end of the previous calendar year. By contrast, periodic check-ins (comprehensive evaluations) were designed to explicitly evaluate how the implemented projects are making progress toward the RPA goals. The next periodic check-in is the 2013 Comprehensive Evaluation due in June 2013.
OR	General Comment 2	The 2011 Progress Report should more clearly and explicitly affirm the Action Agencies' commitment to the court-ordered spill program, now and in future years. The report should also make it clear that the Action Agencies consider the court ordered spill program to be the presumptive path for the spring and summer spill in RPA Action 29. The report does not, but should explicitly document progress toward implementing the annual spill program.	As called for in the FCRPS BiOp, RPA Action 2, the 2011 APR Section 2, pp. 44-45 reports on the Action Agencies' implementation of the 2011 Spring and Summer FOPs describing the annual fish passage spill operations as adopted by the March 24, 2011 and June 14, 2011 court orders. Consistent with the 2010 Supplemental BiOp and the Court orders, the 2011 Spring and Summer FOPs provided for adaptive management for making in-season adjustments addressing real-time conditions in coordination with regional sovereigns. The 2011 APR is intended to document and report what actually occurred in 2011, not speculate on future operations.
OR	Section 1 Comment 1	Page 5-6 (Figure 2 and Table 1): The 2011 Progress Report presents the combined Bonneville Dam counts of hatchery and wild fish as an indication of	Section 1 Figure 2 and Table 1 are included to provide a historical perspective of 2011 adult fish counts at

[1] The State of Oregon provided comments.

		improved status since 1999. Instead, it should track improvements in reproduction, survival, numbers, and distribution of ESA-listed species at the population level. Presenting Bonneville Dam counts is misleading because: a. The dam counts combine all species, including unlisted species/ ESUs, such as: i. Mid-Columbia spring Chinook ii. Mid and upper Columbia fall Chinook, iii. Hatchery/reintroduced coho returning to hatcheries and basins above The Dalles Dam, which are outside of the listed coho ESU. b. The dam counts include hatchery fish, as well as wild fish (including hatchery Chinook, steelhead, coho and sockeye). c. Only about 11% of the dam counts are wild ESA-listed fish.	Bonneville Dam relative to years' past. More specific information on species-specific adult returns is reported in the Section 1 Overview by Species.
OR	Section 1 Comment 2	Page 6 (Adult fish survival): NOAA's PIT tag methodology for measuring adult survival from Bonneville Dam to points upstream remains problematic because the PIT tag data cannot be reconciled with other sources of information, such as dam counts, turn-off/straying, harvest and unaccounted-for losses. The 2011 Progress Report should better acknowledge and explain these discrepancies and their implications.	NOAA Fisheries and the Action Agencies agree that there are discrepancies in estimated adult survival rates using different methodologies. At present, NOAA Fisheries is continuing to evaluate factors that could affect the PIT tag methodologies (relative to those used by other parties for other purposes). Until these analyses are complete, the Action Agencies will continue to report the PIT tag estimates as required by the FCRPS BiOp, and NOAA Fisheries will share and discuss with co-managers the results of its evaluations and work collaboratively on monitoring improvements that could reduce the uncertainty of these estimates. The Action Agencies have added a footnote to the Adult Survival table indicating that survival rate estimates based on PIT tags may not represent the run-at-large, as not all populations in each of the ESU are marked proportionately; and that this is being investigated.
OR	Section 1 Comment 3	Page 7 (Juvenile fish survival): The 2011 juvenile fish survival estimates reported in the 2011 Progress Report are incomplete in that they do not include survival of fish that only pass the dams over the spillway (i.e. fish that are never by-passed or transported). This is because these fish complete their in-river out-migration undetected as juveniles. As a result, survival of these fish can only be measured as adult returns. With respect to juvenile fish survival, the report should make it clear that	Comment noted. An endnote was added to indicate that in-river survival estimates include non-detected, as well as bypassed and detected fish on Page 7.

		survival estimates only include transported and by-passed (detected) juveniles (those not spilled).	
OR	Section 1 Comment 4	Page 7 (Juvenile fish survival): The 2011 Progress Report combines juvenile fish survivals for hatchery and wild fish. Survivals for juvenile hatchery and wild fish differ; therefore they must be reported separately. (see figure 5, page 6).	Comment noted. The Action Agencies reported hatchery and wild juvenile fish survival separately, where possible. However, where there are too few natural production PIT tagged fish to support separate reporting (e.g. the Upper Columbia River ESUs), pooled estimates are reported.
OR	Section 1 Comment 5	Page 7 (Juvenile fish survival): The 2011 Progress Report states "Research is being carried out under the BiOp to better understand any delayed effects of transport." On juvenile fish survival, but doesn't actually report the data that already exists on delayed effects. A wealth of scientific data exists (e.g. Comparative Survival Study OR reports) that indicates that delayed mortality of transported fish is greater than that of fish that migrate in river, especially those that migrate undetected.	Comment noted. See Section 2, RPA Actions 55.1, 55.2, and 55.3 for detailed information including CSS reports on annual results of delayed mortality studies. The Action Agencies recognize that differential delayed mortality (*D*) varies by year, species, environmental conditions, hatchery and natural fish, etc[2]. However, despite variations in *D*, transportation continues to provide benefits over in-river migration during certain time periods especially for steelhead smolts. The Action Agencies, consistent with the ISAB's review of three FPC memos and CSS annual reports regarding latent mortality of in-river migrants due to route of dam passage quoted below, continue to focus on the total mortality of in-river migrants and transported fish. "The ISAB finds that collectively these analyses demonstrate that fish bypass systems are associated with some latent mortality, but the factors responsible for latent mortality remain poorly understood and inadequately evaluated. The significant association between fish bypass and latent mortality might only reflect a non-random sampling of smolts at the bypass collectors (the selection hypothesis) rather than injury or stress caused by the bypass event (the damage hypothesis). Because these hypotheses have very different implications for

[2]Differential Delayed Mortality (*D*) and latent mortality associated with hydrosystem passage are two issues that are frequently comingled, but that have different implications to the Action Agencies' management of the FCRPS. *D* is the relative survival between barged and run-of-river fish after passage through the FCRPS. Latent mortality is the differential survival of in-river migrating fish based on the route of passage through the dams (e.g. bypassed vs. spillway passed fish).

			hydrosystem operations, FPC and CSS conclusions should be re-examined to consider alternative explanations discussed in this review.”
OR	Section 1 Comment 6	Page 7 (Juvenile fish survival): Estimates of total system survival calculated by only including survival of juvenile fish that were by-passed and were transported is biased because (a) it does not include in-river migrants that migrated to sea undetected and (b) it does not include delayed mortality of these fish. Because the weight of scientific evidence indicates that delayed mortality of transported fish is greater than that of fish that migrate in river, especially those that migrate undetected, failing to include delayed mortality will overestimate the relative survival of transported fish, whose direct mortality is only around 2% (from point of collection in the Snake to point of release below Bonneville Dam).	As called for by RPA Action 52.2, the Action Agencies track system survival (a combination of in-river and transport survival) annually. There is no performance target associated with system survival in the BiOp. System survival estimates that incorporate *D* will be presented in the 2013 Comprehensive Evaluation if estimates are available from researchers.
OR	Section 1 Comment 7	Page 7 (Juvenile fish survival): Because the total system survival estimates in the 2011 Progress Report do not account for delayed mortality, and thus overestimate the relative survival of transported fish, the estimates in years when fewer juvenile fish are transported will be less than in other years. However, if the relative survival of juvenile fish that return as adults is compared between those same years, the relationship breaks down because transported fish have much higher delayed (post-Bonneville) mortality than in-river fish, especially those that migrate in river undetected.	Comment noted. See response to comment 5 above. Estimates of total system survival are only intended to be an indicator of combined juvenile survival for fish left in-river and those transported. Estimates currently do not include the effects (either positive or negative) of any differential delayed mortality because the effects cannot be determined until these fish return as adults.
OR	Section 1 Comment 8	Page 7 Juvenile fish survival-Figure 6): The 2011 Progress Report combines juvenile survivals for hatchery and wild fish. The CSS reports have demonstrated that hatchery fish have higher benefits from transportation than wild fish. As support for these points, see analysis in Tuomikoski et al. 2010. comparative survival study (CSS) of PIT-tagged spring/summer Chinook and summer steelhead 2010 annual report, Comparative Survival Study Oversight Committee and Fish Passage Center, Portland OR 388 pages (in administrative record).	Comment noted. We believe these comments refer to Figure 4 rather than Figure 6. Figure 4 reports combined hatchery and wild survival in-river estimates only; it does not convey transportation effectiveness results. To address the transportation issue, additional clarification that was in Section 2 was brought forward into Section 1. See RPA Action 55.2. The Action Agencies acknowledge that differences exist in transportation effectiveness between hatchery and natural fish and that those differences vary both within year (seasonal effects) and also on an inter-annual basis. These differences are reflected in both NOAA’s seasonal analysis as well as the CSS results noted in the comment.

OR	Section 1 Comment 9	Page 10-11 (Ocean and climate conditions): The 2011 Progress Report does not mention, but should explain that analyses (i.e. Schaller and Petrosky 2010 and Haeseker et al 2012) indicate ocean conditions are one of three important variables, along with flow and spill that predict smolt-to-adult returns, and first year ocean survival of Snake River spring/summer Chinook.	Comment noted. The Action Agencies concur that ocean conditions are an important variable, among several variables, affecting smolt-to-adult returns addressed in Section 1--Ocean and Climate Conditions.
OR	Section 1 Comment 10	Page 13 (Hydropower – Improvements for Fish at the Dams): Direct survival of fish passing through bypass systems may appear high when measured at the concrete, however recent data have shown significant delayed mortality effects during the remainder of the juvenile and early ocean-adult life stages that reduces adults returns.	See also response to comment 5. This section addresses improvements at the dam that are aimed at meeting BiOp dam survival performance standards. As such, the zone of inference (the segment of the system through which passage survival is being estimated) and the survival metrics presented are appropriate. The Action Agencies do address the issue of delayed mortality for bypassed fish later in the document, however we are unaware of any data confirming your suggestion that "significant delayed mortality occurs during the remainder of the juvenile migration and early ocean-adult life stages" exclusively as a result of bypass system passage. The Action Agencies are aware of analyses by NMFS, CSS, and Buchanan et al. that show reduced adult returns for fish that pass through multiple bypass systems. However, none of these studies address the causative mechanism(s) of reduced adult returns observed for multiple bypass exposure. ISAB has highlighted this as a critical uncertainty and noted that the correlation between lower adult returns and multiple bypass passage could be attributed to non-random sampling of smolts in the bypass systems. That is why this information is covered under hydro critical uncertainty RME (see response to comment 18).
OR	Section 1 Comment 11	Page 15 (Juvenile Salmonid Dam Passage Survival): The 2011 Progress Report currently states that "Transportation results continue to indicate higher adult returns of yearling Chinook salmon and juvenile steelhead that are collected and transported compared to those that migrate in-river during part of April and all of May, indicating that fish survival to adult would be higher with a greater transportation of fish in the spring." This statement	The Action Agencies confirmed that the statement in the 2011 Progress is accurate. This statement is based on a draft report sent to Oregon in December 2011 (Steven G. Smith, Douglas M. Marsh, Robert L. Emmett, William D. Muir, and Richard W. Zabel, 2011, *A Study to Determine Seasonal Effects of Transporting Fish from the Snake River to*

		does not reflect the latest findings from evaluations of the seasonal effects of transporting fish conducted by NOAA Fisheries (Bill Muir presentation at the 2011 AFEP Annual Review). In an abstract for the presentation, NOAA Fisheries states "Patterns did not change drastically in 2006-2009, but the earliest date on which T:M exceeded standards was more likely to be later in May (e.g., May 10), especially for steelhead."	*Optimize a Transportation Strategy,* Report of research by Fish Ecology Division Northwest Fisheries Science Center National Marine Fisheries Service National Oceanic and Atmospheric Administration, 2725 Montlake Boulevard East, Seattle, Washington. October 2011). Supporting excerpts from this report include the following: "• The years deserving the greatest focus are the recent years (2006 – 2009) when the spill and transport program continued through the entire season regardless of flow conditions. Analyses of these recent migration years did not indicate radical departures from the patterns in temporal T:M ratios observed in earlier years. However, T:M ratios of hatchery steelhead may have changed – the only instances of significantly lower returns for transported hatchery steelhead occurred in the early parts of the 2007 and 2008 migration seasons." Section 2, RPA Action 54.6 states "Overall, T:M ratios (ratio of SARs of transported to in-river migrating fish) reported by NOAA 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 3rd week of April. Transport is beneficial to hatchery Chinook salmon and hatchery and wild steelhead starting April 15 in most years."
OR	Section 1 Comment 12	Pages 18-28. (Tributary Habitat): As is generally the case for the 2011 Progress Report, this entire section describes the total amount of actions completed in 2011, but does not provide any context of how much was planned to be completed or was needed to be completed to meet the commitments made in the 2008/2010 BiOp for survival improvement.	After receiving a similar comment on the 2010 APR, the AAs responded by presenting tributary habitat data more clearly (see Section 3, Attachment 2, Table 1, where 2010-2012 planned metrics can be compared with 2011 actual metrics achieved).
OR	Section 1 Comment 13	Page 29. (Estuary Habitat Actions): As with tributary habitat, the estuary habitat section characterizes a very modest amount of acres treated as making significant progress, but without indicating how	The RPA actions for tributary and estuary habitat improvement call for the Action Agencies to find and implement "comparable replacement projects" for

		many projects were anticipated and relied on in the 2008/2010 BiOp for each year in this implementation cycle. Nor does it describe what projects were delayed or proved to be infeasible that must be replaced in subsequent years or cycles. It also does not reveal how many of the six completed projects were themselves replacement projects from previous years or cycles.	habitat improvement projects that prove to be infeasible. Through adaptive management and relying on the best available science, the Action Agencies in coordination with the ERTG and NOAA Fisheries, formulated and are implementing strategies to ensure accomplishment of the expected survival benefits assumed in the BiOp. This was reported in the 2010 FCRPS Annual Progress Report. The Action Agencies remain committed to replacing the survival benefits that would have been provided by projects that prove to be infeasible. With this approach the Action Agencies seek to implement projects that will achieve the survival benefits identified in the BiOp at appropriate locations, regardless of whether they are strictly comparable to earlier, infeasible projects. As an example, the Action Agencies are now concentrating upon carrying out larger scale estuary habitat improvement projects. Larger scale projects typically provide greater juvenile survival benefits per acre than do smaller projects. In addition, this means fewer projects are required, increasing efficiency and minimizing delays because less time is committed to planning, review, design, and acquiring environmental clearances.. Through its involvement in the ERTG Steering Committee process, NOAA Fisheries is kept aware of developments in Action Agency project selection and implementation strategy.
OR	Section 1 Comment 14	Page 29-30 (Estuary Habitat Actions): The total number of acres shown in Table 3 (234.2) does not match the difference between the acres (239.9) for 2010 and 2011 in Figure 16a and b. Likewise, the total of the number of acres treated (198.37) as shown in Section 3 Attachment 4, Table 1. Action Agency 2011 Estuary Habitat Projects (Pages 61-65) differs from both of the above. These reported numbers of acres should be reconciled and reported in a more consistent manner, or an explanation of the apparent discrepancies provided.	Comment noted. See changes in Table 3 which now indicates 238.7 total acres treated. This is now consistent with Section 3, Attachment 4, Table 1.
OR	Section 1 Comment	Page 41 (Hydro RME): It is stated in the 2011 Progress Report that "NOAA Fisheries evaluation of	The 2011 CSS study results also show differential transport benefits that vary

	15	SARs from wild fish transported and left in-river in the spring continued to indicate benefits from spring transport compared with in-river migration, especially for steelhead smolts." Research findings from the Comparative Survival Study (CSS) do not support these statements. Evaluations of smolt-to-adult survivals (SARs) conducted by state and tribal co-managers, updated to include 2010 returns (CSS 2011 August 31, 2011 Draft Annual Report available on www.fpc.org), have consistently shown that there is little or no transportation benefit (as indicated by a statistical difference in transport vs. in-river SARs >1.0) for Snake River wild Chinook (transport vs. in-river return or TIR > 1.0 in only 2 of 16 years), variable benefits for Snake River hatchery Chinook, and marginal benefits for hatchery steelhead (TIR > 1.0 in 5 of 11 years). The only stock group that has shown positive benefits is Snake River wild steelhead but even then TIRs have been >1.0 in only 7 of 11 years. In addition, in order to provide a more comprehensive evaluation on the benefits of transportation, the potential negative impacts of transportation on other species (specifically Snake River sockeye) and straying of Snake River steelhead need to be considered.	with stock, rearing type, and year. However, it is also important to note that CSS estimates of transportation benefits are based on season-wide averages and do not account for in-season variations (April vs. May) as those estimates developed by NWFSC do.
OR	Section 1 Comment 16	Page 41 (Hydro RME Critical Uncertainty Research): The 2011 Progress Report states beginning on line 22 that "Some juvenile bypass systems (JBS) were not associated with any reduced adult return rate (Lower Granite, McNary, John Day, and Bonneville), while some JBSs were (Little Goose, Lower Monumental)." We assume this statement is based upon the Buchanan et al. (2011) analysis of bypass effects conducted for the US Army Corps of Engineers. If so, the statement mischaracterizes the Buchanan et al. (2011) report, which states in its Executive Summary *"For steelhead…bypass at Lower Granite combined with bypass at downstream dams was associated with reduced adult return rates compared to other in-river steelhead. Spring/summer Chinook salmon that were bypassed at Lower Granite and then transported from Little Goose tended to return as adults at lower than expected rates. Lower than expected adult returns for summer Chinook salmon and steelhead detected in the bypass systems at both Lower Granite and McNary dams suggest a negative synergistic effect of that combination of bypass systems, that is, fewer adult returns than would have been expected from the perceived effects of bypass at those two dams singly. This suggests that there*	Comment noted. Text in Section 1 and Section 2 of the report was reviewed and revised to ensure it accurately reflects the results reported in Buchanan et al. (2011).

		may be a weak effect of bypass at Lower Granite Dam that is exhibited only if bypassed fish experience other bypass or stressful experiences downstream." "Fish that were bypassed at McNary tended to return as adults at lower than expected rates, but only if they were also detected at another dam (Table ES.1). In particular, bypass at McNary combined with bypass at either Lower Monumental or John Day consistently produced fewer returning adults than expected, for all three stocks…Lower than expected adult returns for spring Chinook salmon detected in the bypass routes at both McNary and Bonneville dams, and for steelhead detected in the bypass routes at both McNary and John Day dams, indicate a negative synergistic effect of those combinations of bypass systems. This suggests that there may be a possible latent effect of bypass at McNary that requires other potentially stressful experiences in order to be exhibited." *"Bypass at John* *Day Dam appeared to be associated with reduced adult return rates for both spring and summer Chinook salmon, in particular if the fish had been bypassed previously at an upriver dam (Table ES.1)…Chinook that were detected at John Day produced from 10% to 42% fewer adults than expected, depending on where else the fish were detected." "Chinook that were detected both at Bonneville and another upstream dam (i.e., Little Goose, Lower Monumental, or McNary) tended to return in fewer numbers than expected. However, it should be noted that with relatively low detection numbers at Bonneville and the resulting low expected numbers of adults, there was low statistical power to detect an effect on adult returns at Bonneville, especially for steelhead."* The statement is also inconsistent with the results of the 2010 Comparative Survival Study (CSS) analysis of bypass effects that concluded on page 179 that *"The bestfitting model for yearling Chinook indicated that post-BON SARs were reduced by 10% per bypass experience at upriver dams. The best fitting model for steelhead indicated a 6% reduction in post-BON SARS per bypass experience at Snake River dams and a 22% reduction in post-BON SARs per bypass experience at Columbia River dams."* This 2010 CSS analysis also concluded on page 179 that *"Nonbypassed yearling Chinook SARS averaged 52% higher, and non-bypassed steelhead SARS averaged 91% higher, than smolts that were bypassed at one or more of the collector facilities."*	

OR	Section 1 Comment 17	Section 1 Page 47. (Predation and Invasive Species Management RME): Sea lion predation assessed in Bonneville tailrace is at its lowest since 2006, likely due to removals and harassment. However, the monitoring is geographically limited, it does not include areas further downstream, and it cannot tell us if management actions have just moved pinniped predation impacts downstream.	Comment noted. Clarification has been added to Section 1 and Section 2 that the monitoring covers the Bonneville tailrace only.
OR	Section 1 Comment 18	Section 1 Page 47. (Predation and Invasive Species Management RME): Funding reductions by the Bonneville Power Administration in 2013 will likely eliminate, delay or reduce the scope of work ("well-designed research") to investigate nonnative fish predation and the effect of shad on overwinter predator survival.	Not relevant to the 2011 APR.
OR	Section 1 Comment 19	Section 1 Page 47. (Regional Coordination, Data Management and Implementation): Discussions at a recent Coordinated Assessments workshop indicate that implementation actions identified by state and tribal fishery managers as part of this working group will likely not be funded. Instead the Action Agencies will likely hire additional data stewards. It is not clear how these positions will effectively assist local fisheries managers to improve fishery management agency infrastructures, which was identified as a priority to assure timely reporting of adult abundance, smolt-to-adult returns, and adult productivity data.	Not relevant to the 2011 APR.
OR	Section 1 Comment 20	Individual ESU status reports (starting on page 50): In these sections, total fish numbers at upper basin mainstem dams (Lower Granite and Rock Island dams) are reported. The 2011 Progress Report should instead report individual population status metrics, as were originally used in the 2008 BiOp and not total ESU abundance as measured at these dams. This approach largely ignores the status of ESUs that cannot be measured at mainstem dams.	The APR includes charts of abundance and trends for natural-origin adult returns in order to provide some context to the APR's primary focus, which is the status of BiOp implementation for the year in question. The APR is not intended – nor is it required – to annually update the BiOp's analysis or conduct a thorough review of fish status.
OR	Section 2 Comment 1	Page 58 (Habitat Implementation Reports, RPAs 34–38, Table 10: RPAs 35-37): Annual progress reporting requirements in the BiOp specify that in addition to reporting on the status of project implementation, the Action Agencies should report physical metrics for implementation (e.g., number of acres treated, miles of stream treated or protected, cfs of streamflow acquired, miles of access opened, etc.) relative to the total needed to complete the projects and required to achieve estimated survival benefits. a. RPA 35 for tributary habitat requires the reporting of annual progress in relation to estimated survival benefits, by project.	As noted above, the 2011 APR describes the status of implementing all actions as of the end of the previous calendar year including all tributary habitat and estuary habitat actions and their associated metrics. By contrast, periodic check-ins (comprehensive evaluations) were designed to explicitly evaluate how the implemented projects are making progress toward the RPA goals. The next periodic check-in is the 2013 Comprehensive Evaluation due in June 2013. Estimated survival benefits associated with tributary and estuary

		b. RPA 36 for estuary habitat projects requires reporting of progress relative to the total need to complete the project and achieve the estimated survival benefit. c. RPA 37 for estuary habitat projects and achieving habitat quality and survival improvement targets requires reporting relative to achieving survival benefits by project and by ESU on progress toward ESU/DPS specific survival benefits. RPA 37 also requires that where ESU/DPS specific survival benefits are not achieving the progress outlines, the Action Agencies should identify processes or projects in place to ensure achievements by the next comprehensive report. d. Nowhere in the 2011 Progress Report do the Action Agencies report any results towards achieving survival benefits. The only reporting of metrics is for project completions in terms of the number of acres treated, miles of stream treated or protected, cfs of streamflow acquired, miles of access opened, etc. The Action Agencies confirm this conclusion on page 66 of Section 2 by stating that "Benefits for all 35 actions completed in the 2010–12 cycle, (including any projects carried 36 over from 2007–09) will be evaluated in the next expert panel workshops that will occur in spring/summer 2012."	habitat projects implemented from 2007-2011 will be reported in the 2013 Comprehensive Evaluation.
OR	Section 2 Comment 2	Pages 59-60 (RPA 35 – Tributary Habitat Implementation 2010-2018): Similar to the discussion in Section 1 on tributary habitat projects and metrics completed, information presented regarding RPA 35 for 2010-2018 projects, nothing is presented about how many projects were planned and/or scheduled as necessary during the 2010-2013 period and the relative progress during that period to complete the projects. Likewise, nothing is provided to distinguish projects from the 2007-2009 implementation cycle that may have been completed during 2011.	See response to comment 1, General. After receiving a similar comment on the 2010 APR, the AAs responded by presenting tributary habitat data more clearly (see Section 3, Attachment 2, Table 1, where 2010-2012 planned metrics can be compared with 2011 actual metrics achieved). These tables allow the reader to get a sense of the accomplishment in 2011 compared to the 2010-2013 goals.
	Section 2 Comment 3	Page 69 (RPA 37 Estuary Habitat Implementation 2010-2018): There appears to be a discrepancy in the number of estuary projects completed. Line 15 states that six projects were completed. However, only five projects are listed as having been reviewed by the Expert Regional Technical Group (ERTG). Does this mean that one, unspecified project was completed that was not reviewed by the ERTG? There is a further apparent discrepancy in the number of projects completed in 2011, based on the projects described in Section 3. Attachment 4: Action Agency 2011 Estuary Habitat Projects where	Comment noted. There were four restoration projects completed in 2011. The text and data in Sections 1 and 2 have been revised to reflect this.

		only four projects are shown as having been completed in 2011 with a total acreage of only 198.37.	
OR	Section 2 Comment 4	Page 53 (Section 2, RPA 37 Estuary Habitat, Achieving habitat quality and survival improvement targets): In the 2011 Progress Report, the Action Agencies report that some 2011 projects were delayed but they will be constructed in the 2012-13 cycle. The Action Agencies do not report progress toward ESU/DSU-specific survival benefits, as required by RPA 37 for annual progress reports (page 58, Table 8).	The 2011 APR describes the status of implementing all actions as of the end of the previous calendar year including all tributary habitat and estuary habitat actions and their associated metrics (See response to comment 1, Section 2). Available science does not currently allow the estimation of benefits for individual ESUs or DPSs. Rather, the ERTG process estimates benefits for "stream-type" and "ocean-type" juveniles (yearling and sub-yearling fish, respectively) with each ESU or DPS being either stream-type or ocean-type.
END			

Comments on the 2011 Progress Report on Implementation of the Federal Columbia River Power System Biological Opinion
State of Oregon
August 29, 2012

General Comments

1. The 2011 Progress Report only reports implementation of projects, without demonstrating any survival benefits to species listed under the Endangered Species Act (ESA). Numbers of projects implemented or dollars spent are not performance metrics. Instead, the Progress Report needs to explicitly demonstrate how the implemented projects are making progress toward ensuring the survival and recovery of ESA-listed fish species.
2. The 2011 Progress Report should more clearly and explicitly affirm the Action Agencies' commitment to the court-ordered spill program, now and in future years. The report should also make it clear that the Action Agencies consider the court-ordered spill program to be the presumptive path for the spring and summer spill in RPA Action 29. The report does not, but should explicitly document progress toward implementing the annual spill program.

Specific Comments

Section 1. Protecting Salmon and Steelhead Endangered Species Act Federal Columbia River Power System 2011 Annual Progress Report

1. Page 5-6 (Figure 2 and Table 1): The 2011 Progress Report presents the combined Bonneville Dam counts of hatchery and wild fish as an indication of improved status since 1999. Instead, it should track improvements in reproduction, survival, numbers, and distribution of ESA-listed species at the population level. Presenting Bonneville Dam counts is misleading because:
    a. The dam counts combine all species, including unlisted species/ ESUs, such as:
        i. Mid-Columbia spring Chinook
        ii. Mid and upper Columbia fall Chinook,
        iii. Hatchery/reintroduced coho returning to hatcheries and basins above The Dalles Dam, which are outside of the listed coho ESU.
    b. The dam counts include hatchery fish, as well as wild fish (including hatchery Chinook, steelhead, coho and sockeye).
    c. Only about 11% of the dam counts are wild ESA-listed fish.

2. Page 6 (Adult fish survival): NOAA's PIT tag methodology for measuring adult survival from Bonneville Dam to points upstream remains problematic because the PIT tag data cannot be reconciled with other sources of information, such as dam counts, turn-off/straying, harvest and unaccounted-for losses. The 2011 Progress Report should better acknowledge and explain these discrepancies and their implications.

3. Page 7 (Juvenile fish survival): The 2011 juvenile fish survival estimates reported in the 2011 Progress Report are incomplete in that they do not include survival of fish that only pass the dams over the spillway (i.e. fish that are never by-passed or transported). This is because these fish complete their in-river out-migration undetected as juveniles. As a result, survival of these fish can only be measured as adult returns. With respect to juvenile fish survival, the report should make it clear that survival estimates only include transported and by-passed (detected) juveniles (those not spilled).

4. Page 7 (Juvenile fish survival): The 2011 Progress Report combines juvenile fish survivals for hatchery and wild fish. Survivals for juvenile hatchery and wild fish differ; therefore they must be reported separately. (see figure 5, page 6).

5. Page 7 (Juvenile fish survival): The 2011 Progress Report states "Research is being carried out under the BiOp to better understand any delayed effects of transport." on juvenile fish survival, but doesn't actually report the data that already exists on delayed effects. A wealth of scientific data exists (e.g. Comparative Survival Study reports) that indicates that delayed mortality of transported fish is greater than that of fish that migrate in river, especially those that migrate undetected.

6. Page 7 (Juvenile fish survival): Estimates of total system survival calculated by only including survival of juvenile fish that were by-passed and were transported is biased because (a) it does not include in-river migrants that migrated to sea undetected and (b) it does not include delayed mortality of these fish. Because the weight of scientific evidence indicates that delayed mortality of transported fish is greater than that of fish that migrate in river, especially those that migrate undetected, failing to include delayed mortality will overestimate the relative survival of transported fish, whose direct mortality is only around 2% (from point of collection in the Snake to point of release below Bonneville Dam).

7. Page 7 (Juvenile fish survival): Because the total system survival estimates in the 2011 Progress Report do not account for delayed mortality, and thus overestimate the relative survival of transported fish, the estimates in years when fewer juvenile fish are transported will be less than in other years. However, if the relative survival of juvenile fish that return as adults is compared between those same years, the relationship breaks down because transported fish have much higher delayed (post-

Bonneville) mortality than in-river fish, especially those that migrate in river undetected.

8. Page 7 Juvenile fish survival-Figure 6): The 2011 Progress Report combines juvenile survivals for hatchery and wild fish. The CSS reports have demonstrated that hatchery fish have higher benefits from transportation than wild fish. As support for these points, see analysis in Tuomikoski et al. 2010. comparative survival study (CSS) of PIT-tagged spring/summer Chinook and summer steelhead 2010 annual report, Comparative Survival Study Oversight Committee and Fish Passage Center, Portland OR 388 pages (in administrative record).

9. Page 10-11 (Ocean and climate conditions): The 2011 Progress Report does not mention, but should explain that analyses (i.e. Schaller and Petrosky 2010 and Haeseker et al 2012) indicate ocean conditions are one of three important variables, along with flow and spill that predict smolt-to-adult returns, and first year ocean survival of Snake River spring/summer Chinook.

10. Page 13 (Hydropower – Improvements for Fish at the Dams): Direct survival of fish passing through bypass systems may appear high when measured at the concrete, however recent data have shown significant delayed mortality effects during the remainder of the juvenile and early ocean-adult life stages that reduces adults returns.

11. Page 15 (Juvenile Salmonid Dam Passage Survival): The 2011 Progress Report currently states that "Transportation results continue to indicate higher adult returns of yearling Chinook salmon and juvenile steelhead that are collected and transported compared to those that migrate in-river during part of April and all of May, indicating that fish survival to adult would be higher with a greater transportation of fish in the spring." This statement does not reflect the latest findings from evaluations of the seasonal effects of transporting fish conducted by NOAA Fisheries (Bill Muir presentation at the 2011 AFEP Annual Review). In an abstract for the presentation, NOAA Fisheries states "Patterns did not change drastically in 2006-2009, but the earliest date on which T:M exceeded standards was more likely to be later in May (e.g., May 10), especially for steelhead."

12. Pages 18-28. (Tributary Habitat): As is generally the case for the 2011 Progress Report, this entire section describes the total amount of actions completed in 2011, but does not provide any context of how much was planned to be completed or was needed to be completed to meet the commitments made in the 2008/2010 BiOp for survival improvement.

13. Page 29. (Estuary Habitat Actions): As with tributary habitat, the estuary habitat section characterizes a very modest amount of acres treated as making significant progress, but without indicating how many projects were anticipated and relied on in the 2008/2010 BiOp for each year in this implementation cycle. Nor does it describe what projects were delayed or proved to be infeasible that must be replaced in

subsequent years or cycles. It also does not reveal how many of the six completed projects were themselves replacement projects from previous years or cycles.

14. Page 29-30 (Estuary Habitat Actions): The total number of acres shown in Table 3 (234.2) does not match the difference between the acres (239.9) for 2010 and 2011 in Figure 16a and b. Likewise, the total of the number of acres treated (198.37) as shown in Section 3 Attachment 4, Table 1. Action Agency 2011 Estuary Habitat Projects (Pages 61-65) differs from both of the above. These reported numbers of acres should be reconciled and reported in a more consistent manner, or an explanation of the apparent discrepancies provided.

15. Page 41 (Hydro RME): It is stated in the 2011 Progress Report that "NOAA Fisheries evaluation of SARs from wild fish transported and left in-river in the spring continued to indicate benefits from spring transport compared with in-river migration, especially for steelhead smolts." Research findings from the Comparative Survival Study (CSS) do not support these statements. Evaluations of smolt-to-adult survivals (SARs) conducted by state and tribal co-managers, updated to include 2010 returns (CSS 2011 August 31, 2011 Draft Annual Report available on www.fpc.org), have consistently shown that there is little or no transportation benefit (as indicated by a statistical difference in transport vs. in-river SARs >1.0) for Snake River wild Chinook (transport vs. in-river return or TIR > 1.0 in only 2 of 16 years), variable benefits for Snake River hatchery Chinook, and marginal benefits for hatchery steelhead (TIR > 1.0 in 5 of 11 years). The only stock group that has shown positive benefits is Snake River wild steelhead but even then TIRs have been >1.0 in only 7 of 11 years. In addition, in order to provide a more comprehensive evaluation on the benefits of transportation, the potential negative impacts of transportation on other species (specifically Snake River sockeye) and straying of Snake River steelhead need to be considered.

16. Page 41 (Hydro RME Critical Uncertainty Research): The 2011 Progress Report states beginning on line 22 that "Some juvenile bypass systems (JBS) were not associated with any reduced adult return rate (Lower Granite, McNary, John Day, and Bonneville), while some JBSs were (Little Goose, Lower Monumental)." We assume this statement is based upon the Buchanan et al. (2011) analysis of bypass effects conducted for the US Army Corps of Engineers. If so, the statement mischaracterizes the Buchanan et al. (2011) report, which states in its Executive Summary *"For steelhead…bypass at Lower Granite combined with bypass at downstream dams was associated with reduced adult return rates compared to other in-river steelhead. Spring/summer Chinook salmon that were bypassed at Lower Granite and then transported from Little Goose tended to return as adults at lower than expected rates. Lower than expected adult returns for summer Chinook salmon and steelhead detected in the bypass systems at both Lower Granite and McNary dams suggest a negative synergistic effect of that combination of bypass systems, that is, fewer adult*

returns than would have been expected from the perceived effects of bypass at those two dams singly. This suggests that there may be a weak effect of bypass at Lower Granite Dam that is exhibited only if bypassed fish experience other bypass or stressful experiences downstream." "Fish that were bypassed at McNary tended to return as adults at lower than expected rates, but only if they were also detected at another dam (Table ES.1). In particular, bypass at McNary combined with bypass at either Lower Monumental or John Day consistently produced fewer returning adults than expected, for all three stocks…Lower than expected adult returns for spring Chinook salmon detected in the bypass routes at both McNary and Bonneville dams, and for steelhead detected in the bypass routes at both McNary and John Day dams, indicate a negative synergistic effect of those combinations of bypass systems. This suggests that there may be a possible latent effect of bypass at McNary that requires other potentially stressful experiences in order to be exhibited." "Bypass at John Day Dam appeared to be associated with reduced adult return rates for both spring and summer Chinook salmon, in particular if the fish had been bypassed previously at an upriver dam (Table ES.1)…Chinook that were detected at John Day produced from 10% to 42% fewer adults than expected, depending on where else the fish were detected." "Chinook that were detected both at Bonneville and another upstream dam (i.e., Little Goose, Lower Monumental, or McNary) tended to return in fewer numbers than expected. However, it should be noted that with relatively low detection numbers at Bonneville and the resulting low expected numbers of adults, there was low statistical power to detect an effect on adult returns at Bonneville, especially for steelhead."

The statement is also inconsistent with the results of the 2010 Comparative Survival Study (CSS) analysis of bypass effects that concluded on page 179 that *"The best-fitting model for yearling Chinook indicated that post-BON SARs were reduced by 10% per bypass experience at upriver dams. The best fitting model for steelhead indicated a 6% reduction in post-BON SARS per bypass experience at Snake River dams and a 22% reduction in post-BON SARs per bypass experience at Columbia River dams."* This 2010 CSS analysis also concluded on page 179 that *"Non-bypassed yearling Chinook SARS averaged 52% higher, and non-bypassed steelhead SARS averaged 91% higher, than smolts that were bypassed at one or more of the collector facilities."*

17. <u>Section 1 Page 47. (Predation and Invasive Species Management RME)</u>: Sea lion predation assessed in Bonneville tailrace is at its lowest since 2006, likely due to removals and harassment. However, the monitoring is geographically limited, it does not include areas further downstream, and it cannot tell us if management actions have just moved pinniped predation impacts downstream.

18. <u>Section 1 Page 47. (Predation and Invasive Species Management RME)</u>: Funding reductions by the Bonneville Power Administration in 2013 will likely eliminate,

delay or reduce the scope of work ("well-designed research") to investigate non-native fish predation and the effect of shad on overwinter predator survival.

19. Section 1 Page 47. (Regional Coordination, Data Management and Implementation): Discussions at a recent Coordinated Assessments workshop indicate that implementation actions identified by state and tribal fishery managers as part of this working group will likely not be funded. Instead the Action Agencies will likely hire additional data stewards. It is not clear how these positions will effectively assist local fisheries managers to improve fishery management agency infrastructures, which was identified as a priority to assure timely reporting of adult abundance, smolt-to-adult returns, and adult productivity data.

20. Individual ESU status reports (starting on page 50): In these sections, total fish numbers at upper basin mainstem dams (Lower Granite and Rock Island dams) are reported. The 2011 Progress Report should instead report individual population status metrics, as were originally used in the 2008 BiOp and not total ESU abundance as measured at these dams. This approach largely ignores the status of ESUs that cannot be measured at mainstem dams.

Section 2. Detailed Description of Reasonable and Prudent Alternative (RPA) Action Implementation

1. Page 58 (Habitat Implementation Reports, RPAs 34–38, Table 10: RPAs 35-37): Annual progress reporting requirements in the BiOp specify that in addition to reporting on the status of project implementation, the Action Agencies should report physical metrics for implementation (e.g., number of acres treated, miles of stream treated or protected, cfs of streamflow acquired, miles of access opened, etc.) relative to the total needed to complete the projects and required to achieve estimated survival benefits.

    a. RPA 35 for tributary habitat requires the reporting of annual progress in relation to estimated survival benefits, by project.
    b. RPA 36 for estuary habitat projects requires reporting of progress relative to the total need to complete the project and achieve the estimated survival benefit.
    c. RPA 37 for estuary habitat projects and achieving habitat quality and survival improvement targets requires reporting relative to achieving survival benefits by project and by ESU on progress toward ESU/DPS-specific survival benefits. RPA 37 also requires that where ESU/DPS-specific survival benefits are not achieving the progress outlines, the Action Agencies should identify processes or projects in place to ensure achievements by the next comprehensive report.
    d. Nowhere in the 2011 Progress Report do the Action Agencies report any results towards achieving survival benefits. The only reporting of metrics

is for project completions in terms of the number of acres treated, miles of stream treated or protected, cfs of streamflow acquired, miles of access opened, etc. The Action Agencies confirm this conclusion on page 66 of Section 2 by stating that "Benefits for all 35 actions completed in the 2010–12 cycle, (including any projects carried 36 over from 2007–09) will be evaluated in the next expert panel workshops that will occur in spring/summer 2012."

2. Pages 59-60 (RPA 35 – Tributary Habitat Implementation 2010-2018): Similar to the discussion in Section 1 on tributary habitat projects and metrics completed, information presented regarding RPA 35 for 2010-2018 projects, nothing is presented about how many projects were planned and/or scheduled as necessary during the 2010-2013 period and the relative progress during that period to complete the projects. Likewise, nothing is provided to distinguish projects from the 2007-2009 implementation cycle that may have been completed during 2011.

3. Page 69 (RPA 37 Estuary Habitat Implementation 2010-2018): There appears to be a discrepancy in the number of estuary projects completed. Line 15 states that six projects were completed. However, only five projects are listed as having been reviewed by the Expert Regional Technical Group (ERTG). Does this mean that one, unspecified project was completed that was not reviewed by the ERTG? There is a further apparent discrepancy in the number of projects completed in 2011, based on the projects described in Section 3. Attachment 4: Action Agency 2011 Estuary Habitat Projects where only four projects are shown as having been completed in 2011 with a total acreage of only 198.37.

4. Page 53 (Section 2, RPA 37 Estuary Habitat, Achieving habitat quality and survival improvement targets): In the 2011 Progress Report, the Action Agencies report that some 2011 projects were delayed but they will be constructed in the 2012-13 cycle The Action Agencies do not report progress toward ESU/DSU-specific survival benefits, as required by RPA 37 for annual progress reports (page 58, Table 8).